The biomechanical, anthropometrical, physical, motor and injury epidemiological profile of elite under 19 rugby players

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Dissertation submitted in fulfilment of the requirements for the degree Master of Education specializing in the Movement Education at the Potchefstroom Campus of the North-West University

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November 2006

Potchefstroom

ACKNOWLEDGEMENTS

I would like to thank the special people who contributed to this study. Without their help and support this study would not have been completed. I would like to express my sincere gratitude to the following:

- My study leader, Prof. Manie Spamer, I am very grateful for your assistance, advice and availability in spite of your busy schedule. Thank you for your patience and all the valuable guidelines which contributed to keep this study focused on scientific outcomes. I appreciate it sincerely.
- Dr. Bartholomias Hattingh for initiating this study. Thank you for your support and for the knowledge you shared with me.
- The Rugby Institute of the North-West University, the Leopard Rugby Union and especially Stefan Wiese, for assisting me in obtaining the valuable data of the rugby teams under your jurisdiction.
- Dr. S. Ellis, for helping me with the statistical procedures.
- Miss M. Smuts, for editing the script linguistically.
- Christel Smith, at the Ferdinand Postma Library, for your most valuable assistance and time in finding sources, as well as your encouragement at all times.
- Johan, Yvette, Jolene and Rina for your support.
- My parents, who are always there for me. Thank you for your empathy.
- My Heavenly Father for whom I feel the deepest gratitude for granting me the opportunity to undertake and conclude this study.

Hanna Steenkamp

December 2006

SUMMARY

Keywords: Anthropometrics; Physical and motor; Biomechanical and Postural evaluations; Injury epidemiology; U/19 rugby players.

Background: The multiplicities of factors, which may contribute to injury from sporting activity, and the complexity of the relations among them, indicate that identifying causal mechanisms poses a challenge to epidemiologists. The identification of risk factors associated with the effect of the injury on subsequent participation may be as important in understanding how to reduce the burden of injuries on sports participants, as identifying factors associated with the injury incidence rate.

Aim: The aim of this study was to develop a biomechanical, anthropometrical, physical, motor and injury epidemiology profile for elite U/19 rugby players.

Design: A prospective cohort study.

Subjects: In this study 77 elite rugby players were used during the first testing episode (October 2005). These players had just completed their school career and were selected to form part of the Rugby Institute of the University of North West. The U/19 first team members were (n = 31) tested again in July 2006. Two different profiles were established.

Method: Once approval had been granted by both the players and by the Rugby Institute of the North West University, the players were submitted to a test battery. Anthropometric, Physical and Motor tests were done at the beginning of the season and the players re-tested at the end of the season. A Biomechanical and Postural Evaluation was done once-off at the beginning of the season. The necessary steps were taken to address existing shortcomings identified in the test subjects. After the results had been analyzed, individual programmes were formulated, explained and implemented. The aim was to minimize the possible risk areas indicated by screening.

Results: The results were statistically processed, recorded and compared with previous literature studies, according to both the total group and the different player positions – these are the tight five, the loose forwards, the halfbacks and the backs. The Anthropometrical, Physical and Motor testings showed a low or nil practical significant difference for the total group after a season of professional training and coaching, with slight differences between the player groups. The Biomechanical and Postural Evaluation proved the group to be dynamically overloaded with poor regional stability and musculature as far as the upper and lower limbs were concerned, with asymmetry and weak core stability of the spinal and pelvic region. A total of 184 injuries were reported over the season, with the lower limbs (58%) and upper limbs (23%) as the most commonly injured body parts; and sprains (22%) and strains (17%) the type of injury which occurred most often. The tight five (32%) had the highest injury rate, with the flanker (13%) the least injured player position.

Conclusion: A profile for elite U/19 rugby players has been determined. This profile can be implemented in conjunction with similar findings in existing literature for future guidelines by coaches and the management to select a better team, to ensure a higher quality of performance and to prevent injuries.

OPSOMMING

Sleutelwoorde: Antropometriese; Fisiek-Motoriese; Biomeganiese en Posturale Evaluasies (BMPE); beserings epidemiologie; O/19 elite rugbyspelers.

Agtergrond: Die wye verskeidenheid van faktore wat kan bydra tot sportbeserings, en die kompleksiteit van die verhoudings tussen hulle, bied 'n uitdaging aan epidemioloë om die meganiese oorsaak daarvan te bepaal. Dit is baie belangrik om die risiko-faktore se effek op beserings en die daaropvolgende deelname te bepaal. Dit is egter net so belangrik om te verstaan hoe om die las van beserings in sport te verlig, as hoe om die faktore wat die beserings veroorsaak, te identifiseer.

Doelwit: Die doel van hierdie studie was on 'n biomeganiese, antropometriese, fisiek-motoriese en beserings epidemiologie profiel vir elite O/19 rugby spelers saam te stel.

Ontwerp: 'n Voorgenome toetsgroep studie.

Studiepopulasie: In hierdie studie is 77 elite rugbyspelers gebruik tydens die eerste toets-episode (Oktober 2005). Hierdie spelers het pas hul skoolloopbaan voltooi en is gekies om deel van die Rugby Instituut van die Noordwes Universiteit te wees. Die O/19 eerste span (n = 31) is weer in Julie 2006 getoets. Twee verskillende profiele is saamgestel.

Metode: Na goedkeuring van die spelers en die Rugby Instituut van die Noordwes Universiteit, is die spelers aan toetsbatterye onderwerp. Antropometriese en fisiek-motoriese toetse is aan die begin van die seisoen gedoen en die spelers is weer aan die einde van die seisoen getoets. 'n Biomeganiese en posturale evaluasie is slegs aan die begin van die seisoen gedoen. Die nodige stapppe is gedoen om bestaande tekortkominge van die spelers te identifiseer. Nadat die resultate ontleed is, is individuele programme geformuleer, verduidelik en geimplementeer. Die doel was om moontlike risiko-areas te identifiseer en te beskerm en dus te verminder.

Resultate: Die resultate is statisties verwerk, aangeteken en met vorige literêre studies vergelyk. Volgens die volledige groep en volgens spelerposisies – naamlik die vaste vyf, die los voorspelers, die skakelpaar en die agterspelers. Die antropometries en fisiek-motoriese toetse het 'n lae, of geen praktiese beduidende verskil aan die totale groep na 'n seisoen van professionele afrigting en oefening getoon nie. Daar was slegs geringe verskille tussen die spelergroepe. Die biomeganiese en posturale evaluasie het bewys dat die groep dinamies oorstuur was met swak kern-stabiliteit en muskulatuur wat die boonste en onderste ledemate betref, met asimmetrie en swak kernstabilitiet van die spinale en bekken area. 'n Totaal van 184 beserings is tydens die seisoen aangemeld, met die onderste lededmate (58%) en boonste ledemate (23%) die mees algemene beseerde dele van die liggaam met verstuiting (22%) en verrekking (17%) wat mees algemeen voorgekom het. Die vaste vyf (32%) het die meeste beserings opgedoen terwyl die flank (13%) die speler posisie met die minste beserings was.

Gevolgtrekkings: 'n Profiel vir die O/19 rugbyspeler is saamgestel. Hierdie profiel kan saam met bevindinge in bestaande literatuur aangewend word as riglyne vir afrigters en die bestuur van die span, om sodoende 'n beter span saam te stel, wat beter prestasies lewer, asook om beserings te voorkom.

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LIST OF ABBREVIATIONS

IRB	International Rugby Board
SARFU	South African Rugby Football Union
SAS	Statistical Analysis System

ASIS	Anterior superior ileac spine
BMPE	biomechanical and postural evaluations
cm	centimetre
ext	external
Jul	July
intern	internal
ITB	Iliotibial band
1RM	one repetition maximum
kg	kilogram
L	left
m	metre
min	minimum
max	maximum
n	number
Oct	October
Ph.D	Philosophiae Doctor Degree
R	right
sd	standard deviation
s	second
PSIS	Posterior superior ileac spine
Quad	quadriceps
Q-angle	quadriceps angle
ROM	range of movement
SLR	straight leg raise
TA	tendon Achilles
TLF	Thoraco lumbar fascia
$\bar{x}$	mean value
VMO-L	Vastus medialis obliques-lateralis

CHAPTER 1:

PROBLEM, AIM AND METHOD OF RESEARCH:

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1.1 INTRODUCTION

Benjamin Franklin had a saying that "...nothing in this world is certain but death and taxes" (Whiting & Zernicke, 1998). However, a suggestion is that we add another inevitability: physical injury. Injury is an unfortunate fact of everyday life. While some individuals sustain injuries of greater severity more frequently than others, no one is spared the pain, distraction and incapacity caused by injury. Along with injury come the inevitable physical, emotional and economic costs, as well as loss of time and normal function. Whatever the severity of the injury, most have a mechanically related etiology and might be prevented with the necessary knowledge on biomechanics and causes of the injury (Whiting & Zernicke, 1998).

Over the years, increasing attention has been directed towards describing the size and nature of the sport injury problem all around the world. Sports injuries occur across a range of activities including formal (competitive) and informal sport, school sport, active recreation, fitness activities, and general physical activities. Sports injury is recognized as a public health priority, notwithstanding the well documented limitations of available data (Cassell *et al.*, 2003). Furthermore it showed that routine health sector data collection in defined populations can provide useful information on the size, distribution and characteristics of the problem of sport and active recreation activities.

Rugby is one of the most popular professional team sports in the world and is being played from primary school to senior level in more than a hundred countries world-wide. It is also one of the highest reported sources of injury, irrespective of the injury definition used. South Africa is no exception; it has been known to be the breeding ground for some of the world's greatest players. It is therefore essential that the

national and international governing bodies for rugby union together with coaches and medical teams have a complete understanding of the incidence, nature, severity and causes of injuries in order to review the adequacy of their injury prevention, treatment and rehabilitation strategies. Since rugby union became a professional sport in 1995, epidemiological studies of professional players have been limited to relatively small sample populations (Van Gent, 2003; Brooks *et al.*, 2005).

Nicolas (1997) stated that with the increased physiological demands being placed on the elite players, the anthropometric and physiological characteristics of its players are of paramount importance. This is due to the recent introduction of professionalism, regional championships, the World Cup and major tours, where information about the demands of the game and the assessment thereof as well as methods of improvement are of major concern.

Professionalism was adopted by the International Rugby Board (IRB) after the Second World Cup in South Africa in 1995. Since this introduction of professionalism in rugby union, the science examining the sport and its participants has developed rapidly to meet the increased demand for knowledge of the game and the characteristics of the players (Duthie *et al.*, 2006; Silver, 2002). It has also coincided with an increase in injuries to both professional and amateur players. The penalties for accepting the financial and other rewards accompanying professionalism in rugby union appear to include a major increase in player morbidity (Duthie *et al.*, 2006). The advent of professionalism has resulted in more emphasis being placed on strength, speed and stamina in all players (Silver, 2002). Further, international level rugby is now played for up to eleven months of the year, with inter-provincial or international games scheduled on a weekly basis. Apart from the attraction of match fees, players at these levels are pressured to participate in every game by the coaches' or teams' desire for success and also their own desire not to be replaced in the team by a rival to their position (Upton, 1999).

The Beeld (2006) reports that in Pretoria alone there have been more than 100 critical injuries in school rugby this year! Professor Anita Pienaar, a lecturer in sport science at the North West University, said that there is a physical difference of up to four years between schoolboys of the same age and this difference tends to make contact sports more dangerous (Beeld, 2006). This leads to more injuries, as players of the same age do not necessarily have the same power or strength to compete against one another. By using this information, programs can be developed to prevent injuries.

1.2 PROBLEM STATEMENT

The multiplicity of factors that may contribute to injury from sporting activity, and the complexity of the relations among them, mean that identifying causal mechanisms poses a challenge to epidemiologists. The identification of risk factors associated with the effect of the injury on subsequent participation may be as important in understanding how to reduce the burden of injuries on sports participants as identifying factors associated with the injury incidence rate. Quarrie *et al.* (2001) divided potential risks into those intrinsic (including age, anthropometrical and psychological characteristics, fitness and health status and injury history) and those extrinsic (nature of the sport, environmental conditions and equipment) to the sportsperson. Orchard *et al.* (2001) also divided the mechanism of injury in intrinsic (defined as being related to internal or personal factors) or extrinsic (defined as relating to external and or environmental causes).

Already in the fifties O'Connell (1954) reported rugby as one of the most vigorous of team games, calling for attributes of strength, co-ordination and physical courage to be found in the athletic contest.

In New Zealand, according to Quarrie *et al.* (2001) the larger player base and high incidence of injury, results in rugby being the largest contributor to sports injury costs borne by their mandatory injury compensation scheme. From what is known about rugby injury, it appears that there is a higher incidence rate of particular injuries, for example, spinal cord injuries do not always follow this pattern. The type of injury a

player is likely to sustain is also related to playing position – for example, those in the front row positions are more at risk of cervical spine injury during scrums than those in other positions. Also those who have had a preseason injury have a higher injury rate than those who had no injuries during the previous season.

According to Rotem and Davidson (2001) the importance of appropriate fitness and strength in reducing risk of injury has been identified extensively in the literature as quoted by Silver (1984 & 2002) and Milburn (1993) et cetera. Speed of play and forces of engagement, however, might be the most important etiological factor in the majority of rugby injuries. Of note, then, is the fact that players' fitness and strength influence the velocity and force they are able to exert in an impact. It also influences their ability to keep up with play and position themselves so as to be able to build momentum for head-on impacts. Potentially greater impacts involved with players of increasing fitness might contribute to the higher injury rate for first-grade or elite players, who tend to be fitter, stronger and larger. Nonetheless Rotem and Davidson (2001) suggested that this must be weighed against the limited protective factors that increased size, skill and experience can provide against serious injury.

Gabbe *et al.* (2004) studied the reliability of musculoskeletal screening tests on elite Australian football clubs, both pre-season or pre-participation screening protocols and follow-ups later on to identify risk factors in sports participants. The tests of interest were Sit and Reach, Active Knee Extension, Passive Straight Leg Raise, Slump, Active Hip Internal Rotation Range of Movement (ROM), Active Hip External Rotation ROM, Lumbar Spine Extension ROM and the Modified Thomas Test. They found these clinical measures of flexibility and ROM are reliable and supported their countermeasure towards identifying intrinsic injury risk factors.

Peens (2005) stated that employing a screening mechanism to assess athletes' susceptibility to injury could potentially decrease the incidence of injury. Thus one of the aims of screening athletes is to assess the presence of any predisposing factors to

musculoskeletal injury, such as lack of flexibility, muscle weakness, muscle imbalances, impaired proprioception and abnormal biomechanics.

According to Bell (1998) biomechanical abnormalities are one of the major causes of overuse injuries; therefore it is important to include biomechanical evaluations of the musculoskeletal system in the assessment of injuries.

The increased professionalism in rugby has elicited rapid changes in the fitness profile of elite players. According to Duthie *et al.* (2003:973) recent research, focusing on the physiological and anthropometrical characteristics of rugby players and the demands of competition are reviewed. The paucity of research on contemporary elite rugby players is highlighted, along with the need for standardized testing protocols.

Recent data furthermore reinforce the pronounced differences in the anthropometric and physical characteristics of the forwards and backs (Duthie *et al.*, 2003:974). Forwards are typically heavier, taller, and have a greater proportion of body fat than backs. These characteristics are changing, with forwards developing greater total mass and higher muscularity. The forwards demonstrate superior absolute aerobic and anaerobic power, and muscular strength. Results favour the backs when body mass is taken into account. The scaling of results to body mass can be problematic and future investigations should present results using power function ratios. Recommended tests for elite players include body mass and skin folds, vertical jump, speed, and the multistage shuttle run. Repeat sprint testing is a possible avenue for more specific evaluations of players.

1.3 RESEARCH AIMS AND OBJECTIVES

1.3.1 To determine the effect of an exercise program on the anthropometrical profile of elite U/19 rugby players.

1.3.2 To determine the effect of an exercise program on the physical and motor profile of elite U/19 rugby players.

1.3.3 To determine the biomechanical profile of elite U/19 rugby players.

1.3.4 To determine the relevance of poor biomechanical status in comparison with the epidemiology of intrinsic injuries of elite U/19 rugby players.

1.4 METHOD OF RESEARCH

The research methodology consisted of two main components, namely: literature review and empirical investigations. The empirical investigations included discussions about the study population, procedure and method of data collection, test batteries, interventions and statistical data processing.

1.4.1 Literature review

An analysis of literature resources has been done by making use of electronic media, a library search and a search of sports and sport medicine journals, as well as South African newspapers. Databases such as Science Direct, Pubmed, EbscoHost (Academic Search Elite), Medline, South African Journals and Sportdiscus have been used. A manual search of the university of North West library computer catalogue was also done to find relevant material on the subject.

1.4.2 Empirical investigation

The empirical investigation consisted of the study population, procedure and method of data collection, test batteries, intervention and statistical data processing methods.

1.4.2.1 Study population

In this study a total of 77 elite U/19 rugby players were assessed in 2005. These players had just completed their school career and were selected to form part of the Rugby Institute of the University of North West. The Oxford Dictionary (1983) defines elite as "...group of the best most outstanding of a community" and in this case, players who had made it to the Craven Week in 2005 or had played for their Province during 2005 et cetera. This will lead to a biomechanical, anthropometrical, physical and motor profile of elite rugby players at the end of their school career.

Out of this group, the top of the log U/19 first team (n = 31) were re-tested in July 2006, that is after their first year of training et cetera at the Rugby Institute. This will lead to a second profile of elite rugby players at the end of their first year at the Rugby Institute, i.e. their anthropometrical, physical, motor and injury epidemiological status. The players were divided into groups according to their position played, i.e. tight five, loose forwards, halfbacks and back row.

1.4.2.2 Procedures and methods of data collection

Permission was obtained from the Rugby Institute of North West University to use their U/19 players to participate in this study. Once permission had been granted, players were asked to sign a consent form out of free will.

All players were tested pre-season i.e. their biomechanical, anthropometrical and physical and motor status. These results were analyzed and represented their school career in 2005. Players had to report any injuries sustained during the season on clinics held on Mondays and Wednesdays.

Re-testing was done on the top of the log players only, i.e. their anthropometrical, physical and motor status was then done at the end of the 2006 season to re-evaluate the test subjects and to determine the injury epidemiological profile.

1.4.2.3 Test Battery

The test battery consisted of four components, namely: the biomechanical, anthropometrical, and the physical and motor status, as well as the intrinsic injury epidemiological status.

1.4.2.3.1 Biomechanical Status

Biomechanical testing was conducted using the Biomechanical Assessment Form (Hattingh, 2003). This assessment helped to determine the biomechanical status of the upper and lower limb, pelvic girdle, spine and neurological status of all players. The results of this test are a detailed grading; using a 1/2/3 with an attached

classification for each number. It then also served as a biomechanical test for standardizing the power, flexibility and symmetry of the players.

1.4.2.3.2 Anthropometrical Status

The Anthropometrical Status of players measured by using protocols (body mass, body length and body fat percentage via skin fold measurements) as advocated by the International Body on Kin Anthropometrics, was used in this study (Ross & Marfell-Jones, 1991).

1.4.2.3.3 Physical and Motor Status

The Physical and Motor Status of the players were measured according to the following tests:

- Speed over a 10/30/40m distance (seconds) (Kirby, 1991)
- Illinois agility test (seconds) (Badenhorst, 1998)
- Vertical jump (centimetres) (Thomas and Nelson, 1985)
- Horizontal jump (metres) (Kirby, 1991)
- Abdominal curls (repetitions) (Kirby, 1991)
- Pull-ups (repetitions) (Thomas and Nelson, 1985)
- Bench press (repetitions) (Thomas and Nelson, 1985)
- Bleep test (repetitions) (Léger and Lambert, 1982)
- Speed endurance test (minutes) (Hazeldine and McNab, 1998)

1.4.2.3.4. Injury epidemiology status

All the records of the clinics held twice a week have been used. The records contain information on:

- Injury incidence as occurred in various player positions
- Anatomical regions injured as occurred in various player positions
- Type of injury as occurred in various player positions
- Results of the clinical attendance records of the Institute for Sports Medicine (period of prevalence; acute or chronic injury; specialist reference)

1.4.2.4 Intervention

All players were tested at the beginning of the season (October 2005) i.e. their biomechanical, anthropometrical, physical and motor status. Any intrinsic injuries that occurred during the season were evaluated and treated accordingly. The injured players were monitored till they were fully rehabilitated again. At the end of the season (July 2006) their anthropometrical, physical and motor status were tested again. A profile of the players was then drawn up, consisting of their biomechanical, anthropometrical and physical and motor status as well as all the intrinsic injuries that occurred.

1.4.2.5 Statistical data processing

Statistical software was used for data analysis. The SAS – computer program package of the North West University, Potchefstroom Campus (SAS Institute Inc., 2005) was used. Descriptive statistic evaluations have been done (Cohen, 1988; Steyn, 1999). The comparisons as well as differences between pre-season and post-season testing will be discussed. The intrinsic injuries with their epidemiology during this period will also be discussed.

1.5 CONTRIBUTIONS OF THIS STUDY

Essentially the game rugby is a risk factor insofar as injuries are concerned in South Africa. Limitations to this study need to be addressed e.g. the buy-in by of all unions to address the scourge of injury that plagues South African Rugby. We owe it to the players who place their "life on line" so to speak for the game, we owe it to the South African community who places demands on the teams to perform and win; and who pours huge amounts of money into the game. We also owe it to aspiring rugby players at lower levels of the game who wish to emulate their heroes, in some cases with disastrous consequences. This system seeks collaboration with other rugby playing nations where intervention and or prevention programmes and policies have yielded positive results.

Therefore, the contribution of this study is to:

- Assist the Rugby Institute of the NWU with a profile of an elite U/19 rugby player and therefore help to elect the most suitable players.
- Compare their profile with other groups and eliminate any shortcomings the players indicate.
- Minimize or prevent injuries from occurring during the season since a player must fit into the elite profile if he wishes to be considered worthy of a particular position.
- Motivate local and international management to use the profile to select appropriate players for specific positions.

CHAPTER 2:

LITERATURE SURVEY:

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LITERATURE SURVEY:

2.1 INTRODUCTION

In a biomechanical study by Mullin and Skolfield (2001:1) on the functional analysis of symmetrical motion in athletes, they screened for small imbalances in the hope to help prevent big problems. They sketched the following scenario:

"Brad is an avid basketball player. Some call him a fanatic. He plays for his local high school team and for pickup games every weekend. At centre, he is taller than most players his age. However his vertical leap is very low compared to norms although he is quick off the floor. He also has chronic and crippling bilateral patellar tendonitis. His doctor calls it a classic case of "jumper's knee" caused by overuse. He has been to physical therapy a couple of times, which seems to help somewhat in the short-term, but his symptoms return as his playing increases.

What is the missing piece? He has had a thorough evaluation of his history and clinical presentation, been given an accurate diagnosis, even been treated with all the appropriate therapeutic modalities and had his flexibility, strength deficits and soft tissue restrictions addressed. One practitioner even evaluated his foot and ankle, hip and pelvis, and walking mechanics looking for any other mechanical malfunctions that may have been contributing to his symptoms.

The critical link was actually between his low vertical leap results and his knee symptoms. In analyzing Brad's jump and landing, we discovered that he lacked the flexibility and eccentric control to adequately absorb the forces generated through his body on landing from a jump and decelerating. His trunk was vertically orientated when he landed, with no forward flexion of posterior pelvic movement, and his knees never flexed more than 30°. Over the course of time, this force

fulcrum scenario caused a breakdown in his biomechanical system which, if left undetected, could have resulted in a more debilitating condition.

So what about the Brads of the world? How can we as medical, sport and biomechanical practitioners learn to be more intuitive in our assessment skills and pick up subtle movement changes exhibited by today's athletes?"

The ability to participate in sports at the highest level without injury depends on a host of different factors. Factors such as genetic endowment and environmental conditions cannot be altered, while physiological factors are difficult to measure but may be modified with the appropriate psychological programme. Physiological factors, strength, speed and flexibility can be measured and can be altered by appropriate training (Kibler *et al.,* 1994). To ensure a high level of athletic performance and decrease the potential risk of injury, attention should be given to general medical fitness and sport-specific physiological variables (Peens, 2005).

Rugby consists of various activities that require certain anthropometrical, physical, motor and rugby specific components. These components are specific to the positional requirements in rugby (Van Gent, 2003). At present the positional selection of players, especially at school-level, are left to the coaches who do not necessarily possess the experience or knowledge for proper positional selections. The possibility to identify positional requirements by using a scientifically compiled test battery for rugby players will assist coaches in the correct positional selection of players at specific ages. Rugby will benefit from a much more competent player and the quality of the game will also improve. Elite players would also experience more satisfaction from their participation (Van Gent, 2003).

According to Van Gent (2003) the performance of players in specific positions in rugby is directly linked to certain anthropometric-, physical- and motor characteristics required for the particular position. The increase in the level of the

competition has caused players to become bigger, stronger and faster and to develop better motor ability.

In a study by Plotz (2004), comparing South African with English adolescent elite rugby players, he found it necessary to promote the effectiveness of game-specific preparation and development. Therefore, he recommended that the influence and effect of such programmes on the anthropometric variables, game-specific skill characteristics and physical and motor characteristics of players in particular be investigated. He recommended that further research be undertaken in order to compile an international profile of talented players, which will be of great value to both the coach and the player. Although the norm scales of elite players of different backgrounds and countries may vary, the different profiles of performance components will make a great contribution to talent identification, overall development and lifting the level of professionalism.

This study accentuates Plotz's (2004) recommendations as well as the fact that screening provides an opportunity for the medical support team (doctors, physiotherapists, biokineticists and sport scientists) to offer advice regarding the prevention of injuries (Brukner & Khan, 2002).

2.2 BRIEF HISTORY OF RUGBY

Ball games have been played around the world for centuries but the 'football' codes with which we are familiar today were first formalized in England and spread across the globe by the colonizers and entrepreneurs of the British Empire during the 19th century. The drive to write down a set of rules for the various kicking and handling games that were played across the country came from the private schools. The pupils of Winchester, Harrow, Eton, et cetera, all had their own distinct set of local rules and confusion reigned when the schools came to play each other. They were loosely divided between those favouring the handling style and those preferring the kicking game (SARFU, 2003:7).

Leading the way among the handling enthusiasts was Rugby School in central England. Legend has it that in 1823 a pupil named William Webb Ellis picked up the ball and ran with it "showing a fine disregard for the rules of football" a later historian wrote. This is widely regarded as the moment that rugby union was born although the accuracy of the story is disputed. What is certain is the old boys of Rugby were enthusiastic in their spreading of Rugby's version of the handling code rules – although they bear only passing resemblance to the laws of today's games. To the end confusion over the style of game schools would play when they met, a meeting was called in 1863 to thrash out a unified code. But there the two factions could not see eye-to-eye and rugby union and association football (soccer) were born (SARFU, 2003:7).

Although the first style of rugby played in South Africa at Bishops School in Cape Town conformed to the rules of Winchester School (the headmaster was a former pupil of the English School) by the time the first governing body of the sport – England's Rugby Football Union (RFU) – was founded in 1871, the Rugby's rules held sway. The same year the first international match was played between England and Scotland. Wales and Ireland followed onto the same calendar shortly afterwards and by the end of the century South Africa, New Zealand and two Australian states were also part of the international community (SARFU, 2003:7).

Since that time the game has evolved slowly. The game's international governing body, the International Rugby Football Union (today the International Rugby Board) was founded in 1886 although England declined to take part in a dispute over the number of representatives they would be permitted to supply (Noakes & Du Plessis, 1996; SARFU, 2003; De la Port, 2005). It was agreed that games would be played according to the rules of the Rugby Football Union but it was not until 1930 that the way the game was played was standardized across the world. The first match in South Africa took place between the "Officers of the Army" and the "Gentlemen of the Civil Service" at Green Point in Cape Town in 1862 and ended as a 0-0 draw. The game spread with British colonizers through the Eastern Cape, Natal and along

the gold and diamond routes to Kimberley and Johannesburg (Noakes & Du Plessis, 1996; De la Port, 2005).

The first union to be formed in South Africa was the Western Province, which came into being in 1883. Griqualand West followed in 1886 and the Eastern Province in 1888. South Africa played its first international in 1891 against a touring side from Britain although it was not until the side toured Britain in 1906 that they became known as the Springboks (IRB, 2004; SARFU, 2003).

The sport quickly gripped the imagination of many South Africans and the country's success fuelled the enthusiasm. South Africa won their third series in 1903 and it was not until the 1955 tour of New Zealand that they were to be defeated in a series as they established themselves as arguably the word's leading rugby nation. Their most dangerous rival was invariably New Zealand whom they met for the first time in 1921 to establish what is regarded as rugby's most bitter rivalry (IRB, 2004).

The game remained strictly amateur until 1995 when the inevitable decision to allow players to be paid was made and it became a professional sport. Up until then anyone caught taking money for playing the game was banned for life. In the next decade since that decision, the game has changed more rapidly than in the previous century and a half. New competitions such as the Vodacom Super 14, Vodacom Tri-Nations and the Heineken Championship in Europe have hugely increased the game's revenues and spectator interest.

2.3 DEFINITIONS

The following definitions will be discussed, based on the above literature:

- Biomechanical and postural evaluations
- Anthropometrical measurements
- Physical and motor variables
- Injury epidemiology

2.3.1 Defining Biomechanical and Postural evaluations

During the early 1970's, the international community adopted the term biomechanics to describe the science involving the study of biological systems from a mechanical perspective. Biomechanists used the tools of mechanics, the branch of physics involving analysis of the actions of forces, to study the anatomical and functional aspects of living organisms. Statics and dynamics are two major sub-branches of mechanics, where statics is the study of systems that are in a state of constant motion, that is, either at rest (with no motion) or moving with a constant velocity. Dynamics is the study of systems in which acceleration is present (Hall, 1999).

Biomechanics is the term used by scientists when they refer to the application of mechanical engineering principles to study aspects of animal or human biology. More specifically, sports biomechanics is the application of these principles to enhance sports performance or to reduce the risk of sports injuries. In injury prevention it is essential to consider the study of forces (kinetics) and of movement (kinematics). Excessive forces and abnormal movements can result in tissue damage or lead to injury. Therefore, these forces and movement of joints, limb segments and tissues have to be studied in a scientific manner and the possible relationship to injuries has to be researched (Derman & Schwellnus, 2001; Bell, 1998).

2.3.2 Defining Anthropometrical measurements

Specialization of position has led to the identification of anthropometric and physiological characteristics specific to the different playing positions which are important for optimal performance and have implications for team selection. It highlights the necessity for individualized training programmes and fitness attainment targets; a factor which is widely accepted by selectors, coaches, medics and players of the game. (Nicholas, 1997)

Anthropometry is the science that deals with the measurement of the size, proportions and composition of the human body (McGinnis *et al.*, 2005). In most cases it is the sizes that are directly measured, and these direct measurements can be combined to indicate the shape of the whole body or segments. Body composition typically involves using anthropometric results to predict the relative amount of a particular component in the whole body (McGinnis *et al.*, 2005). The best-known example is the use of skinfold thickness to predict the percentage of fat in the body.

In a study by Meir *et al.* (2001) to determine the positional differences of professional rugby league football players according to their physical qualities, they proved that excess body fat influences performance (for example, power to body mass ratio, thermoregulation and aerobic capacity) negatively.

Therefore, body composition, and its relationship with physical fitness, is of considerable importance to rugby union.

2.3.3 Defining Physical and Motor abilities

The importance of appropriate fitness and strength in reducing the risk of injury has been identified extensively in the literature. Speed of play and forces of engagement, however, might be the most important etiological factors in the majority of rugby injuries. Of note, then, is the fact that players' fitness and strength influence the velocity and force they are able to exert in an impact. It also influences their ability to keep up with play and position themselves so as to be able to build momentum for head-on impacts. Potentially greater impacts involved with players of increasing fitness might contribute to the higher injury rate for first-grade or elite players, who tend to be fitter, stronger and larger. Nonetheless, this must be weighed against the limited protective factors of increased size, skill and experience that limit serious injury (Rotem & Davidson, 2001).

In a study reporting on the anthropometric and physiological characteristics of rugby union players, Nicolas (1997) observed that these individuals had unique

attributes which depended on positional role and playing standard. These have important implications for team selection and highlight the necessity for individualized training programmes and fitness attainment targets.

Nicolas (1997) furthermore quoted Bell and Hazeldine on physical and motor requirements for different positions: agility and suppleness are important characteristics for hookers and props, with leg power, leg speed and a fast reaction speed as essential requirements for success in these positions. Locks also need leg-power together with good jumping ability (especially in order to win possessions in line-outs, as height is also an obvious advantage for this position). Back rows again, require a great capacity for power and mobility (in open play) as well as speed. Finally, wings and full backs require pace or a combination of speed and strength to beat the opposition.

2.3.4 Defining injuries

Injuries are no longer regarded as an Act of God or bad luck but mechanisms of injury have been clearly defined. From the late 1970's club medical officers became concerned by the increasing number of rugby injuries in general and broken necks in particular (Edgar, 1995; Silver, 2002).

Nathan *et al.* (1983) defined an injury as one which is severe enough to prevent the player from returning to rugby for at least 7 days after the injury. There were two reasons for choosing this definition: it was felt that this degree of injury would be easily identified by the particular survey methods we used, whereas less serious injuries which did not prevent the player from playing rugby for 7 days would almost certainly go undetected; and trivial or minor injuries are of little short- or long-term consequence, and can safely be ignored as their inclusion would overestimate the true risk of playing rugby. Injuries were graded further according to the length of time before the schoolboy could return to rugby. Grade 1, 2 and 3 injuries were those which prevented a player from returning to rugby for at least one week, for up to three weeks, and for more than three weeks respectively.

Targett (1998) defined an injury as that which prevented a player from taking full part in two training sessions, from playing the next week, or one that required special medical treatment (such as suturing or special investigation). Injuries were further classified as "minor", if they cause the player to miss less than one week of play, "moderate", if from one to three weeks were missed, or "severe" if more than 3 weeks were missed.

Lee and Garraway (1996) and Babić *et al.* (2001a) defined a rugby injury as an injury sustained in the field during a competitive match, practice game, or other training activity directly associated with rugby, which prevented the player from training or playing rugby from time of the injury or from end of the match of practice in which the injury was sustained. Rugby injuries sustained during training were those sustained during practice scrums or manoeuvres involving a rugby ball (not circuit training or training undertaken to achieve fitness). Injuries that necessitated leaving the field of play or practice and missing the remainder of the match or practice, but did not cause the player to miss subsequent matches or practice for at least 7 days, were classified as transient. Rugby injuries were coded according to the International Classification of Diseases (9^{th} revision) 14 (self report), and were further classified according to the time to resumption of play or training after an injury: within 28 days, mild; 29-84 days, moderate; more than 84 days, severe. According to the nature and site, injuries were classified as either: head, neck and face injuries, shoulder injuries, upper or lower limb injuries, and trunk injuries.

Marshall *et al.* (2001) defined an injury in the previous season as any injury resulting from rugby participation in the 12 months before the start of a specific season; which prevented a player from participating in at least one game, or at least two practices, or required medical attention. Furthermore he defined in-season injuries as any injury resulting from rugby participation that required medical attention or caused the player to miss a scheduled game or team practice.

A year later, Lee *et al.* (2001) again published a study, this time about the influence of preseason training, fitness, and existing injury on subsequent rugby injury. They found that injury risk is more likely to be related to rugby training (type of activities undertaken in rugby training) or personalities and characteristics of players undertaking training more frequently than to overall player fitness. Players who were injured at the end of the previous season were more likely to be injured in the following season. This might have been because they did not allow previous injuries to heal sufficiently before returning to the game, or the intensity of their participation may have increased their risk of injury.

Gabbett (2004) defined an injury as any pain or disability suffered by a player during a training session and subsequently assessed by the head trainer during, or immediately following, the training session. All injuries sustained during training sessions were recorded. The severity of injury was classified as transient (no training missed), minor (one training week missed), moderate (two to four training weeks missed) or major (five or more training weeks missed).

The primary injury definition, used by Brooks *et al.* (2005a), was any injury that prevents a player from taking a full part in all training and match play activities typically planned for that day for a period of greater than 24 hours from midnight at the end of the day the injury was sustained. In order that the overall incidence of injury could be compared with previous studies where a missed match definition of injury was used, injuries were also classified using the secondary definition of all injuries resulting in a player missing at least one competitive match. However, unless specifically stated otherwise, an injury referred to the primary definition throughout their results and discussions. Injury severity was defined by the time it took a player to return to full fitness; where full fitness was defined as "able to take a full part in training activities (typically planned for that day) and the availability for match selection." An injury was furthermore reported as recurrence on the

judgment of the clinician reporting the injury. Absences because of illness and medical conditions were not included in the study.

2.4 LITERATURE REWIEW

A review of all the biomechanical, anthropometrical, physical and motor, and injury epidemiology will follow.

2.4.1 Literature review on Biomechanical and Postural evaluations

In 2002, Brukner and Khan indicated that correct biomechanics provides efficient movement and is likely to reduce injury risk and that abnormal biomechanics should always be considered as a potential cause of a non-traumatic sporting activity. Faulty biomechanics may result from abnormalities, compromising either static (anatomical) abnormalities or functional (secondary) abnormalities. Already in 1994 Kibler *et al.* made a statement that biomechanical variables should target areas of athletic fitness that are specific to a particular sport, where a lack of such fitness may predispose an athlete to injury.

Static abnormalities such as leg length discrepancies or genu valgum cannot be altered. However, the secondary effect of these abnormalities can be minimized by compensatory devices such as a shoe build-up in the case of leg length discrepancy or an orthotic in the case of genu valgum (Brukner & Khan, 2002). Functional abnormalities may occur following injury or because of poor technique. For example, a ligament sprain may result in joint laxity, while a lengthy period of immobilization may lead to muscle imbalance (Brukner & Khan, 2002).

Derman and Schwellnus (2001) reported that up to 50- 60% of all high-level athletes suffer some sort of injury during a sports season. They also made the statement that injury prevention strategies should be put in place to help reduce the injury rate and to ensure that athletes are injury-free for extended periods throughout the season. A thorough biomechanical evaluation of an athlete is seen as an important tool in injury prevention (Mullin & Skolfield, 2001).

Rugby is associated with a number of biomechanical stresses which are frequently associated with injuries. Christey and Tomlinson (1999) found that high-energy contact sport, such as rugby, is the prime cause of severe ankle injury among young males in New Zealand. Although they found abundant literature on the prevention of sports-related ankle injuries - such as improving strength, flexibility, proprioception and the judicious use of external support - they still suggested that specific studies into the biomechanical sequences leading to high-impact sports-related ankle injuries may provide the basis for prevention of this expensive and debilitating injury. Further studies are required to define the specific mechanisms of injury in young male rugby players that may be influenced by preventative strategies.

Gerrard (1998) also found that the treatment of knee injuries by means of the taping of the patella to reduce the pain associated with poor patellar alignment is effective. However, attention must be paid to the correction of other biomechanical influences which are known to predispose athletes to anterior knee pain. This includes forefoot pronation, femoral anteversion, tibial torsion and an imbalance in the strength of the quadriceps and the hamstrings. Correctly applied adhesive tape will correct the position of the patella, but the effectiveness of this measure is also limited by factors such as sweating. Therefore, he suggested the correction of other biomechanical influences, seeing that it plays a very important role in the prevention of re-injury and the rehabilitation of injuries, without any negative side-effects.

Abnormalities of the intervertebral discs have been found in a high frequency among young elite sportsmen. Adams and Dolan (2005) found biomechanics can be used to quantify spinal loading and movements, to analyze distributions and injury mechanisms, and to develop therapeutic interventions. They furthermore suggested that techniques for quantifying spinal loading should be capable of measurement "in the field" so that they can be used in epidemiological surveys and

ergonomic interventions. For an example they used a sportsman who complained of back pain. Studies showed that psychosocial factors influence back pain behaviour but are not important causes of pain itself. Severe back pain most often arises from intervertebral discs, apophyseal joints and sacroiliac joints; and physical disruption of these structures is strongly but variably linked to pain. Typical forms of structural disruption can be reproduced by severe mechanical loading in-vitro, with genetic and age-related weakening sometimes leading to injury under moderate loading. The results showed that training affected mechanical work and back loadings, but not back asymmetries. Training reduced mechanical work on the load and back extensor moments for both load conditions. Therefore, Adams and Dolan (2005) suggested the biomechanical testing of sportsmen.

Injury to the hamstring muscle group represents a significant proportion of the total number of lower limb musculo-tendinous injuries occurring with sports participation. In a study on the management of hamstring injuries by Hoskins and Pollard (2005), they agreed that the treatment, prevention and management of hamstring injuries with its etiology, is complicated and multi-factorial. However, they found that the hamstring injuries only resolute fully after spinal manipulation and correction of lumbar-pelvis biomechanics, and not as previously thought by only treating the hamstring muscle on its own.

In recent years, the emphasis in rehabilitation medicine has been on function. Practitioners have strayed from relatively mundane therapeutic exercises toward movements and exercises that will have more immediate application to the patient's current level of function. By incorporating specific movement patterns similar to those the patient will be confronted with during day-to-day activities or athletics, the practitioner will be better able to help the patient adapt to changes in stimuli (Mullin & Skolfield, 2001).

However, Kibler (1994) identified one of the most important theories related to the sequencing of movements. He noted that human function is directly related to the

ability to perform a succession of movements synchronously and without compensation. During activity, the body is able to make subtle changes in order to be more efficient in completing a given task. However, while acclimatization is good for optimizing movement patterns for efficiency, it can be detrimental in the presence of pathology. These mal-adaptations Kibler called sub-clinical adaptation to athletic activity. The changes are most often insidious in development and not recognized by the athlete. The physiologic and mechanical alternations include deficiencies in overall strength, strength balance between agonist and antagonist muscles, and flexibility that alters the mechanics of performance of activities; which he called the functional biomechanical deficit complex. He also noted that a knowledgeable pre-participation examination can identify and treat these potential pain generators.

Injuries cause interruptions of training and/or decrease the intensity of practice. Adamantios and Bruggeman (2003) said that decreased training intensity and volume will possibly lead to poor preparation for an optimal use of the physiological resources and to poor preparation of the physiological preconditions in terms of muscle strength and/or aerobic capacity but also bone and soft tissue integrity. In general mechanical loading of the musculoskeletal system is a prerequisite for morphological and functional adaptation of biological material. But if stress and strain increase to a certain level and exceed the mechanical limits of the individual structure, mechanical loading may lead to tissue damage. From this point of view injury prevention should play a significant role in the use of biomechanics in elite sports.

In a study by Hattingh (2003:181) to establish a prevention program for rugby injuries among young adolescent players, both biomechanical and postural data revealed a practically significant shortcoming in both dynamic mobility and core positional stability. A negative correlation was reported in dynamic mobility (with increasing age), especially visible in the lower limb, spinal and neural regions. Core positional stability revealed a gradual improvement (as can be expected) with

increasing age, especially in the shoulder and pelvic girdle regions. Clinic attendance records reported a disturbingly high percentage of chronic overuse injuries, correlating with the biomechanical and postural findings, especially the regression in dynamic mobility findings reported by junior elite club players. Hattingh (2003) found that the high chronic overuse type of injuries reported in conjunction with the poor biomechanical and postural findings necessitate the introduction of an injury prevention program already at school level.

Some coaches may not be aware that an individual's posture can be very advantageous in many sports. In fact, after proportionality, posture is probably the most important self-selector for various sports and events (Bloomfield *et al*, 1994). Posture is unique to every individual and no two people have identical postures, although some are very similar. The determinants of an individual's posture are linked to the structure and size of the bones, the position of the bony landmarks, injury and disease, static and dynamic living habits and the person's psychological state. Bloomfield *et al.* (1994) also stated that good posture (both static and dynamic), is important for an attractive appearance, but more importantly it is essential if the body is to function with an economy of effort. If posture is poor it can lead to fatigue, muscular strain and poor muscle tone, the sagging of some parts and even low self-esteem.

In a study of injured runners, Lorenzton (1988) reported that 40% of them had a variety of postural defects, muscle weakness and imbalance, or decreased flexibility. He also reported that the following types of malalignment problems were involved: pronated feet or flat feet (pes planus), which caused excessive pronation during running and resulted in injury; and runners with flat feet were liable to develop further longitudinal arch without eversion, while those with high arches (pes caves) suffered from injuries attributed to excessive motion of the subtalar joint. Both Lorenzton (1988) and Brukner and Khan (2002) found that those individuals with a wide Q-angle or genu valgum (knock knees), experienced injuries to the patellofemoral joint and the patella itself. But athletes with genu

varum (bow legs) predisposed themselves to injuries in the patella region as well as iliotibial band friction syndrome. They also found that athletes with leg length discrepancies accompanied by a pelvic tilt developed trochanteric bursitis and iliotibial band friction syndrome, as well as intervertebral compression on the concave side of the lateral lumbar curve.

The above examples of injuries can be partially eliminated if coaches and sports medicine specialists become more aware of the increased risk of injury among athletes with the above postural defects. During the running cycle, it is necessary to have the correct alignment of the feet and the leg, as well as the upper limb and spine alignment (Lorenzton, 1988; Brukner & Khan, 2002). As mentioned above, runners who did not possess this characteristic or who had eversion of the heel, predisposed themselves to injury and pre-seasonal astute observation therefore, can often save an athlete from developing a chronic and debilitating injury which could have been avoided.

An in-depth analysis of the kinetics of rugby union by Milburn (1990) supported the need for correct alignment of head, neck and trunk, with evaluation of body type and positional stability of players. Because of this close interrelationship of fine to gross motor skills, any disruptions of the normal movement and alignment along this complex chain can result in injury at or beyond that segment. Since the ultimate goal of movement is to be able to produce enough energy to complete a given task and since the resultant force is the sum of all the micro forces along the chain, one can almost trace the injury pattern by following the movement sequence. Subtle injurious changes in the normal kinematics of a joint, shortening of a musculotendinous segment, articular changes on the joint surface, muscular strength deficits and imbalances are prime examples of typically unrecognized changes along the system that ultimately affect the outcome, which is movement (Mullin & Skolfield, 2001).

Pre-season or pre-participation is often used to identify intrinsic risk factors for sports injury (Gabbe *et al.*, 2004; Gabbett, 2004; Lee *et al.*, 2001). Tests chosen are generally based on clinical experience due to the paucity of quality injury risk factor studies for sport and, often, the reliability of these clinical tests has not been established (Gabbe *et al.*, 2004; Lee *et al.*, 2001). Gabbe *et al.* (2004) then launched a study with the purpose to establish the reliability of eight, musculoskeletal tests, commonly used in the screening protocols of elite-level Australian football clubs. The tests of interest were Sit and Reach, Active Knee Extension, Passive Straight Leg Raise, Slump, Active Hip Internal Rotation Range of Movement, Active Hip External Rotation Range of Movement, Lumbar Spine Extension Range of Movement and the Modified Thomas test. The outcome of this study suggested that these simple, clinical measures of flexibility and range of movement are test-retest reliable and support their use as pre-participation screening tools for sports participants.

2.4.2 Literature review on Anthropometrical measurements

The development of lean mass is desirable in rugby union players to enhance speed, strength, and power – which are fundamental components for competitive success. In the 1999 Rugby World Cup, the most successful teams were those that had greater total mass in the forwards (Olds, 2001). In contrast, high body fat levels increase energy expenditure, reduce a player's power to weight ratio and decrease acceleration (Duthie *et al.*, 2003). A higher body mass is therefore better carried as lean mass rather than fat. Despite the necessity for development of lean mass, there is currently a lack of cross sectional and longitudinal data on the anthropometry of elite level rugby players.

Olds (2001) collected data on 1420 high-standard rugby union players measured between 1905 and 1999. This data was collated to chart the evolution of body size and shape in rugby union football. Individual data was available for 843 players. Anthropometric variables included height, body mass, body mass index (BMI) and somatotype where available. The rates of increase in body mass (2,6kg per decade)

and BMI (0,4 kg.m-2 per decade) were well above those of general population of young males. The increase in height (1,0cm per decade) was comparable to the secular increase! The increase in body mass and BMI since 1975 have been three to four times those between 1905 and 1975. Since 1975, players have been less endomorphic (-0,3 units per decade) and less ectomorphic (-0,4 units per decade), but much more mesomorphic (+1,1 units per decade) than before. There is a close association between body size and success. Final ranking in the 1999 World Cup showed significant correlations with the average mass of the squads.

Olds (2001) also found that the development of lean mass is desirable in rugby union players to enhance speed, strength and power; which are fundamental components for competitive success. In the 1999 Rugby World Cup, he found that the most successful teams were those that had greater total mass in the forwards. In contrast, high body fat levels increase energy expenditure, reduce a player's power to weight ratio, and decrease acceleration. A higher body mass is therefore better carried as lean mass rather than fat.

A study on the Croatian-Slovenian rugby league by Babić *et al.* (2001a) showed the following results: forwards on the average weigh 93,5kg, are 182, 4 cm tall, with a BMI of 28.3kg/m2 and BF% of 20,8%. Backs are on average 82,2kg heavy, 178,3cm tall, with BMI 26,1 kg/m2 and BF% 16,9%. Backs from the upper half of the division are on the average heavier than those from lower half, BF% in forwards from upper half of the division is higher in forwards from lower half. Both differences were found to be statistically significant ($p < 0,05$).

Already at the beginning of the professional era, Kaplan *et al.* (1995) found fewer injuries in players with the sum of skinfolds $\leq 95^{th}$ percentile (0,28) in comparison with those with the sum of skinfolds $>95^{th}$ percentile (0,33), but the difference was not statistically significant. Players with greater body mass (more than 90kg) are at 2,5 times greater risk of injury.

Quarrie *et al.* (2001) found that players with a body mass of greater than 81kg sustained a higher injury rate than players whose body mass was less than 74kg. Players with a BMI of greater than 26,5 sustained more injuries than players with a BMI of less than 23 (the reference group). Players who performed between 20 and 33 push ups missed a greater proportion of their playing season than those who completed fewer than 19 push ups.

In Hattingh's (2003) study of junior elite club rugby players (especially 18 and 19 year olds), he found that the mean body mass of all players showed a gradually increasing tendency ($\bar{x}$ = 83,38 kg; $\bar{x}$ = 87, 29kg). He also found that body length increased from 179,35cm to 181,45cm; which correlates with the growth phase of this group (small practical significant difference, d = 0,28). Finally he found that the body fat percentage showed only a slight decrease between the testing episodes. When considering the increase in body mass and the decrease in body fat percentage, an increase in lean body mass was depicted on average.

Spamer and Winsley (2003) drew a comparison between an elite English (Ivybridge) and an elite South African (Northern Bulls) 18-year-old rugby team. They tested their game-specific variables, physical and motor abilities and anthropometric status. They aimed to link up with modern research, and referred to aspects such as innate characteristics and date of birth. Results showed that the South African boys were slightly leaner than their English counterparts and that slight differences in kicking and passing abilities are thought to be more attributable to environmental factors than physical characteristics. The English team ($\bar{x}$ = 52,40cm) outperformed their South African counterparts ($\bar{x}$ = 44,00cm) in the vertical jump with a high practical significant difference (d = 1,15). There was practically nil significant difference in the body mass of the two teams, but a medium practical significant difference in both the length (d = 0,50) and body fat percentage (d = 0,60) of the two teams; with the $\bar{x}$ = 185,6cm for length and $\bar{x}$ = 22,1% for body fat as the highest mean values.

Plotz and Spamer (2006) basically compared the same teams as in the study of Spamer and Winsley (2003), with the only difference that they used an extra South African team namely the Leopards. Results were basically the same.

In a study on elite South African schoolboy rugby players, De La Port (2005:144) recorded a low practical significance in anthropometrical variables during the 2004 season. The U/16 Green Squad players of that study were taller and heavier than their counterparts in Hare's (1997) study and heavier, but shorter than the U/16 provincial rugby players in Van Gent's (2003) study. The U/16 Green Squad players of that study had a lower body fat percentage than the provincial rugby players in Van Gent's (2003) and Hare's (1997) studies. The Green Squad U/16 rugby players recorded an endo-mesomorphic physique although of low practical significance.

Gabbett has done a lot of research on rugby related subjects, whether it was on injury epidemiology, anthropometric and physiological characteristics or training loads related to injuries. More recently in 2005, Gabbett (2005:677) measured anthropometrical characteristics specific to player-position, this time of elite junior rugby league players, aged 16-18years in Australia. The mean height, body mass and sum of skinfolds for all players were 176,10cm; 79,50kg and 40,44mm respectively. Significant differences ($p < 0,05$) were detected among individual positions for height, body mass, and skinfold thickness. Props were significantly ($p < 0,05$) taller, heavier and had a greater skinfold thickness than all other positions. Halfbacks were significantly ($p < 0,05$) shorter than the second row players. When data was analyzed according to positional similarities, it was found that the props positional group was taller, heavier and had a greater skinfold thickness than all other positional groups. The hookers and halves positional group was significantly ($p < 0,05$) shorter and lighter than all other positional groups.

Duthie *et al.* (2006) also released an anthropometrical profile of elite rugby players. They found the typical random variation in an individual player's body mass was

1,6% between tests during a season and 2,1% between tests in different seasons. The body mass of forwards varied between 96-124 kg and those of backs between 78-103 kg. The sum of the seven skinfolds (triceps, subscapular, biceps, supraspinale, abdomen, thigh and calf) varied between 59-130mm for forwards and 30-78mm for backs. In general he found that players with lower skinfolds typically have an increase in total body mass during heavy training loads. Players with higher skinfolds often exhibit a decrease in body mass during training and those who have the average level of skinfold thickness maintain a relatively stable body mass. They concluded that measurement of body mass and skinfolds provides a framework for managing the body composition of individual players irrespective of their initial shape.

2.4.3 Literature review on Physical and Motor variables

The anthropometric, physical and skill characteristics of young rugby players (U/17 and U/19 players) in the North West Province were compared with one another by Malan and Hanekom (2001). In most of the parameters (see chapter 4 for the results) there was an indication that the longer match-playing and physical experience of the U/19 players could have had a positive effect on the better results of the older group. They also quoted Bell (1990:20) stating that rugby has fairly wide variety of body shapes and sizes, meaning that with experience, players would demonstrate differences in the rugby-related variables being tested. Due to the fact that there were no practical significant differences in most of the parameters between the two age groups, it might be concluded that as far as physical characteristics and rugby skills are concerned, the U/17 players could be selected for the older team. Some care and physical strengthening, however, should be applied to the back muscles, since the results revealed that match-playing experience could have a positive effect on the development of the back-muscle strength. Finally, they also concluded that all the above mentioned parameters are important for identifying the performance capabilities of rugby players.

Physiological characteristics of junior and senior rugby league players in Queensland, Australia were determined (Gabbett, 2002). There was a significant difference ($p < 0,05$) between the body mass of all teams with the U/19 forwards (89,4kg) and backs (74,2kg). There was a significant difference between the different age groups, but not between the different playing positions (forwards and backs). The U/19 results follow. Times (in seconds): 2,19 (10m forwards & backs); 3,57 (20m forwards) & 3,53 (20m backs); and 6,20 (40m forwards) & 6,01 (40m backs). Although backs were faster than forwards during these sprints, it was not significantly different for any of the teams tested. The vertical jump (in cm): 37,9 (forwards) & 40,0 (backs). Finally their agility (in seconds): 18,3 (forwards) & 17,9 (backs). Also none of the scores for the vertical jump and agility were significantly different for any of the teams. The results however showed that there was a progressive improvement in the physiological capacities of rugby league players.

Physical and motor abilities of the freshman players in Hattingh's (2003) study showed no practical significant differences in recorded values throughout the three testing episodes for the 30m dash, pull-up and speed endurance testing protocols. Agility testing recorded moderate practical significant differences. In maximum power testing the squat test recorded moderately practical significant differences between the testing episodes.

In the study on applied physiology and game analysis of Rugby Union by Duthie *et al.* (2003), there were clear differences in the physiological and anthropometrical characteristics of forwards and backs in rugby. They found that backs tended to be leaner, shorter, faster, more aerobically fit relative to body mass and more explosive (vertical jump) than their forward counterparts. Forwards again, produce better absolute results when measured for strength and aerobic endurance, but when expressed relative to body mass (kg) the results favour the backs.

Gabbett (2004) did measurements of speed, muscular power, and maximal aerobic power before and after three 4 month (December to March) pre-season-periods (2009-2003) on sub-elite rugby league players in Australia. He found that reductions in pre-season training loads reduce training injury rates in players. Furthermore, he found the pre-training muscular power were similar ($p > 0,05$) across the three pre-season periods. Pre-training speed measurements (10m, 20m and 40m sprint) were significantly faster ($p < 0,05$) in the 2003 pre-season. There were no significant seasonal differences, only $p > 0,5$ for changes in 10m, 20m and 40m speed. There were greater improvements in muscular power in the 2003 pre-season period, with a 76% probability that the improvements were of physiological significance.

More recently in 2005, Gabbett (2005:677) again measured physiological characteristics, this time of elite junior rugby league players, and aged 16-18years in Australia. The mean vertical jump height was 47,5cm, with the mean agility test time as 6,00s. The mean times for the 10m, 20m and 40m respectively were 2,08s; 3,45s and 5,88s. There were no significant differences ($p > 0,05$) among individual positions for 10m and 20m speed, agility of vertical jump height tests. However, the halfback and centre positions were faster than props over 40m. When data was analyzed according to positional similarities, it was found that the props positional group had a significantly lower 20m and 40m speed and agility than the hookers, halves and outside backs positional groups. The hookers and halves had a significantly faster 10m speed than the outside backs positional group.

2.4.4 Literature review on injury epidemiology

Rugby union, which is the most popular worldwide team contact sport involving collision, has one of the highest levels of injury of all team sports (IRB, 2004). Whilst there have been several epidemiological studies of injuries in rugby union at the amateur level (Bird *et al.*, 1998; Lee and Garraway, 2000), the number of prospective studies amongst elite players is small. The importance of reporting the incidence and severity of injuries in epidemiological studies has however been

emphasized in order to assess casual links between risk factors and injuries and to inform decisions on preventive and therapeutic interventions (Brooks *et al.*, 2005).

Lee and Garraway (2000) said it is likely that the long term effects of rugby injuries would be influenced by the type and timing of the initial treatment received, and by other factors, such as whether players attended a comprehensive physical training program during recovery. However, preventing rugby injuries may involve changing the laws of the game, using protective equipment, or assessing the importance of players' physique or level of fitness. The weather and the conditions of the playing surface might also influence the frequency, nature and outcome of injuries – the influence of these factors has not been dealt with in this study.

Whiting and Zernicke (1998) defined epidemiology as the study of the incidence, distribution, control of disease and injury in a given population.

In a study on the incidence of injury in junior and senior rugby league players, Gabbett (2004) found that the incidence of rugby league injuries typically increases as the playing level is increased. The majority of studies (Holtzhausen, 2001; Gabbett, 2004; Brooks *et al.*, 2005) have shown that the head and neck is the most common site of match injuries in senior rugby league players, while knee injuries are the most common site of injury in junior rugby league players. Muscular injuries are the most common type of injury sustained by senior league players, while junior league players more commonly sustain fractures. Thigh and calf strains are the most common injuries sustained during rugby league training, while overexertion is the most common cause of training injuries. Player fatigue may influence the incidence of injury, with the majority of training injuries occurring in the early stages of the season; while match injuries occur in the latter stages of the season, suggesting that the changes in training and playing intensity may influence the incidence of injury in rugby league.

The patterns of sports injuries has gradually changed from acute traumatic injuries such as fractures, dislocations, ligament sprains and muscle tears to overuse injuries such as stress fractures and compartment syndromes. While the acute injuries are still present, it appears as if overuse injuries are becoming increasingly prevalent. This is the result of increased demands of modern-day sports and the load placed upon musculoskeletal structures by these sports (Brukner & Khan, 2002).

Van Mechelen *et al.* (1992) classified overuse injuries into those with intrinsic and those with extrinsic risk factors. The internal or intrinsic risk factors which may play a part in sport injuries are as follows: physical defect, physical fitness, previous injury, psychological factors, physical build, age and gender. Physical fitness is divided into the following categories: aerobic endurance, strength, speed, sporting skill, co-ordination and flexibility of the muscles. Psychological factors are divided into the following categories: self-concept, risk acceptance, type A and type C personality and locus of control. Physical build is divided into the following categories: weight, height, joint stability and body fat.

The external or extrinsic risk factors which may play a part in sports injuries as described by Van Mechelen *et al.* (1992) are as follows: sports-related factors, venue, equipment, weather conditions, trainer, conduct of match, the rules and the referee's application of the rules. Sports-related factors are divided into the following categories: type of sport, exposure, nature of event, role of opponents and team mates. Venue is divided into the following categories: state of floor or ground, lightning and safety measures. Equipment is divided into the following categories: tools (e.g. stick or racket), risk acceptance, protective equipment and other equipment (shoes, clothing). Weather conditions are divided into the following categories: temperature, relative humidity and wind.

Brukner and Khan (2002) also described internal and external risk factors that predispose a player to overuse injuries. The internal risk factors are malalignment, leg-length discrepancy, muscle imbalance, muscle weakness, lack of flexibility,

gender, size, body composition and others. Malalignment is divided into the following categories: pes planus, pes cavus, rearfoot varus, tibia varu, genu valgum, genu varum, patella alta, femoral neck anteversion and tibial torsion. Lack of flexibility is divided into the following categories: generalized muscle tightness, focal areas of muscle thickening and restricted range of motion. Other risk factors are divided into the following categories: genetic factors, endocrine factors and metabolic conditions.

The external risk factors described by Brukner and Khan (2002) are training errors, surfaces, shoes, equipment, environmental conditions and inadequate nutrition. Training errors are grouped into the following: excessive volume and intensity, rapid increase, sudden change in type, excessive fatigue, inadequate recovery and faulty technique. Surfaces are divided into the following categories: hard, soft and cambered. Shoes are categorized into the following: inappropriate and worn out. Equipment has only one subcategory, namely inappropriate equipment, and environmental conditions are divided into the following categories: hot, cold and humid.

McGinnis (2005) described the different intrinsic and extrinsic factors affecting injury as part of the biomechanics of sport. He defined an individual's ability to withstand loading as intrinsic factors, whereas extrinsic factors reflect the nature of the loading that will be imposed on the individual. In this study we only focused on the internal risk factors described by him. Intrinsic factors related to injury included anthropometrics; skeletal structure, such as bone density and joint congruity (alignment); current fitness level, such as muscle strength, endurance, and flexibility; and previous history of injury. These factors are related to an individual's ability to cope with imposed mechanical stress - that is, to how an imposed force creates stress within the individual and how well the tissues are adapted to the level of stress. If one considers the variety of physical shapes evident among individuals in your community, it will be readily apparent that

individual differences in anthropometrics play a potentially large role in protection from or predisposition to injury.

The internal risk factors described by the different authors are similar in content. The internal risk factors are also factors about which something can be done by the individual player. There is some sort of control that can be exercised by the player to reduce the possibility of injury. By doing the right exercises the body can be conditioned to reduce the possibility of injury for one, or by reducing body fat percentage. By doing this, the player is being pro-active in reducing the possibility of injury by the internal risk factor described (Peens, 2005:46).

The external risk factors described above by the different authors are also similar in content. The external risk factors are difficult to control and very little can be done to control them. Weather conditions are difficult to control and if the sport is practiced outside, it can have a profound effect on the players participating in the game (Peens, 2005:46).

Internal and external factors are contributors to overuse injuries. External risk factors play a role in the injuries occurring, but most injuries are caused by internal risk factors. This indicates that the possibility of an injury can be reduced by focusing on that which is controllable. The internal risk factors can be changed because it is in the power of the player to do the right exercises to nullify the risk. These internal risk factors are also incorporated into the biomechanical evaluation, fitness evaluation and anthropometric evaluations used in this study. Any discrepancy can thus be detected and the necessary adjustment in the training procedure made to reduce the possibility of injury occurring.

Seeing that injury is a multifaceted problem, it requires a multidisciplinary approach to find and implement effective solutions. Although certain injuries cannot be avoided, some are avoidable, or at least the severity of the injury can be reduced (Whiting & Zernicke, 1998). Peens (2005) stated that injury prevention

strategies are measures that can counter that which is present or reduce the risk of injury and that different links in the chain of events leading to an injury should be targeted as part of the injury prevention strategies.

Therefore, we are going to look at the following topics:

- Incidence of injuries
- Anatomical site and type of injury sustained
- Position of player injured

2.4.4.1 Incidence of injuries

Injury rates in professional rugby league are higher than in some other contact sports, probably because of the large number of physical collisions that take place. At international level, where the game is the fastest and most spectacular, evidence shows that fitness and experience considerably reduce the injury rate (Jakoet and Noakes, 1998).

Already in the earlier years, Myers (1985) found the rate of injury to be 32 per 1000 player hours, with a significant trend of increasing incidence of injury from the lower to the higher grades of play. Also the site, nature and severity of injury is presented and related to the position and grade of the player. He also quoted Sparks (1980) who reported the injury rate as 19,4 per 1000 player hours over the 1980-1983 period, compared with the rate of 19,8 per 1000 player hours over the 1950-1979 period.

Research studies of rugby are rare in countries where rugby is not popular. During a Croatian-Slovenian rugby project in 2001 the incidence of injuries was 1,24 per 1000 hours of rugby training and 28,22 per 1000 hours of playing in matches (Babic *et al.*, 2001b). They also found the incidence to be more than two times higher than in more developed rugby-playing countries, statistically positively correlating with the team position in division. There were no statistically significant differences in

anthropometric characteristics, body composition and constitution of injured and uninjured players.

Targett (1998) did a study on a New Zealand Super 12 rugby squad and found an overall injury rate of 120 per 1000 player hours, with the rate of significant injuries as 45 per 1000 player hours. He quoted Hughes (1994) who found an injury rate of 62 and 48,8 per 1000 player hours in their studies with a similar injury definition.

Alsop *et al.* (1994) conducted a study on both male and female rugby union players, as part of the Rugby Injury and Performance Project (RIPP) in New Zealand, and found the injury rate for games was higher than for practices (rate ratio 83 per 1000 player hours) with a rate of 109 per 1000 player-games. They also stated that rugby injury was common among the study subjects but varied according to grade and gender.

An analysis of all injuries requiring medical attention during the 1995 Rugby Union World Cup, the last tournament before the start of the professional era, showed an injury rate of 32 injuries per 1000 player game hours (Jakoet and Noakes, 1998). Concern is expressed by the media and medical community about the high prevalence of injury among professional rugby players. Aginsky *et al.*, 2005 did a prospective study on elite Australian rugby union players and showed an increase in the number of injuries from 47-74 per 1000 player hours of game play after the start of the professional era.

Lee and Garraway (1996) found the prevalence rate of schoolboy rugby injuries in Edinburgh was 86,8 per 1000 player-seasons, compared to senior Scottish rugby club injury prevalence which was much higher at 367,0 per 1000 player-seasons. They concluded that schoolboy rugby is much safer than senior club rugby and the outcome of injuries that do occur is less disruptive. In 1999 they did the same kind of study, but just focused more on the frequency of injury in relation to environmental factors. They found an overall rate of 51,7 per 1000 player-hours

and claimed that environmental conditions can significantly affect how athletes perform and can affect the frequency of injuries.

A study on amateur rugby league players in Australia showed an incidence of 160,6 per 1000 player-position game hours, with forwards having a significantly higher incidence of injury than backs (182,3 per 1000 vs. 142,0 per 1000) (Gabbett, 2000).

Rotem and Davidson (2001) completed a survey of acute schoolboy rugby union injuries collected over 30 years (1968-1998) at an Australian private school by their casualty station which operated during all Saturday interschool rugby matches. They found a rate of 18,8 injuries per 1000 player hours, of which the overall rate of severe injury was 1,4 per 1000 player hours.

Holtzhausen (2001) studied professional rugby union players and found the mean incidence of injuries recorded is 86,4 injuries per 1000 player hours of participation. He recommended a standardized format of recording of injuries, seeing that it is necessary to obtain more representative data of injuries in the professional rugby union.

A prospective study of elite Australian rugby union players showed an increase in the number of injuries from 47-74 injuries per 1000 player hours of game play respectively after the start of the professional era (Bathgate *et al.*, 2002). Although comparison of injury rates between studies is difficult because of lack of uniformity in the definitions of injuries and injury rates, the relatively high incidence of injury since the introduction of professionalism in the game of rugby is a common theme. This study confirmed the previously noted trend of an increasing injury rate in higher levels of play. It also confirms the suspicion that injury rates have increased considerably in the professional era in rugby union. But once again, there is a pressing need for standardized data collection to allow valid comparison between studies. This would facilitate the development of management strategies that promote injury prevention and minimize injury risk.

The identification of risk factors associated with the effect of the injury on subsequent participation may be as important in understanding how to reduce the burden of injuries on the participants as identifying factors associated with the injury incidence rate. A recent prospective study (Babic *et al.*, 2001b) into intrinsic risk factors for injuries resulting from physical activity identified previous injury and exposure time as being more important predictors of injury incidence rate than psychological, psychosocial and anthropometric measures. They also quoted Linder *et al.*, (1995) that greater age, higher cigarette consumption, previous low physical activity levels, high or low flexibility, and low levels of aerobic fitness associated with a higher risk of injury.

In 2003 a study on semi-professional rugby league players in Australia showed an injury incidence of 45,3 per 1000 training hours (Gabbett, 2003). The match injury incidence was 824,7 per 1000 player-position game hours.

Brooks *et al.* (2005) conducted two similar studies on the epidemiology of injuries in rugby union players of 11 English Premiership clubs. They differentiated between match and training injuries. They found that the overall incidence rate of match injuries was 91 per 1000 player-hours and those of training injuries only 2.0 per 1000 player-hours and that the incidence of match injuries at international level was found to be higher than previously reported. In the same year, Best *et al.* (2005) reported on the Fifth Rugby World Cup held in October 2003, which was the biggest international sporting event of that year, that an injury rate that was higher than the comparative data (97,9 injuries per 1000 player-hours) was recorded, but explained that these differences might have been due to mismatches in the areas of skill, fitness and the availability of resources for medical care of players.

2.4.4.2 Anatomical site and type of injury sustained

Already before the eighties, Hoskins (1979) reported 5 cases of cervical cord injuries in English schoolboys between 1942 and 1986, 2 fatal and 3 leading to

permanent tetraplegia. In the 6 years from 1973 to 1978, 12 such injuries were reported, 2 fatal and 10 leading to permanent tetraplegia. A further 16 injuries to the cervical spine, compromising fracture, dislocation, subluxation or severe ligamentous damage without permanent neurological deficit, were reported in the 8 years from 1971 to 1978. Just a few years later, Myers (1985) found in a study on English rugby union players, the head and neck (52%) as the most frequently injured region, with lacerations as the most common injury. Facial lacerations accounted for one-third of all injuries and one-half of all injuries were to the head and neck. Both lower and upper limbs were sites for around 20% of injuries. Two thirds of injuries were sites of a minor nature.

Studies were done from the earliest times to establish the anatomical site which get injured the most often. In the eighties Nathan *et al.* (1983) found the upper limbs sustained the greatest number of injuries, representing 29,1% of all injuries; head, neck and facial injuries combined for 38% of all injuries; while Addley & Farren (1988) did a study on Irish rugby club players and found that limb injuries (arms and legs) accounted for 63% of the total injuries, with head 16%, trunk 14% and neck 7%. They also found that soft tissue injuries (strains, sprains, bruising and wounds) accounted for 88% of the total, with joint dislocations and fractures for the rest.

In 1992 O'Brien found the lower limb (23,4%), knee joint (17,5%) and back (13,8%) as the most commonly injured anatomical sites in his study on senior rugby players in the Leinster province of Ireland. In the study of Bird *et al.* (1998) on union rugby players of New Zealand, he said that most players suffered multiple injuries, but strains, sprains and other soft tissue injuries (74%) formed the biggest part on the distribution list of injuries, followed by dislocations and haematomas.

During the RIPP in New Zealand, Alsop *et al.* (1994) found the lower limb to be the body region most often injured (42,5%) with sprains and strains as the most common type of injury (46,7%).

In a study on schoolboy rugby players by Upton *et al.* (1996), fractures were the most common injuries (27%), followed by ligament injuries (22%), muscle injuries (20%), concussions (15%), lacerations (4%) and dislocations (3%). 36% of injuries were to the lower limbs, 28% to the head and neck, 26% to the upper limbs and 10% to the trunk and abdomen.

In 1996, all injuries that led to temporary stoppage of the game or to the substitution of a player during the Rugby World Cup 1995 pre-qualifying tournament were recorded (Wekesa *et al.*, 1996). Six matches were played involving the Arabian Gulf, Kenya, Namibia and Zimbabwe. They found the lower limbs to suffer the most injuries (46,8%), followed by the head (21,3%), trunk (17,0%) and upper limbs (12,8%). The thighs alone accounted for 21,3% of all injuries; 83% affected the muscles, whereas 10,6% affected the ligaments.

From 1990-1997 Noakes *et al.* (1999) again recorded 67 spinal cord injuries, due to rugby, in the Western Cape alone. 80% of these injuries were in adults and 20% in schoolboys, representing a 23% increase and a 46% reduction in the number of injured adults and schoolboys respectively.

In the study on a New Zealand Super 12 rugby squad, the most commonly injured body site was the head and face, accounting for 26,5% of total injuries. The knee (12,2%) and the ankle (10,2%) were the next most commonly injured sites, with the rest of the injuries being evenly distributed among other sites. Injuries to the knee (26,6%) and the ankle (20%) accounted for almost half of the moderate and severe injuries. Musculo-tendinous sprains and strains (28,6%) and contusions (22,4%) accounted for just over half of all injuries (Targett, 1998).

In the study of Wilson *et al.* (1999), they used data of the Rugby Injury and Performance Project (RIPP) in New Zealand. They specifically focused on tackle injuries. They found that most tackle injuries were caused by impact with another

player rather than impact with the ground and the most frequently injured body sites were the head/neck/face (22%), the knee (17%) and the shoulder/clavicle (14%). The most common types of injuries sustained by the players in the RIPP cohort were sprains and strains (41%), followed by haematomas/bruising (26%). When body site and injury type were cross-tabulated, the most common injuries were concussion (8%), shoulder sprains and strains (8%), bruised thighs (8%), knee sprains and sprains (8%), bruised knees (6%) and ankle sprains and strains (6%).

Gabbett (2000) did a survey on Australian amateur rugby league players and found over 25% of the total injuries sustained were to the head and neck, other injuries were to the face (13,3%), abdomen and thorax (13,3%), and knee (11,1%). Muscular injuries (haematomas and strains) (28,5%) were the most common type of injury. Furthermore, injuries were more often sustained in the latter stages of the season and during the second half of matches. These findings suggested that fatigue or accumulative micro trauma, or both, may contribute to injuries in amateur rugby league players.

In the Croatian-Slowenian rugby project of Babić *et al.* (2001b), they observed that it was the lower limbs that were the most frequently injured parts of the body, followed by the head, shoulders, upper limbs and trunk. They found the most frequent injuries were dislocations, strains and sprains of the ankle, foot and knee, and lacerations and contusions of head, neck, and face. In the same year, Holtzhausen (2001) did a study on professional rugby union players and found the highest injury rates were to the lower limb, particularly the knee and the ankle, and those were mainly ligament sprains (25,8%) and musculo-tendinous tears (24,2%).

In a study on the elite Australian Wallabies rugby union players, the head was the most commonly injured body site, with 25,1% of the total injuries. Of these, 75% were lacerations requiring suturing, 19,4% concussions and 5,6% were fractures. The next most injured body sites were the knee (14,0%) and the thigh (13,6%), with the ankle compromising 10,5 % of injuries. The knee joint accounted for 25% of

the severe injuries, and 40% of injuries to the knee were severe; 50% of these severe knee injuries were medial collateral ligament tears. Of the thigh injuries, 53% were hamstring strains or tears, 37% contusions and 10% quadriceps strains/tears. There were only two severe injuries to the neck during the study frame (a C5 neurapraxia and a brachial plexopathy), both players missed four months of play and both made a full recovery. When injuries were categorized according to more general body regions, the lower limb was the most commonly injured region, with 51,7% of injuries. The head and neck accounted for 28,7% and the upper limb 15,4%. Other body parts were rarely represented (Bathgate *et al.*, 2002).

Gabbett (2003) did a study on semi-professional rugby league players where he differentiated between match and training injuries. He found 20% of the total playing injuries were to the thigh and calf, followed by injuries to the face (13,9%), arm and hand (13,9%) and 13,2% to the knee. The incidence of injuries was higher in forwards than backs. Compared with the backs, forwards had a higher incidence of injury for the head and neck, face, arm and hand. Muscular injuries (haematomas and strains) were the most common type of injury sustained during playing (32,9%), while contusions (20,2%) and joint injuries (15,6%) were less common. Compared with backs, forwards had a higher incidence of injury for contusions and joint injuries.

He however recorded that 35% of the training injuries sustained were also to the thigh and calf. Injuries to the ankle and foot (21,5%), knee (12.0%) and thorax and abdomen (11,8%) were less common. The incidence of injury in training was higher in forwards than backs. Muscular injuries were the most common type of training injury (48,7%), while joint injuries (19,1%) and contusions (9,7%) were less common. Compared with backs, forwards had a higher incidence of injury for muscular strains. He also found that changes in training and playing intensity impact significantly upon injury rates in players.

In the study of Brooks *et al.* (2005), they found thigh haematomas to be the most common match injury for forwards and backs, but anterior cruciate ligament injuries for forwards and hamstring injuries for backs caused the greatest number of days absence. In training injuries epidemiology, hamstring, calf, hip flexor/quadriceps and adductor muscle injuries were the most common for backs; whereas hamstring, lateral ankle ligament and lumbar disc/nerve root injuries predominated for forwards. Lumbar disc/nerve root, shoulder dislocation/instability and hamstring injuries for forwards; and hamstring muscle and anterior cruciate ligament injuries for backs caused the greatest number of days' absence.

In the injury surveillance project of the Rugby World Cup 2003, the most frequently injured body parts were the head, neck and face (33,7 injuries per 1000 player game hours), followed by the ankle and foot (14 injuries per player game hours). Open wounds, lacerations or contusions accounted for 42% of all injuries, with joint sprains at 21% of injuries and muscle strains at 8% of all injuries (Best *et al.*, 2005).

2.4.2.3 Position of player injured

Given that rugby players are subjected to different physical and physiological demands depending on the position played, the site nature and cause of injuries sustained during a rugby match may also vary according to playing position. An understanding of the site, nature and cause of injuries sustained by specific playing positions would facilitate the development of effective injury prevention strategies (Meir *et al.*, 2001).

In a study on the applied physiology and game analysis of rugby union, Duthie *et al.* (2003:975) described the physical requirements, skills and tasks of the different positional groups as follows: The front-row positions demand strength and power as the players are required to gain possession of the ball, are in continual close contact with opposition, and have limited opportunities to run with the ball. The locks are generally tall, with a large body mass and power as additional advantage.

The loose forwards require strength and power as players in these positions are expected to gain and retain the possession of the ball. It is a prerequisite for the loose forwards to be powerful and mobile in open play, have excellent speed, acceleration and endurance. A good level of endurance is required by the halfbacks as they control the possession of the ball obtained by the forwards. Good speed is also an important attribute for the halfbacks, as they need to accelerate away from the approaching defenders. Midfield backs require strength, speed and power as they have a high frequency of contact with the opposition. Outside backs require considerable speed to out-manoeuvre their opponents. They perform a large amount of support running, chasing down kicks and covering in defense.

Players who reported a preseason injury (an injury that was affecting their ability to train or play at the time of the preseason assessment) had a higher injury rate than those who had no injuries during the previous season (Babic *et al.*, 2001a). He found a higher incidence of injuries in the forwards, in both trainings and matches.

In the seventies Walkden (1978) had already said the incidence of injuries varied according to the position of the player. He found the scrum-half (13,5%) to be the player in the hot-seat, followed by the hooker (9%), fly-half (9%) and full-back (8%). He also quoted Davies and Gibson (1978) who found that the forwards sustained significantly more injuries than the backs. The standard of rugby, players' body weights, degree of fitness, and presence of joint hyper-mobility did not affect the risk of injury.

In the eighties, Nathan *et al.* (1983) found hookers were injured most often, receiving 19% of all injuries, followed by flanks (14%), centres (12,4%) and wings (11,4%). The high incidence of injury among hookers is particularly remarkable as there is only one hooker per team. When corrected for the unequal number of players in the different teams, hooker (31,6%), full-back (14,6%), eighth man (12,6%), scrum-half (10,5%) and fly-half (8,4%) are the positions in which the highest incidence of injuries are sustained. Addley and Farren (1988) found that

injuries in the forwards accounted for a total of 60,5% in comparison with the backs with 39,5%. On top of that Dungannon injury list was the wing forward followed by the prop.

In the neighties Milburn (1993) found the hooker as the player most likely to be injured, seeing that he is exposed to such great loads throughout the scrums. In Ireland, O'Brien (1992) found the most frequently injured playing position to be the full-back and centre three-quarters. In New Zealand, Gerrard *et al.* (1994) found the most injuries occurred under the forwards. In the study of Upton *et al.* (1996) on adult rugby teams in the Cape Peninsula, they found the hookers (19%), wings (15%), fullbacks (11%) and centres (10%) to be the players most often injured compared with two schoolboy teams, in which the wings, fullbacks and centers were the positions at high risk.

In the study of Targett (1998) on professional rugby players in the Super 12, he found that the number 8 position was the most commonly injured position, with full-back and lock the next two most commonly injured. Wilson *et al.* (1999) found in their study of the nature and circumstances of tackle injuries in rugby union, that the backline players had the highest injury rate.

In France, Berge *et al.* (1999) conducted a study on the cervical spine of rugby players. To evaluate the accumulative effects of this trauma, magnetic resonance imaging scans of the cervical spine were performed. The aim of their study was to compare the changes in the cervical spine of players at different points in their careers. The study of cervical spine changes, including spinal curve, spinal constituents, posttraumatic deformities and degenerative modifications, was completed by a study of cervical measurements. Front-line rugby players showed more early degenerative alternations on magnetic resonance imaging scans than did the control subjects of the same age. These changes correlated with age and were probably linked with repetitive cervical trauma throughout the players' careers.

In the study of Holtshauzen (2001) on professional rugby union players of the Super-12 competition, he did not find any significant trends in the proportion of injury episodes according to player position in the literature of professional and amateur rugby union. In the 1997 Super-12 study, number 8 was the most commonly injured position, followed by the fullback and the lock (Targett, 1998). In the 1999 Super-12 study, fullbacks and centres were most commonly injured positions, followed by hooker (Holtshauzen, 2001).

Bathgate *et al.* (2002) did a study on elite Australian Wallabies rugby union players from 1994-2000 and found the lock to be the most injured player, followed by the number 8. The number 10 was the most injured back and the halfback (number 9), by far the least injured player. Positions represented twice, such as wingers, had their total injury toll halved to allow valid comparison with positions represented once.

In the study of Best *et al.* (2005) on the injury surveillance during the Rugby World Cup 2003, they found the player positions to be most commonly injured were the open side flanker, outside centre and number 8. The injury rates for forwards and backs after adjustment for player position exposure were 104,10 and 91,10 per 1000 player game hours respectively. This however indicated a non-significant rate decrease for the backs.

2.5 SUMMARY

To conclude, it is clear that rugby injuries are of major international concern. The relevant studies conducted previously prove that there is a deep need to address these problems.

The main objective of this study is to assist in minimizing the incidence of injuries on the one hand. On the other hand it is to establish a profile which can be utilized for improvement and development of great elite rugby players.

The new era introduces biomechanical and postural evaluations which build on prior anthropometrical, physical and motor investigations. This is of utmost importance in the future to assist management, coaching staff and players as well as to minimize trauma in rugby.

CHAPTER 3:

EMPIRICAL INVESTIGATION:

CHAPTER 3:

EMPIRICAL INVESTIGATIONS:

3.1 INTRODUCTION

From the previous chapters it is evident that there is a need for a profile of elite under 19 rugby players with reference to their biomechanical, anthropometrical, physical and motor status, as well as the incidence of injuries among them – in order to represent a better quality player for the future, seeing that elite players have certain abilities that distinguish them from the average player (Hare, 1999).

The aim of this study is to determine a biomechanical, anthropometrical, physical, motor and injury epidemiology profile of elite under 19 rugby players. The aim of this chapter is to explain the all methods and materials used for the purpose of this study.

The following will be discussed in this empirical investigations chapter: Firstly the choice of subjects under the study populations. Secondly the different testing protocols used, namely the anthropometrical, physical and motor, and biomechanical and postural evaluations done. Thirdly the clinical injury reports used to determine the epidemiology of the injuries and lastly the statistical methods used in this study.

3.2 STUDY POPULATION

In this study elite Under 19 players were used. Permission was obtained from the Rugby Institute of North West University to use their U/19 players to participate in this study. Once permission had been granted, players were asked to sign a consent form out of free will. Dates and times of testing were pre-arranged with both the Rugby Institute of the North West University, as well as with the players and test-examiners.

In October 2005, a group of 77 players consisted of schoolboys, currently finishing their matric year, were tested. They had been selected for the Craven Week for High Schools, any of the Rugby Academy weeks held in South Africa or had played for their Province during the 2005 season, and were planning to continue their tertiary education at the North-West University. In July 2006, the same group of players was used, but this time only the best of the elite group (n = 31) was chosen to play in the Under 19 first team – seeing that that is the ideal position for any player.

It is important to pay attention to the fact that during the first episode in October 2005 specific established anthropometrical, physical and motor, biomechanical and postural evaluations were performed. A profile was established of what they looked like at the end of their school career. The second testing episode in July 2006 consisted of the same specific anthropometrical and physical and motor testing, and reflected the profile of these elite Under 19 players at the end of one season at the Rugby Institute of the North West University. Since January 2006 they followed a scientifically based exercise programme to help them overcome their shortcomings as determined during the above testing protocols.

During the season (2005/2006) all players had to report any injuries sustained to free of charge clinics held on Mondays and Wednesdays at the Institute for Sports Medicine (see 3.3.2). Details of injuries were recorded specifying the anatomical region injured, the type of injury, match or training during which injury occurred and whether the injury was acute or chronic. According to this information players were referred to a medical practitioner, physiotherapist, biokineticist or sport scientist and if necessary for specialized tests.

Close to the end of the season, in July 2006, the anthropometrical, physical and motor tests were performed once again. This time only the U/19 first team top-of-the-log players (n = 31) were assessed again; and the reason for this was to see what the ideal player, as chosen by the team coaches, according to the players performance, looked like.

3.3 TEST PROTOCOL

The tests and protocols used in this study were selected from the literature; seeing that their usefulness had been proven in previous rugby studies (Malan & Hanekom, 2001; Van Gent, 2003; Spamer & Winsley, 2003; Hattingh, 2003; Plotz, 2004; De la Port, 2005; Peens, 2005). Only the tests suitable for specific ages, gender and sport were used.

This test protocol consisted of different components, namely: the anthropometrical, physical and motor, and biomechanical and postural evaluations – as well as the intrinsic injury epidemiology clinics reports. Two different testing episodes took place, as discussed above.

The same test-examiners or assistants were used at both testing episodes. On the testing dates, players were given an explanation of the different tests, as well as the reason for the conduction of the specific test. All the tests were carried out on the same day and in the following order:

- Anthropometrical measurements
- Physical and motor ability tests
- Biomechanical and postural evaluations (first testing episode only)

The anthropometrical measurements included the following:

- Body mass (kg) (Norton & Olds, 1996)
- Body length (cm) (Norton & Olds, 1996)
- Body fat percentage (sum of seven skinfolds, namely: sum of triceps, biceps, subscapular, supra-iliac, abdominal, front thigh and medial calf) (Thomas & Nelson, 1985)

The physical and motor ability tests were used to determine the following:

- Speed over a 10/30/40m distance (seconds) (Kirby, 1991)
- Illinois agility test (seconds) (Badenhorst, 1998)
- Vertical jump (centimetres) (Thomas and Nelson, 1985)

- Horizontal jump (metres) (Kirby, 1991)
- Abdominal curls (repetitions) (Kirby, 1991)
- Pull-ups (repetitions) (Thomas and Nelson, 1985)
- Bench press (repetitions) (Thomas and Nelson, 1985)
- Bleep test (repetitions) (Lèger and Lambert, 1982)
- Speed endurance test (minutes) (Hazeldine and McNab, 1998)

The biomechanical and postural evaluation included the following (Hattingh, 2003):

- Lower limb region (divided into the lower limb dynamics, the knee complex and the ankle and foot complex)
- Pelvic girdle region
- Spinal region (divided into the dynamic mobility, and positional alignment complex which is sub-divided into the coronal and sagittal axis)
- Upper limb region
- Neurodynamics

3.3.1 TEST BATTERY

The following discussions will be based on a detailed description of all the tests, namely: anthropometrical variables, physical and motor variables, and biomechanical and postural variables.

3.3.1.1 Anthropometrical variables

The following anthropometrical tests were done:

Body mass

According to Norton and Olds (1996), body mass exhibits diurnal variation of about 1kg in children and 2kg in adults. The most stable values are those obtained routinely in the morning twelve hours after food and after voiding. They also suggest that since it is not always possible to standardize the measurement time, it may be important to record the time of day when measurements are made.

Apparatus: Calibrated scale accurate within 100g.

Test procedure: Nude mass can be measured by first weighing the clothing which is to be worn during measurement and subtracting this from the mass. Generally the mass in minimal clothing is of sufficient accuracy. Check that the scale is reading zero and then the subject stands on the centre of the scale without support and with the weight distributed evenly on both feet. The head is up and the eyes look directly ahead. Body mass should be recorded to the nearest 100g.

Length (stature)

There are a lot of different techniques for measuring stature, of which we used the method described by Norton and Olds (1996). It must be remembered that there will be diurnal variation. Generally, subjects are taller in the morning and shorter in the evening. A loss of about 1% in stature is common over the course of the day.

Apparatus: Stadiometer and head-board.

Test procedure: The subject should stand barefoot with the arms hanging by the sides. The heels, buttocks, upper back and head should be in contact with the wall. The head must be placed in the Frankfort plane. (The Frankfort plane is achieved when the orbital, the lower edge of the eye socket, is in the same horizontal plane as the tragion, the notch superior to the tragus of the ear. When aligned the vertex is the highest point on the skull.) Prior to measurement the subject should be instructed to look ahead and take a deep breath. The measurer places the head-board firmly down on the vertex, pressing down the hair as much as possible. The recorder checks that the feet do not come off the floor and that the position of the head is maintained in the Frankfort plane. Measurement is taken at the end of a deep inward breath and recorded to the nearest mm.

Body fat %

Skinfold thickness measurement (as part of derived measurements):

This method is chosen to determine the body fat percentage, seeing that it is recommended if sportspersons are going to be monitored on a regular basis throughout the season (Thomas and Nelson, 1985), that the sum of skinfolds are used, as is the case in this study.

Apparatus: Skinfold caliper.

- Triceps

Test procedure: The skinfold is raised with the left thumb and index finger on the marked posterior mid-acromiale-radiale line. The fold is vertical and parallel to the line of the upper arm. The skinfold is taken on the most posterior surface of the arm over the triceps muscle when viewed from the side. The marked skinfold site should be just visible from the side indicating that this is the most posterior point over the triceps whilst held in the anatomical position (at the level of the mid-acromiale-radiale line). For measurement, the arm should be relaxed with the shoulder joint slightly externally rotated and elbow extended by the side of the body.

- Biceps

Test procedure: The skinfold is raised with the left thumb and index finger on the marked mid-acromiale-radiale line so that the fold runs vertically, that is, parallel to the axis of the upper arm. The subject stands with arm relaxed, the shoulder joint slightly externally rotated and elbow extended. The fold is located on the most anterior aspect of the surface of the right arm. Check that the marked point for the biceps skinfold is on the most anterior surface over the biceps by viewing the arm from the side whilst held in the anatomical position. The marked skinfold site should be just visible from the side, indicating that this is the most anterior point over the biceps (at the level of the mid-acromiale-radiale line).

- Subscapular

Test procedure: The subject should be standing erect with the arms by the side. The thumb palpates the inferior angle of the scapula to determine the undermost tip. The skinfold is raised with the left thumb and index finger at the marked site 2cm along a line running laterally and obliquely downwards from the subscapulare landmark at an angle (approxiamately 45°) as determined by the natural fold lines of the skin.

- Supra-iliac

Test procedure: The skinfold is raised immediately superior to the iliocristale on the ilio-axial line. The subject abducts the right arm to the horizontal or places the arm across the chest to rest the right hand on the left shoulder. Align the fingers of the left hand on the iliocristale landmark and exert pressure inwards so that the fingers roll over the iliac crest. Substitute the left thumb for these fingers and relocate the index finger a sufficient distance superior to the thumb so that this grasp becomes the skinfold to be measured. The fold runs slightly downwards toward the medial aspect of the body.

- Abdominal

Test procedure: This is a vertical fold raised 5 cm (approximately in the midline of the belly of the Rectus Abdominis) from the right hand side of the omphalion (midpoint of the navel). It is particularly important at this site that the measure is sure the initial grasp is firm and broad since often the underlying musculature is poorly developed. This may result in an underestimation of the thickness of the subcutaneous layer of the tissue.

- Front thigh

Test procedure: The measurer stands facing the right side of the subject on the lateral side of the thigh. The subject's knee is bent at right angles by placing the right foot on a box or by being seated. The site is marked parallel to the long axis of the femur at the mid-point of the distance between the inguinal fold and the superior border of the patella (while the leg is bent). The skinfold measurement can be taken while the knee is bent or with the leg straight and resting on a box. The calipers are then located between the recorder's hands, 1 cm from the thumb and forefinger of the right hand.

- Medial calf

Test procedure: With the subject either seated or with the foot on a box (knee at 90) and with the calf relaxed, the vertical fold is raised on the medial aspect of the calf at

a level where it has maximal circumference. This circumference will be determined during the measurement of girths and this level must be marked on the medial aspect of the calf during this process. View the marked site form the front to ensure that the most medial point has been correctly identified.

3.3.1.2 Physical and motor variables:

The following tests were done to assess the physical and motor abilities of the rugby players:

Vertical jump (Explosive leg power)

De la Port (2005) stated that the purpose of this test is to measure the subject's instantaneous explosive leg power, as well as the ability to jump in a vertical direction. A correlation exists between the explosive power in the legs and achievement in sports such as sprints and rugby. According to Thomas and Nelson (1985) this is the relevant method:

Apparatus: Chalk and tape measure.

Test procedure: The subject stands with his right side (hip) against a wall onto which a calibrated measuring board is mounted. The subject then reaches with the right/ left hand to touch the board at the highest point possible (heels of the feet stay on the ground). This point is recorded as "standing height". The subject then places chalk on his fingertips (dominant hand) and then, from a two-footed position the subject flexes at the hip and knee joints and using his arms as momentum, attempts to extend as high as possible. At the top of the jump the subject touches and marks the board with his fingertips. The subject is allowed three attempts and the best one is recorded. The score for the jump is the difference between standing height and jump height. The highest of three separate trials is recorded as the subject's maximum score. It should be noted that if the subject takes any form of step or shuffle prior to the jump, the score is rendered invalid. Record the height to the nearest centimetre.

Horizontal jump

The horizontal jump also measures the explosive power in the legs and the ability to jump in a horizontal direction. Here is also a correlation (just as with the vertical jump) between the explosive power in the legs and achievement in sports such as sprints and rugby. According to Kirby (1991) this is the relevant method:

Apparatus: Flat, even surface and measuring tape.

Test procedure: Subject stood feet together behind the starting line. From a stationary position he was allowed to jump forward (maximally). In this attempt the arms could be used to propel the subject forward. The distance from the starting line to the posterior heel margin was measured. Three attempts were allowed, with the best distance being recorded. Distances jumped were recorded to the nearest metre.

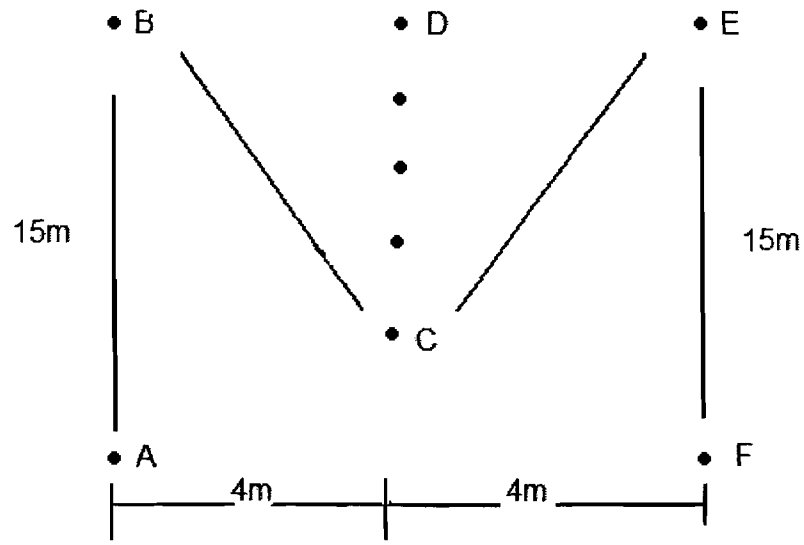
Agility (Illinois test)

The aim of this test was to assess the agility ability; in other words agility is the ability to change direction without the loss of speed, strength, and balance or body control. According to Badenhorst (1998) (quoted by Van Gent, 2003:116) this is the relevant method:

Apparatus: Stopwatch, rugby ball, seven large cone markers, two medium cone markers and measuring wheel.

Test procedure: The station is set up as in the sketch. The test is done holding the rugby ball with both hands at all times. The athlete moves through the cones as shown in the sketch below. The athlete starts at cone A, then run around cone B, to the cone at C. Running around each of the cones, the athlete returns to cone C again. Then runs to and around cone D and then straight to cone E. If the athlete slips or touches one of the cones, the test must be done again. The athlete is allowed two attempts and the best time (in seconds) is recorded.

Figure 3.1: Graphic description of the Illinois Agility Test (Badenhorst, 1998):



Seven stage abdominal strength test

The aim of this test was to determine the absolute strength of the abdominal muscle groups. Your abdominals are the centre of your body and are part of almost every movement you do. They are the core of your strength and power. Every time you lift, bend, twist, shift weight, or balance, power is transferred through your abdominal muscles. According to Kirby (1991) this is the relevant method:

Apparatus: Exercise matt, 2,5kg weight and 5 kg weight.

Test procedure: The subject lies on his back in a sit-up position, both feet are flat on the ground and the knees are bent at approximately 45°. If the feet lift off the ground the last stage completed is recorded. The stages are as follows:

Stage 1: With the arms straight, the subject touches his knees with his wrists.

Stage 2: With the arms straight, the subject touches his knees with his elbows.

Stage 3: With his hands next to his ears, keeping them there, he touches his knees with his elbows.

Stage 4: With his arms crossed over his chest, he attempts to touch his knees.

Stage 5: With his hands behind his neck and the chest open, he attempts to touch his knees with his chest.

Stage 6: With the 2,5kg weight placed behind his head, and keeping the weight there, he attempts to touch his knees with his chest.

Stage 7: With the 5kg weight placed behind his head, and keeping the weight there, he attempts to touch his knees with his chest.

Strength (Bench-press)

The purpose of these tests is to determine the players' maximal upper body (chest) strength. The one repetition maximum (1RM) test is used to determine the players' maximal strength. These 1RM values are useful in prescribing correct loads in exercise programmes and in evaluating strength improvements over time. Maximal strength tests, if performed incorrectly carry a high risk of injury. Never complete any exercise which causes pain (De la Port, 2005).

1RM Bench Press (absolute) – (kg).

1RM Bench Press (relative) – 1RM/(bodyweight x 0,57) (the athlete with the largest numerical index is considered the strongest body mass-adjusted lifter). The bodyweight is multiplied by a combination of the 2-power and 3-power (0,57) before it is divided into the strength.

According to Thomas and Nelson (1985) (quoted by De La Port, 2005:69) this is the relevant method:

Apparatus: Olympic bar, weights and three testing personnel for spotting.

Test procedure: The subject lies supine on a bench with his feet flat on the floor and his hips and shoulders in contact with the bench. An Olympic bar is gripped 5-10 cm wider than shoulder width, so that when the bar is placed on the chest, the elbow joints are flexed to approximately 90°. The subject commences this lift by lowering the bar, in a controlled manner, to the centre of the chest, touching the chest lightly (no bouncing of the bar on the chest) and then extending upwards until the arms are in a fully locked position. The player is advised to inhale when lowering the bar and exhale when pressing it. The maximum amount of weight that can be lifted with one repetition is recorded.

There are several reasons for disqualifying a lift, and these include:

- Lifting the buttocks during the movement
- Bouncing the bar off the chest
- Uneven extension of the arms
- Any touching of the bar by the spotter

The following basic steps can be followed for 1RM testing:

- Complete a light warm-up set of 10 repetitions using the 20kg bar only.
- Complete 6-8 repetitions at approximately 30-40% of the estimated 1RM.
- Complete a 2 minute stretching routine of shoulders and chest at rest.
- Increase the weight to 60% of the estimated 1RM, complete 6 repetitions.
- The subject then rests for 3-4 minutes before attempting his 1RM.
- If above was successful then the subject takes a 5 minute rest period before increasing the resistance (as used above) by 2,5% to 5%.
- If the subject cannot lift the weight, then use the previous successful weight lifted as his 1RM.

Pull-ups (chin-lifts)

The purpose of this test is to measure the athletes' upper body muscular endurance, especially arm and shoulder endurance. According to Thomas and Nelson (1985), this is the relevant method:

Apparatus: Pull-up bar - high enough so that the subject's feet cannot touch the ground while doing the pull-ups.

Test procedure: The subject uses the overhand grip as he grabs hold of the horizontal bar, with hands placed shoulder width apart. The subject must then start from a hanging position with arms fully extended. On ascent, the subject's chin must reach above the bar and with arms fully extending on the descent. The legs are not allowed to swing to assist the pull-up and as soon as the athlete's feet touch the ground, the test is stopped. The athlete has one trial to do as many pull-ups as possible.

Bleep test (multistage shuttle run)

Aerobic fitness is an important component of a number of endurance based sports such as in rugby. The purpose of this test is to enable an approximation of maximal oxygen uptake (VO^2 max). The maximal aerobic power (endurance fitness) of rugby players can be assessed by a progressive multistage shuttle run, according to the protocol of Lèger and Lambert (1982). This test has both excellent test-retest reliability (r = 0,97) and validity (r = 0,84). According to Lèger & Lambert (1982) this is the relevant method:

Apparatus: Compact disk player, multistage fitness test compact disk (CD), marker cones and 20m marked distance on a surface that is flat, even and slip resistant.

Test procedure: Check the speed of the CD by using the one minute calibration period. Measure the 20m distance and mark with cones. Instruct the athlete to run to the opposite end and place one foot behind the line by the time the next bleep sounds. If the athlete arrives before the bleep, he should turn (pivot) and wait for the signal, then run to the opposite line to reach this in time for the next signal. At the end of each minute the time interval between the bleeps is decreased, thereby running speed becomes progressively faster. Ensure that the athlete reaches the end line each time and does not turn short. Emphasize to the athlete to pivot and turn rather than run an arc which some tend to do (this takes more time). Each athlete continues running for as long as possible until able to keep up with the CD. The criterion for eliminating an athlete is two lengths in a row where he is more than two steps from the end. Record the last level and shuttle that the athlete successfully completed.

Speed endurance test

Speed is the ability to move the body through the required range of motion in the fastest time. Speed endurance is the capacity to sustain this movement or effort over a period of time. According to Hazeldine and McNab (1998), this is the relevant method:

Apparatus: One measuring wheel, two stopwatches, markers and two assistants.

Test procedure: The three markers (A, B, C) are placed in a straight line, positioned 10 metres apart (see sketch). With one assistant positioned at marker A, the test is

started. The subject stands at the middle marker (A), sprints to the second marker (B), turns and sprints to the third marker (C), turns again and sprints back to the start marker (A). The one assistant will start the stopwatch at the signal (to go) and will stop it once the subject has completed the full test. Time is noted. The second assistant starts the stopwatch once the subject has reached marker A. After a 20-second break (rest), the subject has to repeat the test procedure, as described above, six times in total, and after every repetition of the test procedure, a 20-second rest is allowed. All six times are recorded and the speed endurance calculated as follows:

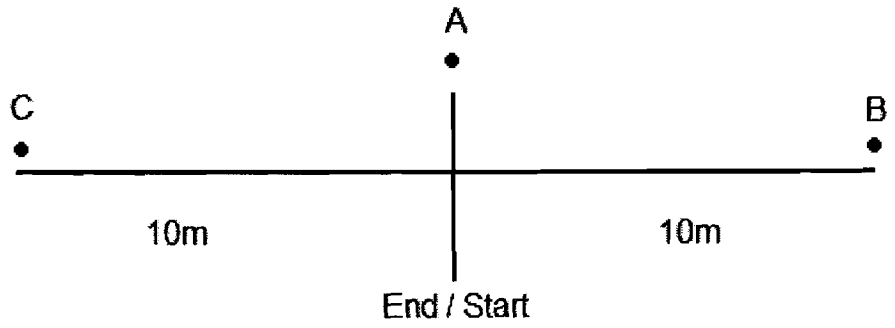
1) $\frac{(X1 + X2)}{2} - \frac{(Y1 + Y2)}{2} = Z$

2) $Z \div \frac{(Y1 + Y2)}{2} \times 100 = X\%$

where:

- X1 + X2 ÷ 2 = average X (where X1 and X2 are the slowest recorded times)
- Y1 + Y2 ÷ 2 = average Y (where Y1 and Y2 are the fastest recorded times)
- average Y – average X = Z
- Z ÷ average Y x 100 = percentage decrease in speed endurance (the lesser this percentage, the better speed endurance)

Figure 3.2: Graphic description of the Speed Endurance Test (Hazeldine and McNab, 1999):



Speed – 10m, 30m and 40m

The purpose of these tests is to determine the players' maximum sprint speed and their ability to accelerate and run from a stationary position; seeing that speed is very important in sports requiring short bursts of activity at high intensity such as sprint running in rugby. According to Kirby (1991) and Hazeldine and McNab (1998) this is the relevant method:

Apparatus: Stopwatch, marker cones and 40m running track that is straight, level and placed cross wind, or if speed lights (gates) are used where applicable – placed at the 0 m, and every following 10 m marks, no stopwatch is required.

Test procedure: Mark the running track with marker cones placed at 10m intervals. The athlete starts in a standing position, one foot in front of the other – with the front foot just behind the starting line. The tester should stand at the finish line; call ready and sweep down their arm quickly to start the athlete (do not call 'go'). As the arm sweeps down, the tester should simultaneously start the stopwatch which is held in the descending hand. Stop the stopwatch when the athlete's chest crosses the trials. The time will automatically be recorded when making use of speed lights. Record both trials then determine the average time for the 4m sprint to the nearest 0,01 sec. The time will automatically be recorded when making use of speed lights (gates).

3.3.1.3 Biomechanical and postural analysis

This biomechanical and postural evaluation (BMPE) was taken from Hattingh (2003); seeing that he developed a prevention programme for rugby injuries based on his analysis of adolescent rugby players (Annexure 3.1). Even though most of the following tests are not original to Hattingh (2003), he was the one who accumulated it into the one BMPE-form which is being used here, and therefore both he and the original author or developer will be quoted.

For all of the following test procedures, subjects were dressed in only rugby shorts. One examiner was used to perform test procedures, and an observer to assist with measurements. Both the examiner and the observer were properly briefed on each

individual test procedure and for consistency only two trained medical personnel were used for all tests.

A) Lower limb region

Achilles tendon suppleness test (TA-test)

According to Kapandji (1970) and McPoil and Brocato (1990) (quoted by Hattingh, 2003:73) the following test consists of:

Apparatus: One plinth and long-arm goniometer.

Test procedure: The subject was placed in the supine position, with both legs straight and the heels just over the edge of the plinth. Examiner took the ankle posterior with the left hand and with the right hand grabbed the ball of the foot and pushed the forefoot into dorsiflexion position. Pressure of approximately 30 kg was applied. Degrees of forced plantar flexion were measured on the lateral aspect of the ankle joint with the long-arm goniometer. Range of movement (ROM) was graded from 1 to 3 (1 is a range of 30° or more, ideal; 2 is between 10° and 30°, non-ideal and 3 is less than 10°, highly unsatisfactory).

Modified Thomas test

According to Kapandji (1970); Hunt (1990) and Saudek (1990) (quoted by Hattingh, 2003:74) the following test consists of:

Apparatus: One plinth, one goniometer and one marker.

Test procedure: For the modified Thomas test 3 lower limb mobility measurements were assessed. This test was used as a functional combination test for all 3 measurements. Subjects stood at the end of the plinth, with posterior aspects of thighs firmly against it. Left hip and knee were flexed towards the chest; the ankle was gripped on the anterior aspect with fingers locking. Subject then lay back in the supine position; the left leg was still locked in the hand grip elbows were extended. The right leg was relaxed and hanging over the edge. From this position the functional combined mobility of the lower limb hanging was measured.

- Illiopsoas mobility: Lateral midline of the hip joint was identified and marked by the examiner. The long lever goniometer was placed on the identified point, with

one goniometer arm parallel to the horizontal and the second in line with the femoral shaft. The angle was measured. This was classified as follows: 1 is > 30° (ideal); 2 is 15°-30° (non-ideal); and 3 is, 15° (highly unsatisfactory).

- Quadriceps mobility: The midline of the knee joint was clearly marked on the lateral aspect. The long-arm goniometer was placed on the identified point; the control arm was positioned in the line of the femoral shaft and the other in line with the lower limb. The angle was measured. Measurements were classified into 3 categories: 1 is > 50° (ideal); 2 is 30°-50° (non-ideal); and 3 is < 30° (highly unsatisfactory).
- Illiotibial band mobility (ITB): The anterior aspect of the ankle joint was clearly marked. With the long-arm of the goniometer the amount of deviation from the coronal mid-position was measured (amount of rotation or deviation of sagittal mid-position from midline). Measurements were classified into 3 categories: 1 is neutral / 0°-10° of deviation (ideal); 2 is 10°-30° of deviation (non-ideal); and 3 is > 30° (highly unsatisfactory).

The same test protocol was then performed on the opposite limb.

Gluteus Maximus mobility test (short hip extensor mechanism mobility test):

According to Kapandji (1970) and Hoppenfeld (1976) (quoted by Hattingh, 2003:75) the following test consists of:

Apparatus: One plinth, one goniometer and one marker.

Test procedure: Subject supine on plinth with legs extended. Examiner positioned at side of plinth facing lower limbs. The knee closest to the examiner was flexed to 90° and the lateral aspect of the ankle rested on the opposite knee, and the thigh was then dropped into external rotation. From this point the flexed knee (90°) and externally rotated hip were flexed cephalate (the examiner maintained the amount of external rotation up to maximum hip flexion). With the lower limb position maintained at full hip flexion, the long-arm goniometer was used to measure ROM. Measurements were classified into 3 categories: 1 is > 90° (ideal); 2 is 60°-90° (non-ideal); and 3 is < 60° (highly unsatisfactory).

Adductor mobility test:

According to Kapandji (1970) and Hoppenfeld (1976) (quoted by Hattingh, 2003:75) the following test consists of:

Apparatus: One plinth and one goniometer.

Test procedure: The subject was placed supine with both knees extended. The examiner stood at the side of the plinth facing the lower limbs. The opposite leg was abducted and the heel hooked over the edge of the plinth. The limb was stabilized and rotation controlled by the observer. The limb closest to the examiner was abductor, with hip rotation controlled in neutral. Movement was continued until the maximum range was reached. The long-arm goniometer was placed on the umbilicus with arms representing femoral shaft positions. The angle was measured. Measurements were classified into 3 categories: 1 is > 120° (ideal); 2 is 100°-120° (non-ideal); and 3 is <100° (highly unsatisfactory).

Hip joint:

According to Kapandji (1970) and Hoppenfeld (1976) (quoted by Hattingh, 2003:75) the following tests consist of:

- **External rotation mobility test**

Apparatus: One plinth, one long-arm goniometer and one marker.

Test procedure: Subject standing at the end of the plinth on right leg, whilst the left was supported over the side of the plinth (knee crease at edge). The examiner clearly marked the apex of the patella on the flexed knee. The left hand stabilized the inferior portion of the thigh; the right held onto the ankle, and maximally externally rotated the hip joint. The goniometer was placed on the identified area and the amount of rotation in comparison with the vertical axis measured. Measurements were classified into 3 categories: 1 is > 90° (ideal); 2 is 60°-90° (non-ideal); and 3 is < 60° (highly unsatisfactory).

- **Internal rotation mobility test**

Apparatus: One plinth, one long- arm goniometer and one marker.

Test procedure: The subject was positioned exactly as for the external rotational mobility test, expect that the ROM now tested for internal rotation, and was

measured. Measurements were classified into 3 categories: 1 is > 30° (ideal); 2 is 15°-30° (non-ideal); and 3 is < 15° (highly unsatisfactory).

Knee complex:

According to Derman and Schwellnus (2001); Gilleard et al. (1998); Kapandji (1970); Wallace et al. (1990) and McConnel (1986, 1999) (quoted by Hattingh, 2003:76) the following tests consist of:

- **Quadriceps angle test (Q-angle test)**

Apparatus: One plinth, one goniometer, one marker and tape measure.

Test procedure: The subject lay relaxed, supine on plinth with both legs extended. The examiner used the marker and identified tibial tuberosity and the apex of the patella. He then carefully marked the medial and lateral aspects of the patella base. The midpoint between these landmarks was measured and identified. The anterior superior ileac spine was palpated, identified and marked. A straight line was drawn from this high position through the superior patella mid-position extending caudate. A second line was drawn from the tibial tuberosity through the apex of the patella cephalate. The point at which these two lines crossed indicated the Q-angle of the measured leg. A small goniometer was placed on the crossing lines and the angle was measured. Measurements were classified into 2 categories: 1 is < 9° (ideal); and 2 is ≥ 9° (non-ideal).

- **Patella tilt test**

Apparatus: One plinth.

Test procedure: The subject lay relaxed supine on the plinth with both legs extended. The examiner was positioned laterally at the level of the left knee.

Phase 1: Using an imaginary coronal axis through the anterior surface base of the patella, the amount of surface deviation from this line was noted and documented. When there was no discrepancy, the patella was categorized as 1, not tilted (ideal).

Phase 2: With deviation the examiner placed the thumbs on the lateral aspect of the patella and gently glided it medially (<1 cm). Only with the range limited, the patella was categorized as 2, tilted (non-ideal).

The project was then repeated on the opposite knee.

- **Patella squint test**

Apparatus: One plinth, one marker and tape measure.

Test procedure: The subject was positioned as with the patella tilt test. The examiner was positioned laterally at the level of the left knee. The examiner used the marker to identify and mark the apex of the patella. He then carefully identified the medial and lateral aspects of the patella base. The midpoint between these landmarks was identified. A line was drawn from the patella mid-position through the inferior pole of the patella. The examiner now identified and categorized the amount of patella squint (rotation) in comparison with the mid-limb sagittal line. Measurements were classified into two categories: 1 is < 10° (ideal); and 2 is > 10° (non-ideal).

- **Vastus medialis obliques-lateralis comparison test (VMO-L)**

Apparatus: One plinth.

Test procedure: The subject was supine on the bed, with both knees extended. The examiner was positioned at the lower limb level, facing the knees. The subject was instructed isometrically to contract the quadriceps and hold it. The examiner compared the muscle bulk of Vastus Medialis left to right. Measurements were classified into two categories: 1 is of no apparent difference (ideal); and 2 is apparent difference (non-ideal).

The foot:

According to Kapandji (1970); Hoppenfeld (1976); Hunt (1990); Derman and Schwellnus (2001) and McPoil and Brocato (1990) (quoted by Hattingh, 2003:78) the following tests consist of:

- **Longitudinal arch status test**

Apparatus: None.

Test procedure: The subject stood erect, but relaxed, feet shoulder width apart, facing the examiner. The longitudinal medial arch (plantar vault) was inspected by inserting the index finger between the plantar surface of the foot and the ground. Foot arches

were classified into three categories: 1 is resisted movement (dropped arch/hypermobile); 2 is easily inserted index finger; and 3 is excessive play between plantar aspect and ground (high arch/hypermobile).

- **Forefoot positional test**

Apparatus: One goniometer and one plinth.

Test procedure: The subject stood as for the longitudinal arch status test. The marker was used to identify the lateral aspect of the talus neck. The Z axis was then identified and marked. A goniometer was placed on the marked area, the control arm on the Z axis and the second arm measured the degrees of forefoot valgus. Measurements were classified into two categories: 1 is 10°- 0° of deviation from Z axis (ideal); and 2 is > 10° of deviation from Z axis (non-ideal).

- **Rear foot standing test**

Apparatus: One plinth, one goniometer, one marker, tape measure and bench press.

Test procedure: The subject lay prone on the plinth with both feet just over the edge of the plinth. The mid-point of insertion of the Achilles tendon (TA) into the calcanei was marked. With the index finger and thumb of the left hand on either side of the calcanei, the mid-position of the posterior calcanei was marked. A line bisecting the calcanei was drawn by connecting these two marks. A third point was marked on the mid-point of the proximal calf muscle bulk. Finally, a fourth point was identified where the calf muscle bulk inserted into the TA. A line was drawn between these two points, which represented the pulling direction of the calf muscle complex.

The subject was ordered to stand erect with feet together on the bench press, facing away from examiner. The angle between the two drawn lines was measured. Measurements were classified into three categories: 1 is > 9° (rear foot pronation); 2 is 0°-9° (ideal); and 3 is < 0° (rear foot supination).

- **Rear foot lying test**

Apparatus: One plinth, one goniometer and one marker.

Test procedure: The subject was positioned and marked as for the rear foot standing test protocol. The examiner was positioned at the end of the plinth, placing the left hand on either side of the talus, approaching from the frontal aspect of the right foot. With the thumb of the right hand placed on the plantar aspect of the fourth and fifth metatarsal heads, the foot was eased into dorsiflexion, whilst controlling the neutrality of the talocrural joint system with the index finger and thumb of the left hand. The position was held in neutral (0°) and the rear foot status was measured with the goniometer. Measurements were classified as for the rear foot standing test protocol.

- **Transverse arch area comparison test**

Apparatus: One plinth.

Test procedure: Subject was positioned as for the rear foot standing test protocol. The examiner was seated at the end of the plinth and inspected transverse arch area. Transverse arch areas were classified into two categories: 1 is normal plantar aspect with slight transverse arch (ideal); and 2 is callus plantar aspect with flat arch (non-ideal).

- **Foot mobility test**

Apparatus: One plinth.

Test procedure: The subject and examiner were placed as for the transverse arch area comparison test. The subject's medial aspect of the foot was first flexed maximally and then extended by the examiner. The amount of mobility was noted. Mobility status was categorized into 1 is hypermobile; 2 is ideal; and 3 is hypomobile.

- **Toe positional test**

Apparatus: None.

Test procedure: The subject stood erect and relaxed, feet shoulder width apart, facing the examiner. The toe position was evaluated and categorized: 1 is ideal position (no valgus, rotation or deviation); and 2 is non-ideal (valgus/rotation/deviation present).

B) Pelvic girdle region:

Leg length discrepancy test

According to Hoppenfeld (1976); Peers (1994) and Rocabado (2000) (quoted by Hattingh, 2003:79) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned supine one the plinth with the heels just over the edge. The examiner ensured the symmetrical positioning of the subject. Placed at the end of the plinth, both thumbs (of the examiner) were placed firmly against the inferior aspect of the medial malleoli. Straight legs were lifted (30), elongated and replaced. Differences in malleoli position were noted, recorded and categorized: 1 is medial malleoli height left equals right (ideal); 2 is < 1cm discrepancy (slightly displaced) (non-ideal); and 3 is > 1cm discrepancy (highly unsatisfactory).

Anterior superior ileac spine (ASIS) comparison test

According to Hoppenfeld (1976); Peers (1994) and Rocabaco (2000) (quoted by Hattingh, 2003:80) the following test consists of:

Apparatus: One plinth and one marker.

Test procedure: The subject was positioned as for the leg length discrepancy test. He was requested to expose the anterior superior ileac spine. The examiner carefully marked the inferior aspect of both prominences. The symmetrical positioning of the subject was then ensured. Thumbs were placed on the marked areas and signs of asymmetry were recorded. Status was categorized as follows: 1 is symmetrical (ideal); and 2 is asymmetrical (non-ideal).

Posterior superior ileac spine (PSIS) comparison test

According to Hoppenfeld (1976); Peers (1994); Porterfield and De Rosa (1990) and Rocabaco (2000) (quoted by Hattingh, 2003:80) the following test consists of:

Apparatus: One plinth and one marker.

Test procedure: The subject was placed in the four-point kneeling position on the plinth. He was then ordered to sit back on his heels (with gluteal area touching) and

while sustaining the position to flex forward until his head was on the plinth. The examiner carefully exposed, palpated, identified and marked the inferior edge of the posterior superior ileac spine. Thumbs were now positioned on the marked areas and the symmetry assessed. Status was categorized as follows: 1 is symmetrical (ideal); and 2 is asymmetrical (non-ideal).

Pelvic ramie positional test

According to Hoppenfeld (1976); Peers (1994) and Rocabado (2000) (quoted by Hattingh, 2003:80) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject lay supine with the superior pubic area just exposed. The examiner ensured symmetrical positioning. Thumbs were placed on the superior rami. The area was assessed for asymmetry. Status was categorized as follows: 1 is symmetrical (ideal); and 2 is asymmetrical (non-ideal).

Sacroiliac cleft test

According to Porterfield and De Rosa (1990) (quoted by Hattingh, 2003:81) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned as for the posterior superior ileac spine comparison test. The examiner carefully exposed the sacro-iliac joint (SIJ) area. He then placed the thumbs on the joint margin and assessed for cleft asymmetry. Status was categorized as follows: 1 is symmetrical (ideal); and 2 is asymmetrical (non-ideal).

Bilateral pelvic positional test

According to Kapandji (1970) (quoted by Hattingh, 2003:81) the following test consists of:

Apparatus: Tape measure, one marker and one stool.

Test procedure: The subject stood erect and relaxed with the ASIS as well as the PSIS well exposed. The examiner was positioned sitting facing the subject's side on.

The inferior edge of the ASIS and then the PSIS were carefully palpated, identified and marked. The difference in height between the lower ASIS and PSIS were measured and recorded. Measurements were categorized into the following: 1 is 2-3cm discrepancy (ideal); 2 is 3-5cm discrepancy (non-ideal); and 3 is > 5 cm discrepancy (highly unsatisfactory).

C) Spinal region

Thoraco-lumbar fascia mobility test

According to Kapandji (1974) (quoted by Hattingh, 2003:81) the following test consists of:

Apparatus: One plinth and tape measure.

Test procedure: The subject was placed in a side-lying position with his head placed at the top end of plinth. The top leg was bent at 90 angles at both hip and knee. The examiner then aided the subject first onto the elbow (sideline) and then onto the hand which was placed at the edge of the plinth. He ensured the subject was positioned in a straight line before the test procedure. The distance between the ileac crest and superior plinth surface was measured. Measurements were classified into 3 categories: 1 is ≤ 1cm (ideal); 2 is 1-3cm (non-ideal); and 3 is >3cm (highly unsatisfactory).

Sacral rhythm test

According to Gould III (1990) (quoted by Hattingh, 2003:82) the following test consists of:

Apparatus: One plinth.

Test procedure: Subject in prone position on the plinth with his head close to the top edge. Arms positioned for push up with hands on both corners of plinth. The examiner, positioned on the side of the plinth, placed both thumbs on L5 transverse processes. He now performed the push-up without lifting his hips. The examiner assessed the symmetry of the extension movement in this region. This was categorized into the following: 1 is symmetrical movement (ideal); and 2 is asymmetrical movement (non-ideal).

Functional extension mobility test

According to Gould III (1990) (quoted by Hattingh, 2003:82) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned as for sacral rhythm test. The push-up was performed with elbows locked in extension. The examiner now measured the distance between the ASIS and the superior aspect of the plinth. Measurements were categorized into the following: 1 is < 2cm (ideal); 2 is 2-3cm (non-ideal); and 3 is > 3 cm (highly unsatisfactory).

Functional flexion mobility test

According to Kapandji (1974) (quoted by Hattingh, 2003:82) the following test consists of:

Apparatus: None.

Test procedure: The subject stood erect and relaxed, with feet at shoulder width. Without bending knees, the subject flexed forward and attempted (with hands crossed) to touch the ground. The subject was urged to flatten the palms on the floor, if possible. Flexion was categorized into: 1 is palms placed flat on the ground (ideal); 2 is fingers touching ground (non-ideal); and 3 is unable (highly unsatisfactory).

Rotational mobility test

According to Kapandji (1974) (quoted by Hattingh, 2003:82) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was seated in a stable position and erect, with lower limbs over the edge of the plinth; arms were crossed, with hands on opposite shoulders. The examiner was positioned behind the subject and placed his hands on the subject's shoulders and rotated the trunk to the edge of its range. The range was noted and categorized as follows: 1 is $\geq 90°$ rotation (ideal); 2 is rotation at 70°-90° (non-ideal); and 3 is $< 70°$ rotation (highly unsatisfactory).

Side flexion mobility test

According to Gould III (1990) and Kapandji (1974) (quoted by Hattingh, 2003:83) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned as for rotational mobility test. With both hands on the shoulders relaxed. Examiner, from the rear, stabilized the pelvic girdle on the left and laterally flexed the trunk to the right up to the end of its range (no rotation). The procedure was then repeated on the left side. The range was categorized as follows: 1 is easy elbow contact with plinth without stretching sensation and resistance (ideal); 2 is contact with stretching sensation and resistance (non-ideal); and 3 is unable to touch surface (highly unsatisfactory).

Coronal axis

According to Kapandji (1974) (quoted by Hattingh, 2003:83) the following test consists of:

Apparatus: One plinth.

Test procedure: Subject standing erect and relaxed, feet at shoulder width, with the examiner seated on a high stool facing the subject laterally. Using an imaginary coronal axis passing through the midline of the subject (line of gravity), the postural position was evaluated. The following spine regions were positionally categorized: cranium (head), cervical, thoracic and lumbar. Regions were identified as: 1 is ideal (within acceptable anatomical postural limits close to the coronal axis); and 2 is non-ideal (exceeding acceptable limits).

Saggital axis

According to Kapandji (1974) (quoted by Hattingh, 2003:83) the following test consists of:

Apparatus: One stool.

Test procedure: The subject was positioned as for the coronal evaluation, with the examiner positioned posterior on a high stool. An imaginary sagittal axis passing through the midline of the subject was used, evaluating the postural position. The

following regions were categorized: cranium (head), cervical, thoracic and lumbar. Regions were identified as: 1 is ideal (with acceptable anatomical postural limits close to sagittal axis); and 2 is non-ideal (deviating from axis).

D) Upper limb region

Hand behind back ROM test

According to Kapandji (1970) (quoted by Hattingh, 2003:84) the following test consists of:

Apparatus: One marker and tape measure.

Test procedure: The subject stood erect, relaxed, feet at shoulder width, with the examiner positioned posterior. With a single movement, the left arm was internally rotated behind the back and with the index finger; the highest possible position was achieved. The examiner carefully marked this level on the spinous process. The procedure was then repeated with the right arm. Differences in height were noted and measured. Measurements were categorized into the following: 1 is distance between two marks $\leq$ 1cm (ideal); 2 is 1-3cm (non-ideal); and 3 is > 3 cm (highly unsatisfactory).

Hand behind neck ROM test

According to Brukner and Khan (2002) and Kapandji (1970) (quoted by Hattingh, 2003:84) the following test consists of:

Apparatus: One marker and tape measure.

Test procedure: Subject positioned as for hand behind back ROM test. With a single movement the left arm was externally rotated behind the neck and the lowest possible point achieved with the index finger. This was marked on the spinous process. The subject repeated the procedure with the right arm. Differences in height between the two marks were noted and measured. Measurements were categorized into the following: 1 is $\leq$ 1cm (ideal); 2 is 1-3cm (non-ideal); and 3 is > 3 cm discrepancy (highly unsatisfactory).

Shoulder coronal positional test

According to Brukner and Khan (2002) and Kapandji (1970) (quoted by Hattingh, 2003:84) the following test consists of:

Apparatus: One high stool.

Test procedure: The subject stood erect, relaxed, feet at shoulder width, with the examiner seated on high stool positioned laterally to subject. Using an imaginary coronal axis (line of gravity) passing through the midline of the subject, the shoulder postural position was noted and categorized as: 1 is anterior displacement of shoulder < 2/3 (ideal); and 2 is anterior displacement > 2/3 (non-ideal).

Winging positional test

According to Brukner & Khan (2000); Halbach and Tank (1990) and Kapandji (1970) (quoted by Hattingh, 2003:85) the following test consists of:

Apparatus: One high stool and one marker.

Test procedure: Subject stood erect, relaxed, feet at shoulder width, with examiner positioned posterior seated on high stool. Inferior medial margins of both scapulae were carefully marked, was well as spinous process of T9. Distances between the spinous process (T9) and the inferior medial margins were noted and recorded. Measurements were categorized as: Distance equal with no winging (ideal), both categorized as 1 is discrepancy > 1cm, winging on the larger measurement side, categorized as 2 (non-ideal); contra-lateral side no winging, categorized as 1; equal distance (larger) plus winging, non-ideal, both categorized as 2.

Shoulder outline composition test

According to Brukner and Khan (2000) and Halbach and Tank (1990) (quoted by Hattingh, 2003:85) the following test consists of:

Apparatus: One high stool.

Test procedure: Subject stood erect, relaxed, feet at shoulder width, with the examiner positioned laterally. Shoulder outline was categorized into: 1 is predominantly muscular with very few to no visible bony landmarks (ideal); and 2 is less muscular with prominent body landmarks well visible (non-ideal).

Throwing ROM test

According to Mullin (1999) (quoted by Hattingh, 2003:85) the following test consists of:

Apparatus: None.

Test procedure: Subject stood erect, relaxed, feet at shoulder width, with examiner positioned laterally on right side. Right shoulder flexed actively to maximum ROM with extended elbow. The examiner with his left hand stabilized the trunk and passively flexed the shoulder to the end of its range. Using as imaginary coronal axis passing through the midline of the subject (line of gravity), the examiner noted the range. Subjects were categorized as: 1 is exceeding coronal midline (ideal); and 2 is short of coronal midline (non-ideal).

E) Neurodynamics

Straight leg raises (SLR)

According to Butler (1991) and Saunders (1990) (quoted by Hattingh, 2003:86) the following test consists of:

Apparatus: One plinth and one long-arm goniometer.

Test procedure: The subject was positioned supine on the plinth, closest to the examiner. Trunk and hips were in a neutral position. The examiner placed one hand under the Achilles tendon and the other above the knee. The leg was lifted perpendicular to the plinth, with the hand above the knee preventing any knee flexion. The limb was lifted as a solid lever moving at a fixed point in the hip joint. The limb was taken up to a symptom response or the end of its range. As in all tension testing, the end of the range was noted. Using the goniometer (with the apex of the trochanter as midpoint) the range of movement was noted and categorized as follows: 1 is $\geq 90°$ (ideal); 2 is 70°-90° (non-ideal); and 3 is $< 70°$ (highly unsatisfactory).

Upper limb tension test

According to Butler (1991) and Halbach and Tank (1990) (quoted by Hattingh, 2003:86) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned in neutral supine, towards the left side of the plinth. The examiner held the left hand of the subject in his right, with his upper left arm resting on thigh. The left shoulder girdle was depressed by the examiner with his left hand, ensuring maintenance of the neutral position of the girdle. The gleno-humeral joint was abducted to 110° in the coronal plane. With this position maintained, the forearm was supinated and the wrist and fingers extended. The shoulder was rotated laterally. The elbow was slowly extended. With position maintained, the subject now added lateral flexion of the cervical spine to the left and then to the right. Subjects were classified into three categories: 1 is 180°- 0° with slight symptoms (ideal); 2 is 180°-10° with symptoms (non-ideal); and 3 is 180°->10° with symptoms (highly unsatisfactory).

L3/4 nerve suppleness test (prone knee bend)

According to Butler (1991) and Gould III (1990) (quoted by Hattingh, 2003:87) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject lay prone on the plinth, facing the examiner. The lower limb was passively flexed towards the gluteal area until either a symptom response or end of range was reached. The range was noted. Subjects were here classified into three categories: 1 is heel touching gluteus area with little resistance (ideal); 2 is heel touching gluteus area with strong resistance (non-ideal); and 3 is heel not touching (highly unsatisfactory).

Slump test

According to Gould III (1990) (quoted by Hattingh, 2003:87) the following test consists of:

Apparatus: One plinth.

Test procedure: The subject was positioned well back with legs over the side of the plinth (knee crease at the edge). Both hands were linked in a relaxed position behind the back. The subject was ordered to slump with cervical spine in extension. The examiner now applied overpressure to thoracic and lumbar spine. This position was

maintained. The order was now given to flex the cervical spine and to press chin to chest, again with gentle overpressure by the examiner. With this position held, the subject was now ordered to extend the knees, first the left, then the right. Range and discomfort were noted. With the same position as above, dorsiflexion of the ankle and foot were carefully added. Range and discomfort were noted again. With previous position held, neck flexion was carefully released. Signs and symptoms were noted. The test was repeated on the opposite side. Finally, with the subject in slump position with overpressure, both knees were extended. Discomfort and range were noted. Subjects were classified into three categories: 1 is full range with dorsiflexion and asymptomatic (ideal); 2 is full range with dorsiflexion and discomfort (non-ideal) and 3 is limited range with tension (highly unsatisfactory).

3.3.2 Injury clinics and injury epidemiology reporting

All players had to report any injuries sustained, to a clinic held free of charge twice a week, on Mondays and Wednesdays, at the Institute for Sports Medicine. This clinic was manned by two qualified sports practitioners/physicians (medical doctors with a special degree in sport sciences), three qualified or trainee physiotherapists specializing in sport, as well as three biokineticists and three sport scientists (fitness conditioning coaches). All of the latter were either honours or masters students, in training at the Human Movement Sciences or Movement Education Departments at the North West University.

Before a player was allowed to be screened by the medical team, a current injury information questionnaire had to be completed. Information had to be documented on:

- player position
- match or training injury (when the injury had occurred)
- anatomical region injured
- whether it is an acute or chronic injury (Annexure 3.2).

Each player was assessed by the medical team and then referred either for further special investigations (such as a specialist opinion or specific investigations like x-rays, sonars, isokinetic tests or physiotherapy treatment or even the necessary medications), and according to this results colored. Colored meaning his ability to participate again: if red, he could not play or exercise till further investigations have been done or due to his medical unfit condition; yellow, meaning he first had to pass certain tests before he could return to play or exercise; and green, he could return to play or exercise immediately. Re-assessments of the injured player were then done during the next clinic held.

The function of these sports clinics were purely to diagnose, refer and programme all players who reported any kind of injury. Information on individual player status was communicated in writing as well as orally twice weekly to the head of the coaching at the Rugby Institute.

3.4 STATISTICAL METHOD

Statistical software was used for the data analysis. The SAS – computer program package of the North West University, Potchefstroom Campus (SAS Institute Inc., 2005) was used. Both descriptive statistics (means, standard deviation, minimum and maximum) as well as practical significant differences (d-values) were used (Cohen, 1988). Effect sizes were used to comment on practical significant differences - namely the difference between the two means divided by the biggest for standard deviation used. The effect size made the difference independent of units and sample size, and relates with the spread of the data (Steyn 1999).

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

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

where: $\bar{x}_1$ is the mean of group 1 and

$\bar{x}_2$ is the mean of group 2.

s_{max} is the biggest standard deviation of the two groups.

Cohen (1988) gives the following guidelines for the interpretation of the effect size in the current case:

- $d < 0,5$: small/low effect size with no practically significant effect.
- $0,5 \leq d < 0,8$: medium effect size that tends towards a practically significant difference.
- $d \geq 0,8$: large/high effect that is a practically significant difference.

These data only serve as guidelines, and values are not absolute.

3.5 SUMMARY

The above mentioned testing batteries discussed were performed on all the players involved. Only when a player had an injury which prevented him from participating in a certain test, due to the possibility of worsening the condition or the incapability of performing the test, he was excused from that specific testing episode.

Results with tendencies will be discussed in the next chapter, with a discussion and conclusion in the last chapter.

CHAPTER 4:

RESULTS AND DISCUSSIONS:

4.1 INTRODUCTION

The aim of this study was to conduct a biomechanical, anthropometrical, physical, motor and injury epidemiology profile of elite under 19 rugby players. This chapter contains the results of the empirical investigations and discusses the results listed in Tables accordingly. The Statistica (Statsoft, 2004) as well as the SAS-computer programme package of the North West University, Potchefstroom Campus (SAS Institute Inc., 2005) was used for data analysis.

This chapter consists firstly of descriptive statistics (mean ($\bar{x}$), standard deviation (sd), minimum (min) and maximum (max) values) (Cohen, 1988) for anthropometrical measurements and physical and motor abilities, and biomechanical and postural evaluations, for the elite Under 19 rugby players as a group during October 2005. Secondly it consists of descriptive statistics for anthropometrical measurements, physical and motor abilities, of the elite Under 19 rugby players during July 2006 as a group.

Thirdly it consists of practical significant differences (d-values) (Cohen, 1988) for the anthropometrical measurements and physical and motor abilities between the October 2005 and the July 2006 testing episodes for the elite U/19 rugby players. There are no practical significant differences for the total group as far as it concerns biomechanical and postural evaluations, seeing that it has only been tested once-off in October 2005 (the positional practical significant differences however follow fourthly).

Fourthly it consists of practical significant differences (d-values) for the anthropometrical measurements, physical and motor abilities, and biomechanical and posture evaluations between the different player positions, namely the tight five, loose forwards, halfbacks and the backs.

Lastly it consists of the results of the epidemiology of all the intrinsic injuries of the 2005/2006 season. This includes the injury incidence (rate of injury) and position of

the injured player, the anatomical region and type of injury, the period of prevalence, chronic or acute injuries and the specific reference.

All these above mentioned variables are compared with findings in the modern literature.

4.2 TEST BATTERY

From the literature numerous tests, analyses and protocols were obtained to identify and select important tests that have been proven to be advantageous to a high level of performance, and also specifically to evaluate the effectiveness of the injury and prevention programme. As mentioned above, this test battery consists firstly of descriptive statistics of the total group and secondly of the different player position groups. The descriptive statistics are furthermore divided into the anthropometrical, physical and motor, and biomechanical characteristics. Thirdly, the epidemiology of the intrinsic injuries will be discussed.

4.2.1 DESCRIPTIVE STATISTICS – TOTAL GROUP

The following discussions include the differences in anthropometrical measurements, physical and motor variables, and biomechanical and postural evaluations according to the total elite U/19 rugby player group.

4.2.1.1 Anthropometrical characteristics of elite U/19 rugby players

The total under 19 elite rugby player–group (n = 77) had their first anthropometrical status, namely length, body mass and body fat percentage, tested in October 2005 (at the end of their school career and the beginning of their off-season program as junior/senior elite rugby players). After the total group had followed a specific program under the supervision of team coaches, the biokineticist and the sport scientist, the top playing squad of the same U/19 group (n = 31) were tested again in July 2006. The results of the two testing episodes are as follows:

Table 4.1: Descriptive statistics and practical significant differences (d-values) of the anthropometrical components of the elite U/19 rugby players

Variables	October 2005					July 2006					
	n	$\bar{x}$	Min	Max	sd	n	$\bar{x}$	Min	Max	sd	d-values
Length	58	182,74	167,10	199,50	6,61	31	180,58	176,70	184,30	7,66	0,28
Mass	58	88,49	60,00	130,20	15,23	31	87,88	73,75	102,24	15,61	0,04
Body fat %	58	13,22	1,08	39,48	6,92	31	12,17	8,46	16,62	6,02	0,15

Table 4.2: Descriptive statistics and practical significant differences (d-values) of the physical and motor components of the elite U/19 rugby players

Variables	October 2005					July 2006					
	N	$\bar{x}$	Min	Max	sd	n	$\bar{x}$	Min	Max	sd	d-values
Bench	77	94,03	68,00	128,00	17,02	31	97,03	87,66	114,01	18,35	0,16
Vertical jump	52	52,54	33,00	67,50	7,47	31	51,19	45,39	58,00	9,03	0,15
Horizontal jump	52	2,46	1,68	2,94	0,27	31	2,52	2,41	2,61	0,21	0,21
Abdominal strength	71	5,19	1,00	7,00	1,78	31	5,25	4,82	6,00	1,94	0,03
10m speed	51	1,85	1,30	2,17	0,15	31	1,91	1,86	1,97	0,10	0,40
30m speed	51	4,42	4,06	4,19	0,17	31	4,43	4,26	4,62	0,24	0,04
40m speed	51	5,65	5,18	6,29	0,22	31	5,68	5,44	5,94	0,32	0,13
Agility	51	18,45	16,88	20,68	0,88	31	18,27	17,69	18,96	1,00	0,18
Speed endurance	49	12,70	10,00	14,00	0,87	31	13,02	12,50	13,50	1,08	0,30
Bleep	49	9,03	6,18	2,38	1,64	31	10,54	9,32	12,00	1,76	0,86**
Chin lifts	56	6,56	0,00	19,00	4,59	31	7,01	5,92	9,50	5,19	0,09

Results of the total group:

In Table 4.1 the differences can be seen between the two testing periods for the under 19 anthropometrical data. The mean value for both the length, mass and body fat percentage tested lower at the end of the season. When compared, all the anthropometrical groups showed a low to nil practical significant difference.

The mean length of these players ($\bar{x}$ = 182,74 cm in October 2005 and $\bar{x}$ = 180,58cm in July 2006) correlates well with findings of the study done by Hattingh (2003) where $\bar{x}$ = 180,68cm. Overall, they were however slightly shorter than in the study of Spamer & Winsley (2003), when compared with the Northern Bulls ($\bar{x}$ = 185,61cm) and the English College teams ($\bar{x}$ = 181,86cm), but a little taller than in the study of Plotz and Spamer (2006) with the Leopards Provincial U/19 team ($\bar{x}$ = 179,52cm).

The difference in length between the first and second testing is if you think about it, impossible! A player cannot decrease in length from October 2005 to July 2006. It would be even more ridiculous to imply that a player will loose some length during the season! No, the answer is as follows: Seeing that a total group of players (n = 77) was tested at the beginning of the season, but only the top-players (n = 31) were tested again in July 2006, it is possible that the length of the top-players varied slightly.

During the testing episode in October 2005 it was unknown that one was only going to be interested in the top group in July 2006, therefore everyone has been tested. The reason for testing only the top-players at the second testing episode, and not the total group is mainly due to the fact that they usually have the desired profile of a player for a specific position.

The mean body mass ($\bar{x}$ = 84,29kg in October 2005 and $\bar{x}$ = 87,21kg in July 2006) of this group is lower during the first testing episode than in other literature, but

correlates well during the second testing episode with findings of Hattingh (2003), who measured 87,13 kg between school rugby players; Spamer & Winsley (2003) who measured similar elite age-groupers ($\bar{x}$ = 87,38kg for the Northern Bulls and $\bar{x}$ = 87,84kg for the English College team). Plotz and Spamer (2006) found $\bar{x}$ = 84,90kg for the Leopards, which is again slightly lighter.

The body fat percentage ($\bar{x}$ = 13,22% in October 2005 and $\bar{x}$ = 12,17% in July 2006) correlates well with the results found by Hattingh (2003) ($\bar{x}$ = 12,98%), but is remarkably lower than the results found by Spamer & Winsley (2003) – with values of 15,80% for the Northern Bulls and 22,11% recorded for the English College team. The Leopards had a value of 14,70% (Plotz & Spamer, 2003). Considering the decreasing fat percentage from the start to the end of the season, transformation in each individual skinfold is possible, but seeing that there is no (d-value is 0,15) practical significant difference notable here, it is beyond the scope of this study.

There were low or nil practical significant differences in the anthropometrical components of the elite U/19 group between October 2005 and July 2006, indicating that the elite U/19 group showed little improvement over the season, even though they had been through months of intensive training and professional coaching. However, it has to be reiterated that two different profiles are under discussion. The first profile analyzes the variables of the U/19 players at the end of their school career, whereas the second profiles analyzes the variables of the elite U/19 players at the end of their first year of training and coaching at the Rugby Institute of the North West University.

To conclude, the anthropometrical results show that the findings regarding the elite U/19 group correlate well with similar studies in the literature.

4.2.1.2 Physical and motor characteristics of elite U/19 rugby players

The total under 19 elite rugby player–group (n = 77) had their first physical and motor abilities; namely muscle strength, explosive power, agility and speed, muscle

and aerobic endurance tests, tested in October 2005 (the end of their school career and the beginning of their off-season program as junior/senior elite rugby players). After the total group followed a specific program under the supervision of team coaches, the biokineticist and the sport scientist, the top playing squad of the same U/19 group (n = 31) was tested again in July 2006. The results of the two testing episodes were the following:

Results of the total group:

In Table 4.2 the differences can be seen between the two testing periods for the under 19 physical and motor data. The mean value for all variables tested higher at the end of the season; except for the vertical jump and agility tests. When compared, all the physical and motor groups showed a low to nil practical significant difference; except for the bleep test (d = 0,86) with a high practical significant difference.

Compared to the results of the study done by Hattingh (2003), this U/19 group outperformed them in the all the tests, except for the chin lift ($\bar{x}$ = 10,29) test and the pull-up ($\bar{x}$ = 5,76) test of his 18year old group. Compared to Spamer & Winsley (2003), the explosive tests compared well, namely the vertical jump ($\bar{x}$ = 52,40cm Northern Bulls and $\bar{x}$ = 44,00cm English College team) test; and the horizontal jump ($\bar{x}$ = 240,00cm) test compared with Hattingh (2003). Plotz & Spamer (2006) found a slightly lower value ($\bar{x}$ = 50,54cm) for the vertical jump for the Leopards team.

There was a high practical significant difference only for the bleep test (d = 0,86), with low practical significant differences for the horizontal jump (d = 0,21), 10m speed (d = 0,40) and speed endurance (d = 0,30) tests. The other physical and motor components showed no practical significant differences.

To conclude, the physical and motor results indicated that the elite U/19 group showed little improvement over the season, even though they had been through months of intensive training and professional coaching. Once again it has to be

reiterated that two different profiles are under discussion. The first profile analyzes the variables of the U/19 players at the end of their school career, whereas the second profiles analyzes the variables of the elite U/19 players at the end of their first year of training and coaching at the Rugby Institute of the North West University.

4.2.1.3 Biomechanical characteristics of U/19 elite rugby players

Biomechanical and postural evaluations (BMPE) were done once off only in October 2005, due to the unavailability of players and the period of competition later on in the season. Table 4.3 displays the biomechanical and postural data collected of the total group (n = 61). Usually both the right and left side of the anatomy would be displayed, but seeing that in this particular group, only 2 of the players showed some difference in measurements between their right and left side (which is of no significant value), the left side will be treated as equal to the right side (with only one value to be seen). This data is divided into five main categories, namely: the lower limb, the pelvic girdle region, the spinal region, the upper limb and neurodynamics.

This data will then be compared to the studies by Hattingh (2003), seeing that he is the founder of this BMPE-variables. Except for Erasmus (2006), who used Hattingh's BMPE on U/15 and U/16 school rugby players; and Peens (2005), who used it on cricket players, Hattingh is the only researcher up to date who has done biomechanical and postural testing on rugby players of all ages – and then more specifically on the U/19 age group as well.

Results of the total group:

The results of the total group will now be discussed.

Table 4.3: Descriptive statistics of the biomechanical and postural variables of elite U/19 rugby players (n = 61)

Variables	$\bar{x}$	Min	Max	sd
LOWER LIMB				
Lower limb dynamics				
TA	1,32	1,00	2,00	0,37
ITB	1,58	1,00	2,00	0,38
Quad	1,46	1,00	3,00	0,45
Iliopsoas	1,70	1,00	3,00	0,53
Gluts max	1,67	1,00	2,50	0,38
Adductor	1,40	1,00	2,00	0,30
Hip int rot	1,02	1,00	2,00	0,14
Hip ext rot	1,61	1,00	2,00	0,38
Knee region				
Knee Q-angle	1,13	1,00	3,00	0,36
Knee squint	1,12	1,00	2,00	0,31
Knee tilt	1,72	1,00	2,00	0,35
Knee height	1,71	1,00	2,00	0,32
VMO-L	1,11	1,00	2,00	0,29
Ankle and foot region				
Longitudinal arch	1,67	1,00	2,50	0,43
Fore foot	1,64	1,00	2,50	0,38
Rear foot standing	1,82	1,00	2,00	0,38
Rear foot lying	1,84	1,00	2,00	0,36
Transverse	1,66	1,00	2,50	0,36
Mobility	1,80	1,00	3,00	0,54
Toes	1,95	1,00	2,00	0,22
PELVIC GIRDLE REG				
Leg length	1,39	1,00	2,50	0,50
ASIS	1,39	1,00	2,00	0,49
PSIS	1,39	1,00	2,00	0,49
Rami	1,36	1,00	2,00	0,48
Cleft	1,11	1,00	2,50	0,32
Pelvis bilateral	1,86	1,50	3,00	0,34
SPINAL REGION				
Spinal dynamic mobility				
TLF	1,40	1,00	2,00	0,27
Sacrum rhythm	1,11	1,00	2,00	0,28
Extension	1,12	1,00	2,00	0,31
Flexion	1,37	1,00	2,50	0,44
Rotation	1,14	1,00	2,00	0,24

Side flexion	1,17	1,00	2,00	0,26
Spinal positional alignm				
Coronal axis				
Head	1,02	1,00	1,50	0,12
Cervical	1,00	1,00	1,00	0,00
Thoracic	1,16	1,00	2,00	0,36
Lumbar	1,72	1,00	3,00	0,45
Sagittal axis				
Head	1,08	1,00	2,00	0,25
Cervical	1,03	1,00	2,00	0,18
Thoracic	1,35	1,00	5,00	0,65
Lumbar	1,15	1,00	2,00	0,36
UPPER LIMB				
Hand behind back	1,14	1,00	2,00	0,34
Hand behind neck	1,11	1,00	2,00	0,30
Shoulder position	1,61	1,00	2,00	0,40
Winging	1,62	1,00	2,50	0,42
Outline	1,39	1,00	2,00	0,41
Throwing position	1,22	1,00	2,00	0,37
NEURODYNAMICS				
SLR	1,38	1,00	2,50	0,40
Upper limb tension	1,15	1,00	2,50	0,32
L3,4	1,29	1,00	2,00	0,39
Slump	1,16	1,00	2,00	0,30

Biomechanical and postural variables of the total U/19 group:

The first category is the lower limb region, with the first assessment being the lower limb dynamic mobility, consisting of eight tests. This is analyzed by using the TA test, the modified Thomas test with its three components (ITB, quadriceps and iliopsoas), gluteus maximus, adductor and hip internal and external rotational tests. When compared to one another, the TA ($\bar{x}$ = 1,32), quadriceps ($\bar{x}$ = 1,46), the adductor ($\bar{x}$ = 1,40) and the hip internal rotation (x = 1,02) tests have reasonable mean values, that is close to the ideal. Contrary to these are the mobility range tests of the iliopsoas ($\bar{x}$ = 1,70), gluteus maximus ($\bar{x}$ = 1,67), hip external rotation ($\bar{x}$ = 1,61) and ITB ($\bar{x}$ = 1,58) which recorded higher mean values; rendering these areas more hypomobile and also dynamically loaded, with tendencies to injuries (or other stressors). In the study of Hattingh (2003), he also finds that the mean values of the

TA ($\bar{x}$ = 1,60 left and 1,65 right), adductor ($\bar{x}$ = 1,55 bilaterally) and hip internal rotation ($\bar{x}$ = 1,35 bilaterally) tests are reasonably mobile and therefore close to the ideal.

The second assessment of the lower limb is the postural alignment of the knee region complex, consisting of five tests. The highest mean value recorded is the patella tilt ($\bar{x}$ = 1,72) test, which shows a more tilted tendency, and the height ($\bar{x}$ = 1,71) test, which shows an anomaly from the ideal norm. This high value of the patella tilt test correlates well with the tendencies of the modified Thomas and Gluteus Maximus tests in this region, which are close to the non-ideal. Of all the weight-bearing joints, the knee is the most vulnerable to injury, particular in the bipedal athlete. In part, this is attributable to the irregular opposing bony surfaces compromising the knee, but it is also clearly influenced by the biomechanical demands of sports such as rugby (Gerrard, 1998). In the study of Hattingh (2003) he also finds the patella tilt ($\bar{x}$ = 1,73 left and $\bar{x}$ = 1,78 right) has high mean values close to the non-ideal. In other words, the knee joint, a hinge joint, is stabilized by ligaments, muscle and other soft tissues; therefore we can conclude that the knee joint is unstable and mechanically overloaded.

The third and final assessment of the lower limb is the ankle and foot region, consisting of seven regional status tests. Both the longitudinal ($\bar{x}$ = 1,67) and transverse ($\bar{x}$ = 1,66) arch status tend to be clinically more of a flat foot. All the positions of the fore ($\bar{x}$ = 1,64) and rear foot ($\bar{x}$ = 1,82 and $\bar{x}$ = 1,84) tend to have a normal to > 9° deviation. There is a slight hypermobility of the foot ($\bar{x}$ = 1,80) and the toes ($\bar{x}$ = 1,95) tend to have slight positional anomalies. In the study of Hattingh (2003), both the longitudinal ($\bar{x}$ = 1,58) and transverse ($\bar{x}$ = 1,50) arch status also tend to be clinically more of a flat foot. The positional abnomalies of the two studies correlate well with one another, with reference to the tendencies seen higher up in the

mechanical chain, which are the modified Thomas, gluteus maximus and patella tilt tests.

The second category is the pelvic girdle region, consisting of six positional tests. All the positions have some discrepancy, and therefore some asymmetry, and tend to be between the anomalies value-borders – thus a lack in core stability. The bilateral count for the pelvic area ($\bar{x}$ = 1,86) has the highest mean value and tend to have the highest discrepancy (≥2cm and <3cm) which once again correlates well with the high modified Thomas values. This positional area-category can then be rendered as asymmetric and reasonably unstable. In the study of Hattingh (2003) the bilateral pelvic positional test also has a high mean value of 2,03.

The third category is the spinal region. The first aspect is the six spinal dynamic mobility tests. Only two of the tests show moderate mean values (closer to non-ideal), namely TFL ($\bar{x}$ = 1,40) and functional flexion mobility ($\bar{x}$ = 1,37). In the study of Hattingh (2003), the TLF ($\bar{x}$ = 1,80 left and $\bar{x}$ = 1,70 right) test has the highest mean value, followed by the functional flexibility test ($\bar{x}$ = 1,58). A second aspect is the eight postural positional assessments, which are equally divided into coronal and sagittal axis. The measurements in the coronal axis are very similar, with the mean values between 1,02 and 1,16; except for the lumbar area, with a mean value of 1,72 which again correlates with the lower limb dynamic tendencies. In the sagittal axis, measurements vary between 1,03 and 1,15; except for the thoracic area, with a mean value of 1,35 due to quadrant dominance. So here is an overall low deviation from normal, with no BIG anomalies.

The fourth category is the upper limb region, which consists of a total of six evaluations. The shoulder position ($\bar{x}$ = 1,61) and the winging ($\bar{x}$ = 1,62) which occur, as well as the muscular (opposing the bony) outline ($\bar{x}$ = 1,39), show higher mean values. This means poor regional positional stability and musculature, and it

also correlates with Hattingh's (2003) findings of the shoulder positional ($\bar{x}$ = 1,74 bilaterally) and winging ($\bar{x}$ = 1,73 left and 1,75 right) tests.

The fifth and last category consists of the four neurodynamic evaluation tests. All the tests show low mean values between 1,15 and 1,38 which correlate with a full ROM and no tension category. This category is the only one which does not correlate with the study of Hattingh (2003). His results showed the upper limb tension test ($\bar{x}$ = 1,38 left and $\bar{x}$ = 1,28 right) as the most ideal mean value recorded, with the rest of the testing protocols showing high mean values (closer to non-ideal).

To conclude, this elite U/19 group showed a lot of shortcomings during the October 2005 testing episode. In the lower limb region they were dynamically loaded and hypomobile, with tendencies to injury in the knee region. The postural alignment of the lower limb was mechanically overloaded and unstable, with a hypermobile ankle and foot, which might once again lead to different kinds of biomechanical stressors. The pelvic girdle presented with an asymmetric position, which led to a lack in core stability. Whereas the spinal region was dynamically mobile with no big anomalies, except for slight quadrant dominance in the coronal and sagital axes of the postural positional assessments. The upper limb region tended to have poor regional stability and musculature, which might lead to poor postural alignment and therefore also to overuse injuries et cetera. Neurodynamically, this elite U/19 group had full range of movement with no tension on the neural structures.

4.2.2 DESCRIPTIVE STATISTICS OF THE DIFFERENT PLAYER GROUPS

The following discussions include the differences in anthropometrical measurements, physical and motor variables, and biomechanical and postural evaluations according to player-position in the elite U/19 rugby player group. There are four different groups, namely: tight five, loose forwards, halfbacks and the backs (Duthie et al, 2003). The tight five consists of the loose head prop (nr 1), the hooker (nr 2), the

tight head prop (nr 3), the left lock (nr 4) and the right lock (nr 5). The loose forwards consist of the left flanker (nr 6), the right flanker (nr 7) and the number eight (nr 8). The halfbacks consist of the scrum half (nr 9) and the fly half (nr 10). The backs consist of the left wing (nr 11), the left centre (nr 12), the right centre (nr 13), the right wing (nr 14) and the fullback (nr 15).

4.2.2.1 Anthropometrical characteristics of the different elite U/19 rugby player positions

LENGTH

As indicated in Table 4.4 and 4.5, during the first ($\bar{x}$ = 185,41) and second ($\bar{x}$ = 184,30) testing episodes, the tight five were the tallest group of players. In contrast with the tight five, were the halfbacks, who on both occasions presented with a mean stature of 175,12cm and 176,70cm, and were therefore the shortest group of players. During both testing episodes, there were a high practical significant difference between the tallest and shortest group of players, with the d-values respectively 1,53 and 0,81. There were also a high practical significant difference between the loose forwards ($\bar{x}$ = 183,20 and $\bar{x}$ = 183,40) and the halfbacks (the shortest group) during both testing episodes, with a d-value of 1,35 and 0,89. There was also a high practical significant difference between the backs ($\bar{x}$ = 180,78 and $\bar{x}$ = 177,86) and the halfbacks during the first testing episode, with a d-value of 0,95; together with the loose forwards during the second testing episode, also with a d-value of 0,95.

It seems impossible that there is such a big practical significant difference between certain player groups, as mentioned above; and between others, such as the backs compared with the halfbacks (d-value is 0,15) and the loose forwards compared with the tight five (d-value is 0,10) during the second testing episode, no practical significant difference whatsoever. Referring to paragraph 4.2.1.1, the reason for testing only the top-squad at the second episode, and not the total group, is mainly due to the fact that they are usually the desired profile of a player for a specific position. In the case of the big practical significant difference in length, or as a matter of fact, no practical significant difference in length: a player for example has

Table 4.4: Descriptive statistics for the different elite U/19 player-positions with regard to the anthropometrical component LENGTH

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	23	185,41	6,72	172,40	199,50	11	184,30	9,35	173,00	194,20
Loose forwards	17	183,20	5,91	172,80	195,00	6	183,40	4,56	178,20	186,70
Halfbacks	6	175,12	5,98	167,10	180,70	4	176,70	7,53	167,60	185,30
Backs	12	180,78	4,22	173,30	190,00	10	177,86	5,82	169,20	185,70
Group	58	182,74	6,61	167,10	199,50	31	180,58	7,66	167,60	194,20

Table 4.5: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the anthropometrical component LENGTH

Variables	Variables	d-values (Oct 2005)	d- values (Jul 2006)
Backs	Loose forwards	0,41	0,95**
Backs	Halfbacks	0,95**	0,15
Backs	Tight five	0,69	0,69
Loose forwards	Halfbacks	1,35**	0,89**
Loose forwards	Tight five	0,33	0,10
Halfbacks	Tight five	1,53**	0,81**

High practical significant difference: $d \geq 0,8^{**}$

Medium practical significant difference: $d \geq 0,5$

Low practical significant difference: $d < 0,5$

undergone the measurement of length while in a halfback position, but when he is tested again at the end of the season, his position changed and he is now playing in the tight five position.

Hattingh (2003) also found a high practical significant difference (d = 1,21) between the forwards ($\bar{x}$ = 184,04cm) compared to the backline ($\bar{x}$ = 176,79cm). Plotz and Spamer (2006) found a medium practical significant difference (d = 0,75) only between the Northern Bulls ($\bar{x}$ = 185,61) and the Leopards ($\bar{x}$ = 179,52). Spamer and Winsley (2003) also found a medium practical significant difference (d = 0,50) between the Northern Bulls and Ivybridge ($\bar{x}$ = 181,86cm).

BODY MASS

As indicated in Table 4.6 and 4.7, there was an overall increase in body weight from the first ($\bar{x}$ = 88,49kg) to the second ($\bar{x}$ = 87,88kg) testing episodes. This might be due to the increased physical activity levels during the season. However, when player-position is more specifically described, the backs are the only player-group who had a decrease in body mass throughout the season, with the mean value dropping from 81,13kg to 79,09kg. When the backs are compared to the other groups, there are two extremely high practical significant differences: firstly between them and the tight five ($\bar{x}$ = 98,11kg and $\bar{x}$ = 102,21kg) throughout the season with d-values of 1,10 and 1,82; and secondly with the loose forwards ($\bar{x}$ = 1,38kg) player group at the end of the season, with a d-value of 1,38.

The tight five player group was the heaviest at the beginning of the season, with a mean value of 98,11kg and became even heavier throughout the season, with a mean value of 102,21 at the end of the season. This might be due to factors such as the natural growth phase of boys, or even the fact that muscle tissue weighs more than fat tissue (Duthie et al, 2006) and since they had a lot of physical exercise throughout the season, an increase in muscle tissue is quite possible. When the tight five is compared to the halfbacks, respectively presenting with a mean body mass of 71,13kg

Table 4.6: Descriptive statistics for the different elite U/19 player-positions with regard to the anthropometrical component BODY MASS

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	23	98,11	15,49	72,90	130,20	11	102,21	12,71	83,10	116,90
Loose forwards	17	86,79	10,30	64,20	101,10	6	93,77	6,52	86,50	99,10
Halfbacks	6	71,13	7,60	60,00	79,00	4	73,75	9,24	60,50	81,40
Backs	12	81,13	10,97	65,80	105,30	10	79,09	10,63	61,50	90,60
Group	58	84,29	15,23	60,00	130,20	31	87,21	15,61	60,51	116,90

Table 4.7: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the anthropometrical component BODY MASS

Variables	Variables	d- values (Oct 2005)	d– values (Jul 2006)
Backs	Loose forwards	0,52	1,38**
Backs	Halfbacks	0,92**	0,50
Backs	Tight five	1,10**	1,82**
Loose forwards	Halfbacks	1,52**	2,17**
Loose forwards	Tight five	0,73	0,66
Halfbacks	Tight five	1,74**	2,24**

and 73,75kg and in this section, with the highest practical significant differences with d-values of 1,74 and 2,24; it can be concluded that the halfbacks are also the lightest group of players.

Hattingh (2003) found a high practical significant difference (d = 1,80) between results of the mean body mass of the forwards ($\bar{x}$ = 96,25kg) and the backline ($\bar{x}$ = 76,72kg). Both Spamer and Winsley (2003) and Plotz and Spamer (2006) found hardly any significant differences between the teams.

BODY FAT PERCENTAGE

Just as in all the previous anthropometrical variables, the tight five had the highest body fat percentage, respectively at 16,36% and 16,62% – as indicated in Table 4.8 and 4.9. Within this group (on the two different testing occasions), they compared against the halfbacks, respectively presented with a mean body fat percentage of 8,36 and 9,16 and with d = 1,00 and 1,06; and against the backs at 8,46 (second testing episode) with d = 1,16. The loose forwards at 12,54 and 11,05 compared against the halfbacks with d = 1,02 and 0,88 respectively; and the backs with d = 1,28 (second testing episode). Again, in the above compared body fat percentage values, a high practical significant difference is indicated. Similarly to the other anthropometrical variables, Hattingh (2003) found a high practical significant difference (d = 1,12), with the forwards ($\bar{x}$ = 15,46%) outperforming the backline ($\bar{x}$ = 10,12%). Spamer and Winsley (2006) found a medium practical significant difference (d = 0,60) between the Northern Bulls ($\bar{x}$ = 15,8%) and Ivybridge ($\bar{x}$ = 22,1%).

To conclude the anthropometrical results regarding the specific player positions of the elite U/19 group, one has to keep in mind that these results were divided into the two different profiles as mentioned previously, namely: the first profile which analyzes the variables of the U/19 players at the end of their school career, whereas the second profile analyzes the variables of the elite U/19 players at the end of their first year of training and coaching at the Rugby Institute of the North West University.

Table 4.8: Descriptive statistics for the different elite U/19 player-positions with regard to the anthropometrical component BODY FAT PERCENTAGE

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	23	16,36	8,04	7,24	39,84	11	16,62	7,01	8,30	33,80
Loose forwards	17	12,54	4,09	5,96	20,63	6	11,05	1,83	9,60	13,10
Halfbacks	6	8,36	1,63	6,33	10,70	4	9,16	2,14	6,09	11,93
Backs	12	10,59	7,16	1,08	30,41	10	8,46	2,02	6,02	11,47
Group	58	13,22	6,92	1,08	39,84	31	12,174	6,02	6,02	33,80

Table 4.9: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the anthropometrical Component BODY FAT PERCENTAGE

Variables	Variables	d- values (Oct 2005)	d- values (Jul 2006)
Backs	Loose forwards	0,27	1,28**
Backs	Halfbacks	0,31	0,33
Backs	Tight five	0,72	1,16**
Loose forwards	Halfbacks	1,02**	0,88**
Loose forwards	Tight five	0,48	0,79
Halfbacks	Tight five	1,00**	1,06**

4.2.2.2 Physical and motor characteristics of the different elite U/19 rugby player positions

BENCH PRESS

The descriptive results of the bench press test (Table 4.10) showed that there was an improvement in performance of their upper body strength for all the different player positions from October 2005 to July 2006. The best score during the first testing was achieved by the loose forwards ($\bar{x}$ = 101,29kg) and the lowest score by the halfbacks ($\bar{x}$ = 82,56kg). However, when you compare these results to the other strength test, namely the abdominal strength test in Table 4.15, it is the halfbacks ($\bar{x}$ = 6,00 both testing episodes) who achieved the highest score and respectively the loose forwards ($\bar{x}$ = 4,82) and the tight five ($\bar{x}$ = 4,68) with the lowest scores during the testing episodes.

If one looks at the practical significant differences (Table 4.11) of the raw data between the first and second testing episode, the following can be reported: During October 2005 there was only medium practical significance between the different player position groups, with the highest d-value 0,69, where the tight five outperformed the halfbacks. At the end of July 2006, there was a high practical significant difference between the loose forwards and both the backs (d = 1,36) and the halfbacks (d = 1,32), with the loose forwards outperforming their counterparts. It seems that there is now an even bigger difference between the player positions than at the beginning of the season. This might well be because of the different physical activities and game skills undertaken by the different player groups. It can also be noted that the smallest practical significant difference of 0,21 was between the backs and halfbacks, which once again can be the result of the similarity between their specific player-position training programmes.

The results of the 2006 testing episode can be compared with the study conducted by Hattingh (2003) who found a medium practical significant difference (d = 0,69) between the forwards ($\bar{x}$ = 95,33kg) and the backline ($\bar{x}$ = 85,27kg) players, which

Table 4.10: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component BENCH PRESS

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	25	94,12	16,73	66,00	128,00	11	103,61	18,07	66,00	140,00
Loose forwards	21	101,29	17,70	60,00	128,00	6	114,01	13,46	74,00	140,00
Halfbacks	9	82,56	10,81	66,00	99,00	4	87,66	19,95	66,00	110,00
Backs	22	91,68	16,46	64,00	128,00	10	91,68	16,46	64,00	128,00
Group	77	94,03	17,02	60,00	128,00	31	97,03	18,35	64,00	140,00

Table 4.11: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component BENCH PRESS

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,54	1,36**
Backs	Halfbacks	0,55	0,21
Backs	Tight five	0,15	0,66
Loose forwards	Halfbacks	1,06**	1,32**
Loose forwards	Tight five	0,40	0,58
Halfbacks	Tight five	0,69	0,80**

compares well with this first testing episode but is relatively lower than compared to this second testing episode.

ABDOMINAL STRENGTH

The descriptive results of the abdominal strength test (Table 4.16) showed that there was a slight improvement in the overall performance of all the different player positions from 2005 to 2006, except for the loose forwards who showed a decrease. The halfbacks outperformed their counterparts with the best score during both testing episodes, with a mean value of 6,00 both times. The tight five ($\bar{x}$ = 4,68) had the lowest scores during the first testing episode and the loose forwards ($\bar{x}$ = 4,82) during the second testing episode.

If one looks at the significance of the raw data between the first and second testing episode, the following can be reported (Table 4.17): During the October 2005 testing highly practical significant differences were found only between the halfbacks and the tight five (d = 0,82). At the end of July 2006, there were only medium practical significant differences notable, those between the loose forwards and respectively the backs (d = 0,55) and the halfbacks (d = 0,59). This might be due to gaining of muscle power and a decrease of body fat; since fat tissue cannot be transferred into muscle tissue, only be replaced.

It can also be noted that there was the smallest practical significant difference between the backs and the halfbacks (d = 0,02). This can be expected regarding these two player groups, since they had the same small d-value for their upper body strength test (Table 4.10) as well as the fact that they normally have the same kind of scientific training program.

If the results of the July 2006 testing are compared with Hattingh (2003), it shows similarity in the finding of only a small practical significant difference between the groups.

Table 4.12: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component VERTICAL JUMP (cm)

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	20	51,45	8,77	49,50	33,00	11	45,38	10,25	23,00	59,00
Loose forwards	16	50,61	6,88	41,00	65,00	6	50,00	5,66	46,00	54,00
Halfbacks	5	57,60	4,39	52,00	62,00	4	58,00	2,37	55,00	62,00
Backs	11	55,00	5,67	45,00	62,00	10	54,90	5,45	47,00	66,00
Group	52	52,54	7,47	33,00	67,50	31	51,19	9,03	23,00	66,00

Table 4.13: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component VERTICAL JUMP (cm)

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,64	0,87**
Backs	Halfbacks	0,46	0,57
Backs	Tight five	0,40	0,93**
Loose forwards	Halfbacks	1,02**	1,41**
Loose forwards	Tight five	0,10	0,45
Halfbacks	Tight five	0,70	1,23**

HORIZONTAL JUMP

The descriptive results of the horizontal jump (Table 4.14) showed that there was an improvement in performance for all the different player positions from October 2005 to July 2006. The best score during the first testing episode was achieved by the halfbacks ($\bar{x}$ = 2,64m) and the lowest score by the tight five ($\bar{x}$ = 2,40m). The front row players could have contributed to this phenomenon. If you look at Table 4.5 it verifies this conclusion because the tight five were also the heaviest player-group. The results of the second testing episode indicated a slight difference namely that the backs were now the best performers ($\bar{x}$ = 2,60m). As expected, the tight five still obtained the lowest score.

If one looks at the significance of the differences of the raw data between the first and second testing episode, the following can be reported (Table 4.15): During the October 2005 testing episode, high practical significant differences were found between the loose forwards and the halfbacks, with a d-value of 0,98 and with the halfbacks the best performers; and also between the halfbacks and the tight five, with a d-value of 0,84 with the halfbacks again the best performers.

At the end of July 2006, only medium practical significant differences were reported, that is between the tight five and the halfbacks, with a d-value of 0,69; and between the tight five and the backs, with a d-value of 0,76. In total it seems that the raw scores of the different player-groups are now much closer to each other than during October 2005. The conclusion can be made that this is due to a scientific training programme that was followed by each elite player; something that was not done during the school rugby program. It can also be noted that the smallest practical significance was found between the backs and halfbacks with a d-value of 0,05. This was expected because these players normally have good explosive strength.

If the results of the 2006 testing are compared with other researchers who did similar studies, the following can be reported: Hattingh (2003) found small to no practical

significant differences here, with the backline ($\bar{x}$ = 52,78cm) outperforming the forwards ($\bar{x}$ = 48,63cm).

VERTICAL JUMP

The descriptive results of the vertical jump (Table 4.12) showed that there was a slight decrease in mean values for all the different player positions, except for the halfbacks who showed a slight increase in mean values ($\bar{x}$ = 57,60cm to $\bar{x}$ = 58,00cm) and therefore some improvement in performance from October 2005 to July 2006. The best scores during the testing episodes were also achieved by the halfbacks and the lowest scores respectively by the loose forwards ($\bar{x}$ = 50,61cm) and tight five ($\bar{x}$ = 45,38cm). It is clear that the front row players could have contributed to this phenomenon. If you look at Table 4.5 it verifies this conclusion because the tight five were also the heaviest player group, followed by the loose forwards player-group.

If one looks at the significance of the differences of the raw data of the vertical jump between the first and second testing episode, the following can be reported (Table 4.13): During the October 2005 testing episode, a high practical significant difference was found between the loose forwards and the halfbacks, with a d-value of 1,02 and with the halfbacks the best performers; with a medium practical significant difference (d = 0,70) between the halfbacks and the tight five, with the halfbacks again the best performers. This correlates well with findings in Table 4.14, where the same practical significant difference was seen in the horizontal jump test of these player groups. This conclusion was expected, seeing that these players normally have good explosive strength or power.

At the end of July 2006, very high practical significant differences were reported, with d-values as high as 1,41 between the loose forwards and the halfbacks and a d-value of 1,23 between the tight five and the halfbacks. In total it seems that the raw

Table 4.14: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component HORIZONTAL JUMP (m)

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	20	2,40	0,29	1,68	2,80	11	2,41	0,25	1,95	2,76
Loose forwards	16	2,43	0,22	2,04	2,94	6	2,53	0,71	2,53	2,54
Halfbacks	5	2,64	0,17	2,49	2,84	4	2,59	0,06	2,48	2,65
Backs	11	2,53	0,13	2,26	2,70	10	2,60	0,16	2,38	2,91
Group	52	2,46	0,27	1,68	2,94	31	2,51	0,21	1,95	2,91

Table 4.15: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component HORIZONTAL JUMP (m)

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,48	0,09
Backs	Halfbacks	0.66	0,05
Backs	Tight five	0,45	0,76
Loose forwards	Halfbacks	0,98**	0,08
Loose forwards	Tight five	0,09	0,17
Halfbacks	Tight five	0,84**	0,69

scores of the different player-groups are now much further apart than during October 2005. The conclusion can be made that this is due to a scientific training programme.

If the results of the 2006 testing are compared with other researchers who did similar studies, the following can be reported: Hattingh (2003) found small to no practical significant differences here, with the backline ($\bar{x}$ = 52,78cm) outperforming the forwards ($\bar{x}$ = 48,63cm).

AGILITY

The descriptive results of the agility test (Table 4.18) showed that there was an improvement in performance for the total group from 2005 to 2006. The best score during the 2005 testing episode was achieved by the halfbacks ($\bar{x}$ = 17,30s) and the worst performance by the tight five ($\bar{x}$ = 18,91s). Attention should be paid here to the fact that the highest mean value does not indicate the best performance because the higher the mean value, the less agile the player-group. Seeing that the tight five were the tallest (Table 4.3) and heaviest (Table 4.5) player group, this conclusion that they have less agility, was expected. The halfbacks on the other hand, were the shortest (Table 4.3) and the lightest (Table 4.5) and one could have expected them to be the most agile group. When looking at the 2006 testing episode, the backs achieved the best score ($\bar{x}$ = 17,69s) and as expected, the tight five still had the worst score ($\bar{x}$ = 18,96s) and therefore was the least agile group.

If one looks at the significant differences of the raw data between the first and second testing episodes, the following can be reported (Table 4.19): During the October 2005 testing, high practical significant differences were found in all the different player-groups, except for the loose forwards compared to the tight five – who had only a small practical significant difference (d = 0,37). In July 2006, there were only three high practical significant differences left between the player-groups – and even though it is still a lot, it seems that the different player-groups are now much closer to one another than in October 2005. The other player-groups showed only small

Table 4.16: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component ABDOMINAL STRENGTH

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	N	$\bar{x}$	sd	Min	Max
Tight five	24	4,68	1,60	2,00	7,00	11	5,34	1,83	3,00	7,00
Loose forwards	22	5,44	1,80	1,00	7,00	6	4,82	2.01	2,00	7,00
Halfbacks	11	6,00	1,61	2,00	7,00	4	6,00	1,91	2,00	7,00
Backs	20	5,23	1,97	1,00	7,00	10	5,97	2,09	4,00	7,00
Group	77	5,19	1,78	1,00	7,00	31	5,25	1,94	2,00	7,00

Table 4.17: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component ABDOMINAL STRENGTH

Variables	Variables	d- values (Oct 2005)	d- values (Jul 2006)
Backs	Loose forwards	0,11	0,55
Backs	Halfbacks	0,39	0,02
Backs	Tight five	0,28	0,30
Loose forwards	Halfbacks	0,31	0,59
Loose forwards	Tight five	0,42	0,29
Halfbacks	Tight five	0,82**	0,35

practical significant differences. The conclusion can once again be made that this is due to a scientific training programme that was followed by each elite player; something that was perhaps not done during the school rugby programme.

SPEED ENDURANCE

During the speed endurance tests, as indicated in Table 4.20, all the player-groups showed an improvement in performance from 2005 to 2006. The loose forwards had the worst results during the first testing episode ($\bar{x}$ = 12,47s), but their performance improved to such an extent that they recorded the best score during the second testing episode ($\bar{x}$ = 13,50s). When looking at the aerobic endurance tests (Table 4.21 and 4.22), it verifies the improved performance of the loose forwards, seeing that their score in the bleep test also improved (from $\bar{x}$ = 9,35s to $\bar{x}$ = 10,92s).

If one looks at the difference between the player-groups in October 2005 (Table 4.21), there were high practical significant differences between the halfbacks and both the loose forwards (d = 0,94) and tight five (d = 1,18), with the halfbacks outperforming their counterparts. In July 2006, there were only medium practical significant differences between the tight five and their counterparts, most probably due to the tight five being the worst performers with a mean value of only 12,50s. It seems that the scores of the different player-groups are now much closer to one another than during the testing done at the end of the players' school year. It can be noted that the smallest practical significant differences were found between the halfbacks and the backs (d = 0,08) and the loose forwards (d = 0,11).

Hattingh (2003) found a high practical significant difference here (d = 1,00), with the backline ($\bar{x}$ = 13,19s) outperforming the forwards ($\bar{x}$ = 12,50s).

Table 4.18: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component AGILITY

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	20	18,91	0,89	17,52	20,68	11	18.96	0,90	17,00	20,17
Loose forwards	15	18,57	0,58	17,46	19,59	6	18,05	0,30	17,84	18,26
Halfbacks	5	17,30	0,28	17,12	17,75	4	17,78	0,82	16,60	18,85
Backs	11	17,95	0,75	16,88	19,12	10	17,69	0,80	16,74	18,97
Group	51	18,45	0,88	16,88	20,68	31	18,27	1,00	16,60	20,17

Table 4.19: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component AGILITY

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,83**	0,45
Backs	Halfbacks	0,86**	0,10
Backs	Tight five	1,07	1,41**
Loose forwards	Halfbacks	2,18**	0,33
Loose forwards	Tight five	0,37	1,02**
Halfbacks	Tight five	1,81**	1,32**

Table 4.20: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component SPEED ENDURANCE

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	N	$\bar{x}$	sd	Min	Max
Tight five	18	12,53	0,74	11,00	13,50	11	12,50	1,31	10,00	15,00
Loose forwards	15	12,47	0,99	10,00	14,00	6	13,50	0,00	13,50	13,50
Halfbacks	5	13,40	0,65	12,50	14,00	4	13,42	0,74	12,50	14,50
Backs	11	13,00	0,81	12,00	14,00	10	13,35	0,82	12,00	14,00
Group	49	12,70	0,87	10,00	14,00	31	13,02	1,08	10,00	15,00

Table 4.21: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component SPEED ENDURANCE

Variables	Variables	d- values (Oct 2005)	d- values (Jul 06)
Backs	Loose forwards	0,54	0,18
Backs	Halfbacks	0,50	0,08
Backs	Tight five	0,59	0,65
Loose forwards	Halfbacks	0,94**	0,11
Loose forwards	Tight five	0,06	0,77
Halfbacks	Tight five	1,18**	0,70

BLEEP SHUTTLE RUN TEST

The bleep shuttle run test was used to assess their aerobic fitness and form part of the endurance tests (together with the speed endurance and upper body muscular endurance / chin lift tests). The descriptive results of this test (Table 4.22) showed that there was an overall improvement of performance for the different player-groups. This correlates well with the findings of the speed endurance test (Table 4.19). The halfbacks ($\bar{x}$ = 10,20s and $\bar{x}$ = 12,00s) had the best testing results at both episodes. The backs ($\bar{x}$ = 8,62s) had the worst score during the first and the tight five (d = 9,32) during the second testing episodes.

If one looks at the practical significant difference during October 2005, Table 4.23 indicates high practical significant differences when the halfbacks are compared to the tight five (d = 0,84) and the backs (d = 1,03). During the July 2006 testing episode, there were high practical significant differences between the tight five and all their counterparts, with the highest d-value of 1,39. This once again correlates well with findings of the agility test (as indicated in Table 4.18), that the tight fives' physical exhaustion interferes with their motor capabilities and are therefore less agile than other player-groups.

If the results of the 2006 testing are compared with those of other researchers who did similar studies, the following can be reported: Hattingh (2003) found a medium practical significant difference (d = 0,58) here, with the backline ($\bar{x}$ = 10,13s) outperforming the forwards ($\bar{x}$ = 9,16s).

CHIN LIFTS

This test forms part of the endurance tests, but also part of the upper body strength tests. The descriptive results of the chin lift test (Table 4.24) showed that there was an improvement in performance for both the tight five and the loose forwards player-group from 2005 to 2006. During the 2005 and 2006 testing episodes, the best scores

Table 4.22: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component BLEEP SHUTTLE RUN

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	N	$\bar{x}$	sd	Min	Max
Tight five	19	8,69	1,79	6,18	12,38	11	9,32	1,93	7,14	12,41
Loose forwards	15	9,35	1,48	7,10	11,92	6	10,92	1,57	8,08	13,09
Halfbacks	5	10,20	1,44	8,08	12,08	4	12,00	1,53	9,43	14,35
Backs	10	8,62	1,53	7,10	12,08	10	11,71	1,88	9,87	14,22
Group	49	9,03	1,64	6,18	12,38	31	10,54	1,76	7,14	14,35

Table 4.23: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component BLEEP SHUTTLE RUN

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,48	0,42
Backs	Halfbacks	1,03**	0,15
Backs	Tight five	0,04	1,24**
Loose forwards	Halfbacks	0,57	0,69
Loose forwards	Tight five	0,37	0,83**
Halfbacks	Tight five	0,84**	1,39**

were achieved by the halfbacks ($\bar{x}$ = 11,50 and $\bar{x}$ = 9,50), and the worst scores by the tight five ($\bar{x}$ = 4,36 and $\bar{x}$ = 5,92).

The halfbacks ($\bar{x}$ = 11,50 and $\bar{x}$ = 9,50) were able to perform the most chin-lifts repetitions during these testing. The halfbacks also had a high practical significant difference (d = 1,06 and d = 1,83) when compared to the loose forwards ($\bar{x}$ = 6,71) and the tight five ($\bar{x}$ = 4,36) during the first testing episode. Compared to the backs ($\bar{x}$ = 8,00), the tight five also had a high practical significant difference (d = 0,82) during the first testing episode (Table 4.25). Hattingh (2003) found a high practical significant difference (d = 1,20) here, with the backline ($\bar{x}$ = 13,24) outperforming the forwards ($\bar{x}$ = 7,75) by far.

10m SPEED

During the 10m speed test, the backs ($\bar{x}$ = 1,96s) in the first and tight five ($\bar{x}$ = 1,97s) in the second testing episode had the highest mean values, in other words they were the slowest to accelerate and run at a maximum speed. Whereas the loose forwards ($\bar{x}$ = 1,75s) during the first and backs ($\bar{x}$ = 1,86s) during the second testing episode had the quickest response times (Table 4.26). When compared, the backs outperformed their counterparts in having a high practical significant difference in one of all the compared areas: against the loose forwards ($\bar{x}$ = 1,75s) and halfbacks ($\bar{x}$ = 1,86s) in the first testing episode, with d- values of 1,48 and 1,14; and against the tight five during the second testing episode (d = 0,96). The tight five measured up and also had a high practical significant difference in all the second testing episodes (included the previous mentioned result): against the loose forwards ($\bar{x}$ = 1,88s) and the backs, with d-values of 0,81 and 0,92 respectively (Table 4.27).

Table 4.24: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component CHIN LIFTS

Variables	October 2005					July 2006				
	n	$\bar{x}$	Sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	22	4,36	3,90	0,00	13,00	11	5,92	4,77	3,00	13,00
Loose forwards	17	6,71	4,52	0,00	19,00	6	6,86	5,14	7,00	19,00
Halfbacks	6	11,50	2,74	8,00	15,00	4	9,50	4,33	9,00	24,00
Backs	11	8,00	4,45	3,00	17,00	10	7,94	5,03	6,00	17,00
Group	56	6,56	4,59	0,00	19,00	31	7,01	5,19	3,00	24,00

Table 4.25: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component CHIN LIFTS

Variables	Variables	d- values (Oct 2005)	d –values (Jul 2006)
Backs	Loose forwards	0,29	0,21
Backs	Halfbacks	0,79	0,31
Backs	Tight five	0,82**	0,40
Loose forwards	Halfbacks	1,06**	0,51
Loose forwards	Tight five	0,52	0,18
Halfbacks	Tight five	1,83**	0,75

Table 4.26: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component 10m SPEED

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	N	$\bar{x}$	sd	Min	Max
Tight five	20	1,85	0,15	1,62	2,17	11	1,97	0,12	1,83	2,22
Loose forwards	15	1,75	0,14	1,30	1,89	6	1,88	0,11	1,80	1,96
Halfbacks	5	1,86	0,06	1,78	1,93	4	1,87	0,05	1,79	1,94
Backs	11	1,96	0,09	1,84	2,13	10	1,86	0,06	1,80	2,00
Group	51	1,85	0,15	1,30	2,17	31	1,91	0,10	1,79	2,22

Table 4.27: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component 10m SPEED

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	1,48**	0,06
Backs	Halfbacks	1,14**	0,17
Backs	Tight five	0,77	0,96**
Loose forwards	Halfbacks	0,79	0,12
Loose forwards	Tight five	0,66	0,81**
Halfbacks	Tight five	0,10	0,92**

30m SPEED

During the 30m speed test, the tight five ($\bar{x}$ = 4,48s and $\bar{x}$ = 4,61s) had the highest mean values, in other words they were the slowest to accelerate and run at a maximum speed; and the halfbacks ($\bar{x}$ = 4,31s) and the backs ($\bar{x}$ = 4,26s) respectively had the quickest response times (Table 4.28). When compared, the backs once again outperformed their counterparts in having a high practical significant difference in one of all the compared areas: against the halfbacks in the first testing episode, with a d- values of 1,04; and against the loose forwards ($\bar{x}$ = 4,44s) and the tight five during the second testing episode (d = 1,04 and d = 1,52). The halfbacks also measured up and once again had a high practical significant difference in one of the testing episodes (including the previous mentioned result): against the loose forwards and the backs, with d-values of 0,82 and 1,37 respectively (Table 4.29).

The 30m speed test was the only speed test done by Hattingh (2003), he did not do the 10m or 40m. He found a high practical significant difference (d = 1,04) with the backline ($\bar{x}$ = 4,19s) completing the test in a faster time than the forwards ($\bar{x}$ = 4,43s).

40m SPEED

Lastly, the 40m speed test was done. The tight five ($\bar{x}$ = 5,75s and $\bar{x}$ = 5,94s) had the highest mean values, in other words they were the slowest to accelerate and run with a maximum speed; and the backs ($\bar{x}$ = 5,59s and $\bar{x}$ = 5,44s) had the quickest response times (Table 4.30). When compared, the halfbacks ($\bar{x}$ = 5,47s) had high practical significant differences during one or another episode against all other counterparts: the backs with d = 0,87; the loose forwards ($\bar{x}$ = 5,60s and $\bar{x}$ = 5,72s) with d = 0,83 and d = 0,85; and the tight five with d = 1,00 and d = 1,48 (Table 4.31). When the backs were compared to both the loose forwards and the tight five during the second testing episode, high practical significant differentiating values of d = 1,11 and d = 1,71 were recorded.

Table 4.28: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component 30m SPEED

Variables	October 2005					July 2006				
	n	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	20	4,48	0,25	4,12	4,91	11	4,61	0,23	4,17	5,00
Loose forwards	15	4,37	0,13	4,06	4,53	6	4,44	0,17	4,32	4,56
Halfbacks	5	4,31	0,02	4,28	4,34	4	4,30	0,11	4,19	4,45
Backs	11	4,43	0,12	4,22	4,67	10	4,26	0,13	4,10	4,45
Group	51	4,42	0,17	4,06	4,91	31	4,43	0,24	4,10	5,00

Table 4.29: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component 30m SPEED

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,47	1,04**
Backs	Halfbacks	1,04**	0,28
Backs	Tight five	0,20	1,52**
Loose forwards	Halfbacks	0,52	0,82**
Loose forwards	Tight five	0,47	0,76
Halfbacks	Tight five	0,77	1,37**

To conclude the physical and motor results regarding the specific player positions of the elite U/19 group, one has to keep in mind that these results were divided into the two different profiles as mentioned previously, namely: the first profile which analyzes the variables of the U/19 players at the end of their school career, whereas the second profile analyzes the variables of the elite U/19 players at the end of their first year of training and coaching at the Rugby Institute of the North West University.

4.2.2.3 Biomechanical and postural characteristics of the different elite U/19 rugby player-positions

Table 4.32: Descriptive statistics for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations

Variables	Tight five (n = 21)		Loose forwards (n = 22)		Halfbacks (n = 7)		Backs (n = 11)	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	Sd
LOWER LIMB								
Lower limb dynamics								
TA	1,12	0,27	1,48	0,36	1,42	0,24	1,50	0,38
ITB	1,69	0,29	1,63	0,38	1,36	0,38	1,41	0,44
Quad	1,64	0,48	1,43	0,42	1,29	0,39	1,32	0,40
Iliopsoas	1,93	0,68	1,66	0,32	1,57	0,53	1,45	0,42
Gluts max	1,57	0,33	1,80	0,40	1,50	0,41	1,72	0,34
Adductor	1,24	0,26	1,50	0,35	1,43	0,35	1,50	0,00
Hip int rot	1,00	0,00	1,05	0,21	1,00	0,00	1,05	0,15
Hip ext rot	1,55	0,38	1,70	0,33	1,50	0,50	1,60	0,38
Knee region								
Knee Q-angle	1,33	0,56	1,05	0,15	1,00	0,00	1,00	0,00
Knee squint	1,26	0,44	1,09	0,25	1,00	0,00	1,00	0,00
Knee tilt	1,67	0,40	1,75	0,34	1,57	0,35	1,86	0,23
Knee height	1,83	0,24	1,61	0,38	1,50	0,29	1,81	0,25
VMO-L	1,07	0,24	1,14	0,32	1,14	0,38	1,09	0,30
Ankle and foot region								
Longitudinal arch	1,55	0,31	1,86	0,56	1,50	0,00	1,64	0,32
Fore foot	1,57	0,40	1,77	0,40	1,43	0,19	1,64	0,32
Rear foot standing	1,60	0,49	1,98	0,11	2,00	0,00	1,81	0,40

Rear foot lying	1,60	0,49	1,98	0,11	2,00	0,00	1,91	0,30
Transverse	1,62	0,45	1,80	0,33	1,43	0,19	1,64	0,23
Mobility	1,76	0,62	2,00	0,56	1,50	0,00	1,68	0,40
Toes	1,95	0,22	1,95	0,21	2,00	0,00	1,91	0,30
PELVIC GIRDLE REGION								
Leg length	1,17	0,37	1,32	0,48	1,57	0,53	1,86	0,45
ASIS	1,19	0,40	1,32	0,48	1,57	0,53	1,82	0,40
PSIS	1,19	0,40	1,32	0,48	1,57	0,53	1,82	0,40
Rami	1,14	0,36	1,27	0,46	1,57	0,53	1,81	0,40
Cleft	1,05	0,22	1,11	0,34	1,29	0,49	1,09	0,30
Pelvis bilateral	1,93	0,40	1,82	0,36	1,71	0,27	1,91	0,20
SPINAL REGION								
Spinal dynamic mobility								
TLF	1,36	0,32	1,39	0,26	1,43	0,19	1,50	0,22
Sacrum rhythm	1,02	0,11	1,14	0,32	1,14	0,24	1,18	0,40
Extension	1,07	0,24	1,18	0,36	1,00	0,00	1,18	0,40
Flexion	1,33	0,43	1,43	0,47	1,07	0,19	1,50	0,45
Rotation	1,05	0,15	1,14	0,23	1,00	0,00	1,41	0,30
Side flexion	1,10	0,20	1,18	0,25	1,00	0,00	1,41	0,30
Spinal positional alignment								
Coronal axis								
Head	1,00	0,00	1,02	0,11	1,00	0,00	1,10	0,20
Cervical	1,00	0,00	1,00	0,00	1,00	0,00	1,00	0,00
Thoracic	1,05	0,22	1,30	0,45	1,00	0,00	1,18	0,40
Lumbar	1,69	0,51	1,75	0,48	1,64	0,38	1,77	0,34
Sagittal axis								
Head	1,10	0,30	1,05	0,21	1,14	0,24	1,10	0,20
Cervical	1,05	0,22	1,04	0,21	1,00	0,00	1,00	0,00
Thoracic	1,33	0,91	1,30	0,45	1,43	0,53	1,45	0,52
Lumbar	1,19	0,41	1,09	0,29	1,00	0,00	1,27	0,47
UPPER LIMB								
Hand behind back	1,10	0,30	1,18	0,39	1,07	0,19	1,18	0,40
Hand behind neck	1,14	0,36	1,11	0,31	1,00	0,00	1,09	0,30
Shoulder position	1,52	0,49	1,70	0,30	1,64	0,38	1,59	0,44
Winging	1,57	0,48	1,55	0,38	1,71	0,39	1,81	0,40
Outline	1,24	0,37	1,43	0,39	1,57	0,45	1,45	0,47
Throwing position	1,14	0,36	1,25	0,34	1,36	0,48	1,23	0,41
NEURODYNAMICS								
SLR	1,55	0,42	1,32	0,36	1,14	0,24	1,32	0,46
Upper limb tension	1,10	0,26	1,23	0,43	1,07	0,19	1,14	0,23
L3,4	1,36	0,48	1,34	0,36	1,00	0,00	1,23	0,34
Slump	1,12	0,31	1,20	0,30	1,07	0,19	1,23	0,34

Comparison of the biomechanical and postural variables between the different U/19 player positions:

Firstly, a value closer to the ideal was rendered as follows (as seen in Table 4.32 under the lower limb dynamic mobility): the tight five outperformed all their counterparts in the TA ($\bar{x}$ = 1,12), adductor mobility ($\bar{x}$ = 1,24) and hip internal rotation ($\bar{x}$ = 1,00) tests. The halfbacks again, outperformed their counterparts in the ITB ($\bar{x}$ = 1,36), quadriceps mobility ($\bar{x}$ = 1,29), gluteus maximus ($\bar{x}$ = 1,50) and hip external rotation ($\bar{x}$ = 1,50) tests. The backs outperformed their counterparts only in the iliopsoas ($\bar{x}$ = 1,45) test. Hattingh (2003) found the forwards outperformed the backline on the right and left anatomical side in the hip internal rotation ($\bar{x}$ = 1,27) and on the right side with the adductor mobility ($\bar{x}$ = 1,50) tests. The backline outperformed the forwards in the other lower limb dynamic tests, both on the right and left sides.

In the knee region (as seen in Table 4.32 under the lower limb dynamic mobility), the halfbacks outperformed their counterparts in the tilt ($\bar{x}$ = 1,57), the height ($\bar{x}$ = 1,50) and together with the backs, in the q-angle ($\bar{x}$ = 1,00) and squint (1,00) tests. The tight five outperformed their counterparts in the VMO-L ($\bar{x}$ = 1,07) test. Hattingh (2003) found the backline to outperform the forwards on the left side only in the Q-angle test ($\bar{x}$ = 1,39), but the forwards again outperform the backline on the right side in the patella tilt test ($\bar{x}$ = 1,73).

In the ankle and foot region (as seen in Table 4.32 under the lower limb dynamic mobility), the halfbacks outperformed their counterparts in the longitudinal ($\bar{x}$ = 1,86) and transverse ($\bar{x}$ = 1,43) arch status, the forefoot position ($\bar{x}$ = 1,43), the rear foot standing ($\bar{x}$ = 2,00) and lying ($\bar{x}$ = 2,00) position and the toes position ($\bar{x}$ = 1,91). The loose forwards outperformed their counterparts in the foot mobility ($\bar{x}$ = 2,00) test. Here, Hattingh (2003) bilaterally found the forwards to outperform the

backline in the rear foot standing ($\bar{x}$ = 1,32 and $\bar{x}$ = 1,36) and lying ($\bar{x}$ = 1,27 and $\bar{x}$ = 1,36) tests, as well as the toe position ($\bar{x}$ = 1,77 and $\bar{x}$ = 1,73) test.

Secondly, as seen in Table 4.32 under the pelvic girdle region, the tight five outperformed all their counterparts, except for the halfbacks with the bilateral pelvis positional ($\bar{x}$ = 1,71) test. The values closer to the ideal were as follows: the leg length discrepancy ($\bar{x}$ = 1,17) test, the anterior superior ileac spine ($\bar{x}$ = 1,19) and posterior superior ileac spine ($\bar{x}$ = 1,19) comparison test, the pelvic rami positional ($\bar{x}$ = 1,14) test and lastly the sacroiliac cleft test ($\bar{x}$ = 1,05). In this region, Hattingh (2003) found the backline to outperform the forwards only in the sacroiliac test with $\bar{x}$ = 1,29.

Thirdly, the spinal region was divided into two segments, namely: the spinal dynamic mobility segment (as seen in Table 4.32 under the spinal region) and the spinal positional alignment segment (also as seen in Table 4.32 under the spinal region). As seen in the spinal dynamic mobility segment, the tight five outperformed their counterparts in the Thoraco-lumbar fascia mobility ($\bar{x}$ = 1,36) and sacral rhythm ($\bar{x}$ = 1,02) tests. The halfbacks outperformed their counterparts here in the functional extension ($\bar{x}$ = 1,00) and flexion ($\bar{x}$ = 1,07) mobility tests; as well as in the rotational ($\bar{x}$ = 1,00) and side flexion ($\bar{x}$ = 1,00) mobility tests. In the spinal dynamic mobility area, Hattingh (2003) found the backline to outperform the forwards in all tests, except for the rotational mobility test, where the forwards have a mean value of 1,09 and 1,18.

The spinal positional alignment segment was divided into two axes (Table 4.32). The coronal mid position axis was ideal ($\bar{x}$ = 1,00) for all groups as far as the cranium and cervical region were concerned. The thoracic region was ideal, except for the loose forwards ($\bar{x}$ = 1,30), which had a less ideal position. The lumbar region was non-ideal for all groups ($\bar{x}$ = 1,64 to $\bar{x}$ = 1,77). The sagittal mid position axis was

within ideal limitations ($\bar{x}$ = 1,00) for all groups (cranium, cervical and lumbar region), except the thoracic area, which was less ideal with $\bar{x}$ = 1,33 to $\bar{x}$ = 1,45. In this segment, Hattingh (2003) found the backline to outperform the forwards in the head position ($\bar{x}$ = 1,17) of the coronal axis, as well as the cervical position ($\bar{x}$ = 1,00) in the sagittal axis.

Fourthly, as seen in Table 4.32 the upper limb region rendered values closer to the ideal as follows: the halfbacks outperformed their counterparts in the hand behind back ($\bar{x}$ = 1,07) and neck ($\bar{x}$ = 1,00) ROM tests. The tight five outperformed their counterparts in the shoulder coronal positional ($\bar{x}$ = 1,52) and outline composition ($\bar{x}$ = 1,24) tests, as well as the throwing ($\bar{x}$ = 1,14) ROM test. The loose forwards outperformed their counterparts in the winging positional ($\bar{x}$ = 1,55) test. In Hattingh's study (2003), he found the backline players bilaterally to outperform the forwards in the hand behind back and neck tests, as well as the shoulder position test. Further, he found the forwards to outperform the backline bilaterally in the winging and throwing positional tests and the shoulder outline composition test.

Finally, as seen in Table 4.32, the neurodynamics of all the groups fall within relatively ideal ranges, with the halfbacks outperforming their counterparts in all tests: straight leg raise ($\bar{x}$ = 1,14), upper limb tension test ($\bar{x}$ = 1,07), L3 nerve suppleness/prone knee bend ($\bar{x}$ = 1,00) and slump ($\bar{x}$ = 1,07) test. In this neurodynamical section, Hattingh (2003) found the forwards to outperform the backline only in the upper limb tension test bilaterally with $\bar{x}$ = 1,23.

All the groups have been compared to one another, and each BMPE – item has its own table now. As mentioned earlier in this study (Chapter 3, paragraph 3.4), d-values are used to indicate practically significant differences between the different groups; where d-values equal to or greater than 0,8 indicate a high practically significant difference, d-values equal to or greater than 0,5 indicate a medium

practical significant difference and d-values smaller than 0,5 indicate a low practical significant difference.

LOWER LIMB comparisons:

Lower limb dynamical mobility comparisons:

In the dynamic mobility comparison of the lower limb complex (Table 4.33), there is a high practically significant difference in the TA-test for the backs compared with the halfbacks (d = 0,92) and tight five (d = 0,98); and also the loose forwards compared to the halfbacks (d = 0,93) and the tight five (d = 0,99). Secondly, there is a high practical significant difference only in the modified Thomas test for the halfbacks compared with the tight five (d = 0,88) for the iliopsoas component. In the gluteus maximus test, there are medium practically significant differences for the loose forwards with the halfbacks (d = 0,72) and the tight five (d = 0,56); and also the backs compared with the halfbacks (d = 0,56). In the adductor mobility test, there is a high practically significant difference between the backs and the tight five (d = 1,02). Lastly, in the hip joint mobility test (both internal and external rotational tests) only small or nil practical significant difference could be seen between the groups. Hattingh (2003) found that the backline outperformed their forward counterparts in all but the illiopsoas, adductor mobility and hip internal rotational dynamic tests, with only the right ITB mobility test recording a high practical significant difference (d = 0,86).

Knee region comparisons:

In the knee region comparison of the lower limb complex (Table 4.34), there is a only a high practical significant difference in the patella tilt (d = 0,85) for the backs compared to the halfbacks. The VMO-L comparison between the groups is of very small to no practically significant difference. Hattingh (2003) observed no differences here, except for the VMO-L comparison test, where the backline players outperformed their counterparts, recording a moderate practical significant difference on the left side (d = 0,71).

Table 4.30: Descriptive statistics for the different elite U/19 player-positions with regard to the physical and motor component 40m SPEED

Variables	October 2005					July 2006				
	N	$\bar{x}$	sd	Min	Max	n	$\bar{x}$	sd	Min	Max
Tight five	20	5,75	0,28	5,32	6,29	11	5,94	0,29	5,38	6,45
Loose forwards	15	5,60	0,16	5,18	5,79	6	5,72	0,25	5,54	5,89
Halfbacks	5	5,47	0,06	5,39	5,55	4	5,51	0,15	5,36	5,76
Backs	11	5,59	0,14	5,34	5,85	10	5,44	0,18	5,20	5,70
Group	51	5,64	0,22	5,18	6,29	31	5,68	0,32	5,20	6,45

Table 4.31: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the physical and motor component 40m SPEED

Variables	Variables	d- values (Oct 2005)	d-values (Jul 2006)
Backs	Loose forwards	0,08	1,11**
Backs	Halfbacks	0,87**	0,37
Backs	Tight five	0,56	1,71**
Loose forwards	Halfbacks	0,83**	0,85**
Loose forwards	Tight five	0,51	0,76
Halfbacks	Tight five	1,00**	1,48**

Table 4.33: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: LOWER LIMB – LOWER LIMB DYNAMIC MOBILITY

Variables	Variables		Modified Thomas					Hip joint	
		TA	Illiopsoas	Quadriceps	ITB	Gluteus max	Adductor mobility	Ext rot	Int rot
Backs	Loose forwards	0,06	0.52	0,27	0,49	0,17	0,00	0,30	0,00
Backs	Halfbacks	0,92	0,12	0,08	0,22	0,56	0,21	0.18	0,30
Backs	Tight five	0,98	0,64	0,68	0,70	0,45	1,02	0,11	0,30
Loose forwards	Halfbacks	0,93	0,73	0,35	0,16	0,72	0,21	0,41	0,21
Loose forwards	Tight five	0,99	0,14	0,44	0,40	0,56	0,76	0,41	0,21
Halfbacks	Tight five	0,09	0,88	0,75	0,53	0,17	0,55	0,10	0,00

Table 4.34: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: LOWER LIMB –KNEE REGION

Variables	Variables	Q-angle	Patella tilt	Patella squint	VMO-L
Backs	Loose forwards	0,31	0,34	0,36	0,14
Backs	Halfbacks	0,00	0,85	0,00	0,14
Backs	Tight five	0,60	0,50	0,60	0,06
Loose forwards	Halfbacks	0,31	0,52	0,36	0,02
Loose forwards	Tight five	0,52	0,21	0,39	0,21
Halfbacks	Tight five	0,60	0,24	0,60	0,19

Ankle and foot region comparisons:

In the ankle and foot region of the lower limb complex (Table 4.35), there is a high practical significant difference in the forefoot position of the loose forwards compared to the halfbacks (d = 0,86). There is also a high practical significant difference between the halfbacks and tight five as far as rear foot standing (d = 0,83) and rear foot lying (d = 0,83) components are concerned. The transverse arch status (d = 0,89) shows a high practical significant difference between the halfbacks and the backs. There is also a high practical significant difference between the loose forwards compared to the halfbacks as far as the transverse arch status (d = 1,10) and the foot mobility (d = 0,90) are concerned. There is only a very small or no practical significant difference in the toes position of the group. As found above, Hattingh (2003) only had a medium practical significant difference for the left rear foot standing test (d = 0,51).

PELVIC GIRDLE comparisons:

In the pelvic girdle region (Table 4.36), there were high practical significant differences between the backs and the loose forwards for the leg length discrepancy (d = 1,14), anterior superior ileac spine comparison (d = 1,05) and posterior superior ileac spine (d = 1,05) tests, as well as for the pelvic rami positional (d = 1,20) test. There were also a high practical significant difference for the backs compared to the tight five for the leg length discrepancy (d = 1,54), anterior superior ileac spine comparison (d = 1,55) and posterior superior ileac spine (d = 1,55) tests, as well as for the pelvic rami positional test (d = 1,67). Here Hattingh (2003) found that the forwards had a better core stability, seeing that they presented closer values to the ideal in the leg length discrepancy, ASIS and PSIS comparisons tests.

Table 4.35: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: LOWER LIMB – FOOT AND ANKLE REGION

Variables	Variables	Longitud arch	Forefoot position	Rear foot standing	Rear foot lying	Transverse arch	Foot mobility	Toe positions
Backs	Loose forwards	0,41	0,34	0,39	0,23	0,48	0,57	0,15
Backs	Halfbacks	0,42	0,64	0,45	0,30	0,89	0,45	0,30
Backs	Tight five	0,27	0,16	0,45	0,64	0,04	0,13	0,14
Loose forwards	Halfbacks	0,65	0,86	0,21	0,21	1,10	0,90	0,21
Loose forwards	Tight five	0,56	0,50	0,78	0,78	0,40	0,38	0,01
Halfbacks	Tight five	0,15	0,36	0,83	0,83	0,43	0,42	0,22

Table 4.36: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: PELVIC GIRDLE REGION

Variables	Variables	Leg length discrepancy	ASIS	PSIS	Pelvic rami position	Sacroiliac cleft	Bilateral pelvic pos
Backs	Loose forwards	1,14	1,05	1,05	1,20	0,07	0,25
Backs	Halfbacks	0,55	0,46	0,46	0,46	0,40	0,73
Backs	Tight five	1,54	1,55	1,55	1,67	0,14	0,05
Loose forwards	Halfbacks	0,47	0,47	0,47	0,56	0,35	0,29
Loose forwards	Tight five	0,32	0,27	0,27	0,28	0,19	0,28
Halfbacks	Tight five	0,76	0,71	0,71	0,80	0,49	0,54

SPINAL REGION:

Spinal dynamic mobility:

In the spinal region (Table 4.37), comparisons have been made between groups in the spinal dynamic mobility segment, followed later by comparisons in the spinal positional alignment segment. The backs compared to the halfbacks had a high practical significant difference in the functional flexion mobility (d = 0,96), rotational mobility (d = 1,36) and side flexion mobility tests (d = 1,36). The backs compared with the tight five had a high practically significant difference in the rotational mobility (d = 1,20) and side flexion mobility (d = 1,04) tests. Finally, the backs compared to the loose forwards also had a high practically significant difference in the rotational mobility test (d = 0,90). The TFL mobility test showed a medium practically significant difference between the halfbacks compared with the backs (d = 0,73) and the tight five (d = 0,54). The functional extension mobility test also showed a medium practical significant difference between the loose forwards and the backs (d = 0,50). There was a small to no practical significant difference in the group for the sacral rhythm test. Hattingh (2003) found that the TLF, extension and side flexion mobility tests favoured the backline with values closer to the ideal, but with only the TLF mobility test (d = 0,55) on the left side recording a medium practical significant difference.

Spinal positional alignment:

The spinal positional alignment test (Table 4.38) was divided into the coronal mid position axis and the sagittal mid position axis. In the coronal axis, only the loose forwards compared to the halfbacks (d = 0,65) and the tight five (d = 0,55) showed a medium practical significant difference in the thoracic region. In the sagittal axis, only the backs compared to the halfbacks showed a medium practical significant difference in the lumbar region (d = 0,58); all the other showed a small or no practical significant difference between the groups. Hattingh (2003) also found a medium practical significant difference in the thoracic area (d = 0,73) of the coronal axis between the forwards and the backline; but with low or no practical significant differences noted in the sagittal axis.

Table 4.37: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: SPINAL REGION – SPINAL DYNAMIC MOBILITY

Variables	Variables	TLF mobility	Sacral rhythm	Functional ext mob	Functional flex mob	Rotational mobility	Side flex mobility
Backs	Loose forwards	0,25	0,11	0,00	0,14	0,90	0,75
Backs	Halfbacks	0,73	0,10	0,45	0,96	1,36	1,36
Backs	Tight five	0,05	0,39	0,27	0,37	1,20	1,04
Loose forwards	Halfbacks	0,29	0,02	0,50	0,77	0,60	0,74
Loose forwards	Tight five	0,28	0,36	0,30	0,21	0,39	0,35
Halfbacks	Tight five	0,54	0,49	0,30	0,61	0,32	0,47

Table 4.38: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: SPINAL REGION – SPINAL POSITIONAL ALIGNMENT

Variables	Variables	Coronal axis				Sagittal axis			
		Head position	Cervical	Thoracic	Lumbar	Head position	Cervical	Thoracic	Lumbar
Backs	Loose forwards	0,34	0,35	0,25	0,05	0,21	0,21	0,30	0,39
Backs	Halfbacks	0,45	0,33	0,45	0,34	0,21	0,00	0,05	0,58
Backs	Tight five	0,45	0,49	0,33	0,16	0,01	0,22	0,13	0,18
Loose forwards	Halfbacks	0,21	0,00	0,65	0,22	0,40	0,21	0,25	0,31
Loose forwards	Tight five	0,21	0,21	0,55	0,12	0,17	0,01	0,04	0,25
Halfbacks	Tight five	0,00	0,22	0,22	0,09	0,16	0,22	0,10	0,47

UPPER LIMB region:

In the upper limb region complex (Table 4.39), there are no high practical significant differences between player positions. However, the backs compared to the loose forwards (d = 0,67) and the tight five (d = 0,51) have a medium practical significant difference with the winging positional test; and the tight five compared to the loose forwards (d = 0,50) and to the halfbacks (d = 0,74) also have a medium practical significant difference in the shoulder outline composition test. The Hand Behind Back and Hand Behind Neck, the Coronal Shoulder Positional and Throwing Tests all have a small to no practical significant difference in value between the player-positions. Here Hattingh (2003) found all the recorded results to be very similar, except for the hand behind back test, where the backline players outperformed the forwards with a medium practical significant d-value of 0,66 on the left side.

NEURODYNAMICS:

In this neurodynamical complex (Table 4.40), high practical significant differences were recorded between the halfbacks and the loose forwards (d = 0,95) in the L3/4 nerve suppleness test; and between the halfbacks and the tight five (d = 0,97) in the straight leg raise test. There is a medium practical significant difference in the L3/4 nerve suppleness test between the halfbacks compared to the backs (d = 0,66) and to the tight five (d = 0,75). There is also a medium practical significant difference in the straight leg raise test between the tight five compared to the loose forwards (d = 0,55) and to the backs (d = 0,50). The upper limb tension test and the slump test showed small to no practical significant differences between the player-positions compared. Hattingh (2003) only found a medium practical significant difference between the L3/4 prone knee bend bilaterally test (d = 0,50 and d = 0,56); with the backline outperforming the forwards, against the upper limb tension tests, where the forwards showed better values.

To conclude the biomechanical and postural results regarding this elite U/19 group, it can be seen that the results showed a lack of regional stability and musculature as far as the upper and lower limbs are concerned. Furthermore they also tended to be

Table 4.39: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: UPPER LIMB

Variables	Variables	Hand behind back ROM	Hand behind neck ROM	Shoulder coronal position	Winging position	Shoulder outline composition	Throwing position
Backs	Loose forwards	0,00	0,07	0,26	0,67	0,05	0,06
Backs	Halfbacks	0,27	0,30	0,12	0,26	0,25	0,27
Backs	Tight five	0,21	0,14	0,14	0,51	0,46	0,21
Loose forwards	Halfbacks	0,28	0,37	0,16	0,43	0,31	0,23
Loose forwards	Tight five	0,22	0,08	0,37	0,05	0,50	0,30
Halfbacks	Tight five	0,08	0,40	0,24	0,30	0,74	0,45

Table 4.40: Practical significant differences (d-values) for the different elite U/19 player-positions with regard to the biomechanical and postural evaluations: NEURODYNAMICS

Variables	Variables	Straight leg raise	Upper limb tension	L3/4 prone knee bend	Slump
Backs	Loose forwards	0,00	0,21	0,32	0,07
Backs	Halfbacks	0,38	0,28	0,66	0,45
Backs	Tight five	0,50	0,16	0,27	0,31
Loose forwards	Halfbacks	0,48	0,36	0,95	0,45
Loose forwards	Tight five	0,55	0,31	0,03	0,27
Halfbacks	Tight five	0,97	0,09	0,75	0,15

dynamically and mechanically overloaded with spinal and pelvic asymmetry and weak core stability. The neurodynamical tests were satisfying.

4.2.3 EPIDEMIOLOGY OF INTRINSIC INJURIES OF U/19 ELITE RUGBY PLAYERS

Throughout the 2006 rugby season all injured players had to report to clinics held twice weekly, on Mondays and Wednesdays. These clinics were held at the Institute for Sports Medicine and were manned by sport physicians, physiotherapists, biokineticists and sport scientists. The aim of these clinics is to diagnose the injured player; and then either refer to a physiotherapists or biokineticist, etc. for treatment or refer for special investigations for example X-rays or a sonar or then for evaluations by a specialist. Statistics were kept on player positions injured, anatomical region affected, type of injury, grade of injury, when injury occurred and lastly, necessary referrals. The data collected on these findings, will be discussed below and will be compared to modern literature:

- Injury incidence as occurred in various player positions of this elite U/19 rugby players (Table 4.41)
- Anatomical regions and injury incidence of this elite U/19 rugby players (Table 4.42)
- Type of injury as occurred for this elite U/19 player group (Table 4.43)
- Results of the clinical attendance records (period of prevalence, acute or chronic injuries and specialist reference) of the Institute for Sports Medicine, as for this elite U/19 rugby players (Table 4.44)
- Rate of injury, as for this elite U/19 rugby players (Table 4.45)

Table 4.41: Injury incidence as occurred in various player positions of the elite U/19 rugby players

INJURY INCIDENCE AND PLAYER POSITION			
Combination of positions	N of injuries = 184	Specific player position	N of injuries = 184

Tight five	32,07 %	Props	10,45 %
		Hookers	8,79 %
		Locks	12,83 %
Loose forwards	26,09 %	Flankers	14,20 %
		Eighth men	11,90 %
Halfbacks	15,22 %	Scrumhalves	9,32 %
		Fly-halves	5,90 %
Backs	26,63 %	Wings	7,85 %
		Centres	12,28 %
		Fullbacks	6,45 %

- Injury incidence as occurred in various player positions of the elite U/19 rugby players

Table 4.41 displays information gathered from the U/19 elite rugby players' clinic records. Among them, 184 injuries were reported throughout the 2006 season. When player position is considered, the U/19 players reported 32,07% of the injuries among the tight five, 26,09% of the injuries among the loose forwards, 15,22% of the injuries among the halfbacks and lastly 26,63% of the injuries belonged to the backs. When these results are analyzed, it is evident that the most injured player among the loose forwards were the flankers (14,20%), followed by the locks (12,83%) among the tight five, the scrumhalves (9,32%) were the most injured halfback, and the centres (12,28%) had the most injuries among the backs. The fly-halves (5,90%) were the least injured player of them all, followed by the fullbacks (6,45%).

If these results are compared to Hattingh (2003) who conducted a similar study, the following can be reported: Hattingh (2003) found the loose forwards (36,38%) followed by the backs (31,81%) to be the most injured player-groups. He also found the locks, eighth men and wings in equal positions regarding injuries with 13,64%. His results on the least injured player-positions correlate well with this study, seeing that he also found it to be the fly-halves (4,54%) followed by the full-backs (9,09%).

Table 4.42: Anatomical regions injured as occurred in various positions of the elite U/19 rugby players

ANATOMICAL REGION							
Anatomical region	Total Nr of injuries = 184	Body part injured	Total Nr of injuries = 184	Tight five (53 injuries)	Loose forwards (47 injuries)	Halfbacks (36 injuries)	Backs (48 injuries)
Head and face region	1,09%	Head and face region	1,09%	1,09%	-	-	-
Upper limb	23,91%	Shoulder	14,67%	3,67%	5,87%	0,73%	4,40%
		Arm	4,38%	-	-	4,38%	-
		Hand	4,89%	2,89%	-	-	2,01%
Spinal region	17,39%	Spine	7,06%	1,18%	1,18%	1,18%	3,53%
		Neck	5,44%	2,72%	2,72%	-	-
		Ribs	4,89%	-	2,45%	2,45%	-
		Abdominal	-	-	-	-	-
Lower limbs	57,61%	Pelvic girdle	9,24%	3,70%	-	1,85%	3,70%
		Thigh area	9,24%	0,92	2,77%	2,77%	2,77%
		Knee	15,21%	4,56%	4,56%	0,76%	5,32%
		Lower leg	10,87%	2,51%	2,51%	3,34%	2,51%
		Ankle	11,96%	5,58%	3,19%	2,39%	0,80%
		Foot	1,09%	-	-	-	1,09%

- Anatomical regions injured as occurred in various positions of the elite U/19 rugby players

Table 4.42 displays information about the anatomical region which was reported most injured for the U/19 players. The lower limb (57,61%) was the most often injured region, followed by the upper limb region (23,91%). The head and face regions (1,09%) were the least injured areas. The knee (15,21%) followed by the shoulder (14,67%) were the body parts most at risk of injury.

If one concentrates more on the specific player-positional-groups, the results are as follows: When looking at the tight five, the ankle (5,58%) and knee (4,56%) were the most commonly injured body part. Both the backs and the loose forwards mainly injured the shoulder (4,40% and 5,87%) and the knee (5,32% and 4,56%). The halfbacks mainly injured the arm (4,38%) and the lower leg (3,34%).

The above results could have been concluded earlier, if these players had been compared to their biomechanical and postural characteristics as indicated in Table 4.31. When looking at the lower limb dynamics of the tight five, one can see that there is a tendency to injury, since their knee region and ankle and foot region showed mean values close to the non-ideal and therefore dynamically loaded with an increased risk of injuries. The loose forwards had more shoulder injuries than the backs because of the poor positional and musculature status of the upper limb, but less injuries in the knee region because of better mean values and therefore increased postural alignment. The halfbacks had the worst upper limb score of all player-groups and when looking at the biomechanical status, they also had the biggest anomalies, correlating well with them scoring the highest percentage of lower leg injuries.

Once again these results correlate well with those found by Hattingh (2003): The lower limbs (56,67%) followed by the upper limbs (16,67%) were also the most injured anatomical regions. The body part most injured in his study was also the knee

Table 4.43: Type of injury as occurred for the elite U/19 player group

TYPE OF INJURY					
Type of injury	Total nr of injuries = 184	Tight five (53 injuries)	Loose forwards (47 injuries)	Halfbacks (36 injuries)	Backs (48 injuries)
Strains (muscle)	16,67%	3,70%	1,85%	4,63%	6,48%
Sprains (ligt)	22,22%	8,33%	6,48%	1,85%	5,56%
Dislocations	2,77%	0,92%	0,92%	-	0,92%
Joint injuries	6,48%	1,85%	2,77%	-	1,85%
Fracture	6,48%	1,85%	0,93%	1,85%	1,85%
Contusions (haemt)	5,56%	0,93%	1,85%	0,93%	1,85%
Concussions	3,70%	-	-	0,93%	2,77%
Peri osteum &stress fract (shints)	7,40%	1,85%	1,85%	1,85%	1,85%
Bursa (capsel &fat pad imp)	8,33%	3,70%	2,78%	-	1,85%
Compartments	2,77%	-	2,77%	-	-
Dental trauma	-	-	-	-	-
Cartilage	5,56%	1,85%	1,85%	-	1,85%
Biom lumb &disc	12,04%	4,63%	0,93%	2,78%	3,70%

(16,67%), but it was followed by the ankle (13,33%) and head and face (13,33%) regions.

- Type of injury as occurred for the elite U/19 rugby players

In Table 4.43 types of injury are considered. Sprains (22,22%) were the most common and often reported, followed by strains (16,67%). Neither dislocations (2,77%) nor compartment syndromes (2,77%) occurred frequently.

Focusing on the specific player-positional-groups, the results were the following: The tight five had by far the most ligament sprain injuries (8,33%), followed by biomechanical lumbar pain and disc-lesions (4,63%). The loose forwards also had the most ligament sprain injuries (6,48%), followed by bursa, capsule and fat pad syndrome-injuries (2,78%). Both the halfbacks and the backs had the most muscle-strain injuries (4,63% and 6,48%), respectively followed by biomechanical lumbar pain and disc-lesions (2,78%) and ligament strains (5,56%).

In the study analysis of young adolescents, Hattingh (2003) further found ligament sprains (27,02%) and muscles strains (24,67%) to be the type of injury which occurred most often.

Table 4.44: Results of the clinical attendance records of the Institute for Sports Medicine, as for the elite U/19 rugby players

PERIOD OF PREVALENCE	
Period	**n of injuries = 184**
January to March 2006	25,41 %
April to June 2006	52,96 %
July to September 2006	21,63 %
ACUTE OR CHRONIC INJURY	
	n of injuries = 184
Acute	62,47%
Chronic	37,53 %

SPECIALIST REFERENCE		
		n of injuries = 184
Specialist opinion	42,14%	
Specific assessments:	X-rays	21,17%
(57,86%)	Sohar	14,79%
	Isokinetic tests	21,90%

- Results of the clinical attendance records of the Institute for Sports Medicine, as for the elite U/19 rugby players

In Table 4.44 the data on the period prevalence of the reported injuries, showed that most injuries occurred during the April to June (52,96%) period, most probably due to reduced match fitness and the tendency to withdraw the best players from games if they were not quite fit. Possible reasons for the increased injury rates as the season progressed, also included cumulative physical and mental fatigue caused by stresses such as travel, the intensity of the games themselves or even reduced fitness as a result of other minor injuries. The amount of matches also decreased at the end of the season, seeing that most leagues only had the final rounds left and therefore only the top log players kept on competing – with the total number of players decreasing, and therefore most probably also the rate of injury.

Most injuries reported were acute (62,47%), with the rest being chronic or caused by overuse. As can be expected, the majority of injuries occurred during matches and were acquired injuries, with a disconcertingly high percentage still as chronic or overuse injuries. And finally, most of the injuries needed specific assessments (57,86%), such as isokinetic tests (21,90%).

4.3 SUMMARY:

The anthropometrical, physical, motor and biomechanical results of this elite U/19 rugby group during the first testing episode in October 2005 have been discussed and analyzed. The anthropometrical, physical and motor results of the U/19 first team

during the second testing episode in July 2006 have also been discussed, analyzed and compared to that of October 2005.

The injury epidemiology throughout the season has been discussed under the following headings: Injury incidence as occurred in various player positions, the anatomical region and type of injury which occurred most often and the results of the clinical attendance records.

In the next chapter, the characteristics of this elite U/19 group will be concluded with a profile of the above mentioned injury epidemiology results in mind. Shortcomings and recommendations for further studies in this field will also be made.

CHAPTER 5:

SUMMARY

CHAPTER 5:

SUMMARY:

5.1 INTRODUCTION

The aim of this study was to develop a profile of elite U/19 rugby players, with knowledge of the anthropometrical, physical and motor, and biomechanical status of an elite U/19 rugby player. Furthermore, with reference to the epidemiology of injuries throughout this study, shortcomings among these players in their training programmes or in the treatment and rehabilitation of their injuries can be identified and addressed in future. To achieve the aim of this study, a group of elite schoolboy rugby players were anthropometrically, physical and motor, and biomechanically assessed at the end of their matric year. Clinic attendance records of this group were used to determine the epidemiology of intrinsic injuries during the up-following season. Finally their anthropometric and physical and motor statuses were re-tested after a season of training at the Rugby Institute of the North-West University.

Firstly in this chapter, all the main findings of the empirical study will be discussed and reported on, according to the aim of this study. This will be done under the following three main subdivisions, namely: the profile/status of an elite U/19 rugby player; the comparisons between the positional player groups – which consist of the tight five, the loose forwards, the halfbacks and the backs; intrinsic injuries (through clinic attendance records) which occurred throughout the season and the influence it had on the game/injury rate per 1000 hours played. These findings will be compared with similar studies in modern literature.

Secondly, the important findings will be highlighted, analyzed and discussed. Based on the findings, a physical and motor, and a biomechanical and postural prevention programme will be formulated to address the identified overuse and acquired injuries.

It will also be applied to correct identified shortcomings already at school level to address current tendencies and trends.

Lastly, this chapter will conclude with the shortcomings of this study as well as recommendations for improvement or further research on relevant or follow-up studies.

5.2 SUMMARY OF THE LITERATURE REVIEW

The practice of sports medicine is often governed by the principles of what seems like "common sense" of "the right thing to do", yet how much of what we practice is actually substantiated by high quality research? The management principles we apply to our patients and teach to our students and peers may have no scientific basis and yet they are still accepted because nobody has challenged the dogma. To what degree are our practices governed by what we are told is right rather than what is scientifically proven to be right? The purpose of this research was to challenge some common sports medicine clinical practices and to discuss the evidence either supporting or rejecting what we hold to be true. This study may not answer all questions regarding "what is the best clinical practice" although hopefully it will make you question and explore the evidence, or lack thereof, behind most of what we practice daily.

Various studies on the anthropometrical, physical and motor variables have been conducted in the past, both in South Africa (Spamer & Winsley, 2003; Plotz, 2004; Hattingh, 2003; De la Port, 2005; Van Gent, 2003; Holtshauzen, 2001) and internationally (Nicolas, 1997; Babić *et al.*, 2001a&b; Carlson, 1994; Gabbett, 2002; Gabbett, 2005; Meir, 2001). All of the above studies recorded different values from time to time, but overall they compared well. Most of them, however, suggest further studies, seeing that the game has changed a lot, and therefore the specific needs to improve performance have also changed.

Studies on the biomechanical and postural variances have been done before by Hattingh (2003) and Erasmus (2006) on rugby players, by Peens (2005) on cricket players and only certain components of this BMPE throughout the years (Kapandji, 1970; Adams and Dolan, 2005; Derman and Schwellnus, 2001; Milburn, 1993; Mullin and Skolfield, 2001) on different athletes. Seeing that Hattingh (2003) developed the BMPE, it can be of great help to better the performance of rugby-players, but also to use as a test-retest method to determine the improvement in performance by different player groups and individuals.

The understanding of biomechanics of sporting activities is therefore a vital foundation for the sports medicine practitioner – in the same way that understanding the anatomy provides an important foundation for the surgeon. Once the practitioner understands normal sporting biomechanics, he or she is in a position to apply injury prevention strategies.

Various studies on the epidemiology of injuries have also been done (Babić *et al.*, 2001a&b; Bathgate *et al.*, 2002; Beardmorre, 2005; Brooks *et al.*, 2005; Lee and Garraway, 1996; Upton, 1999; Jakoet and Noakes, 1998; Peens, 2005) both national and internationally. It has however only been researched in connections with the biomechanical and postural component by Hattingh (2003) in adolescent players and Erasmus (2006) in U/15 and U/16 rugby players. The idea that biomechanical instability and postural imbalances together with asymmetry cause injuries, has not been researched in depth. Therefore, this study assists in the development of an injury prevention programme which can be used in future.

Injury prevention strategies are required to reduce the incidence, severity and cost of rugby injuries. These injury prevention strategies could include coaching on defensive skills, correct tackling technique, correct falling technique and methods to minimize the absorption of impact forces in tackles. Game-specific attacking and defensive drills practiced before and during fatigue may also encourage players to make appropriate decisions under fatigued conditions and to apply learnt skills under

pressure in competitive matches. Further studies investigating risk factors for injury in junior and senior rugby league players, injuries sustained by specific playing positions and the influence of injuries on playing performance are warranted (Gabbett, 2004). This motivated the research done in this study and hopefully the implementation of this profile will help to reduce the incidence of injuries in future.

5.3 THE PROFILE OF ELITE UNDER 19 RUGBY PLAYERS REGARDING THEIR ANTHROPOMETRICAL, PHYSICAL AND MOTOR AND BIOMECHANICAL STATUS

When looking at the main objectives of this study again, the aim was to determine the effect of a scientific exercise program on the anthropometrical, physical and motor and biomechanical profiles of elite U/19 rugby players. It was also aimed to determine the relevance of a poor biomechanical status on the intrinsic injury epidemiology of elite U/19 players. The presentation of the most important findings in the empirical investigations regarding the profiles of the players will follow in the next paragraph.

This profile will include both the results of the group as well as the different player positions, which were divided into the following groups:

- Backs vs. Loose forwards
- Backs vs. Halfbacks
- Backs vs. Tight five
- Loose forwards vs. Halfbacks
- Loose forwards vs. Tight five
- Halfbacks vs. Tight five

5.3.1 Aim one: To determine a profile for elite U/19 rugby players regarding Anthropometrica:

The specific profile of this group will be discussed, followed by a comparison of the profile of the different player positions (see Annexure 5).

The *anthropometric* testing done on this elite U/19 group revealed the following: Overall the group showed no or low practical significant difference between the first and second testing episodes for all the anthropometrical values. Recordings correlate well with those of Hattingh (2003) for body mass, length and fat percentage. In correlation with recordings of Spamer and Winsley (2003) and Plotz and Spamer (2006), this group was slightly shorter but a little bit heavier, with a remarkably lower body fat percentage. This leads us to the conclusion that they gained muscle mass, seeing that they were heavier with a lower fat percentage, and muscle weighs more than fat.

BACKS vs. LOOSE FORWARDS

The *anthropometrical* testing done between these two player positions revealed the following: The loose forwards were heavier and taller with a higher body fat percentage than the backs during the testing episodes, with a high practical significant difference during the second testing episodes. This was foreseen, seeing that backs are usually the shorter and lighter of the two positions.

BACKS vs. HALFBACKS

The *anthropometrical* testing done between these two player positions revealed the following: The backs are slightly taller and heavier than the halfbacks, with a high practical significant difference during the first testing episode. The body fat percentage varied a little bit between the two testing episodes, but there was no or a low practical significant difference between them.

BACKS vs. TIGHT FIVE

The *anthropometrical* testing done between these two player positions revealed the following: The tight five are heavier and taller than the backs, with a higher body fat percentage. There is also a medium to high practical significant difference between them.

LOOSE FORWARDS vs. HALFBACKS

The *anthropometrical* testing done between these two player positions revealed the following: The loose forwards are taller, heavier and have a higher body fat percentage than the halfbacks, with a high practical significant difference in all tests.

LOOSE FORWARDS vs. TIGHT FIVE

The *anthropometrical* testing done between these two player positions revealed the following: The tight five are heavier, taller and have a higher body fat percentage than the loose forwards, with only a medium practical significant difference in the mass and second testing episode of the body fat percentage.

HALFBACKS vs. TIGHT FIVE

The *anthropometrical* testing done between these two player positions revealed the following: The tight five are heavier, taller and have a higher body fat percentage than the halfbacks, with a high practical significant difference in all tests.

To conclude, anthropometric testing on this group revealed data on body mass, body length and body fat percentage (see Annexure 5). During both testing episodes in October 2005 and July 2006, these values correlated well with other relevant studies in the literature. There were also low or nil practical significant differences in the anthropometrical components of this group.

5.3.2 Aim two: To determine a profile for elite U/19 rugby players regarding Physical and Motor abilities

The specific profile of this group will be discussed, followed by a comparison of the profile of the different player positions.

The *physical and motor* testing done on this elite U/19 group revealed the following: on the whole the group showed a low or nil practical significant difference between the first and second testing, except for the bleep test, which had a high practical significant different value. This might be due to their increased fitness level and

therefore their increased endurance. Except for the chin lift and pull-up test, this group outperformed all the recordings in the study of Hattingh (2003). The results of these U/19 group's explosive tests, namely the vertical and horizontal jumps, compared well with the tests done by Spamer & Winsley (2003). Furthermore it outperformed all the recordings in the study of Hattingh (2003), except for the chin lift and pull-up tests.

BACKS vs. LOOSE FORWARDS

- The backs outperformed the loose forwards in both the explosive power tests namely the vertical and horizontal jump, with a high practical significant difference in the second vertical jump testing episode. In the muscle strength division, namely the bench and abdominal tests, the loose forwards outperformed the backs, respectively with a high and medium practical significant difference in the second testing episodes. This was foreseen seeing that the main functions/activity of loose forwards is jumping in line-outs etc.
- The backs were more agile than the loose forwards with a high practical significant different value, but they shared values for the endurance tests, namely speed and aerobic (bleep).
- The backs outperformed the loose forwards in both the muscle endurance test (chin lifts) as well as the speed tests – except for the first testing episode of the 10m and 30m speed test. All the speed tests showed a high practical significant difference in the second testing episodes, but the chin lift tests showed low practical significant differences.

BACKS vs. HALFBACKS

- In the explosive power tests, namely the vertical and horizontal jumps, the halfbacks outperformed the backs, with a medium practical significant difference in the first testing episodes. In the muscle strength division, the halfbacks outperformed the backs, only in the abdominal strength test with a low practical significant difference; whereas the backs showed better values than the halfbacks for the bench test with a medium practical significant difference during the first testing episode.

- The halfbacks outperformed the backs in both endurance tests (speed and aerobic), but were only more agile than the backs during the first testing episode. There were only medium practical significant different values during the first testing episodes.
- The halfbacks had better values in the muscle endurance test (chin lifts), with a medium practical significant difference. They also had better values during the first speed (10m, 30m and 40m) testing episodes, but the backs outperformed them during the second speed testing episodes. All the first testing episodes showed a high practical significant difference.

BACKS vs. TIGHT FIVE

- The backs outperformed the tight five in both explosive tests, namely the vertical and horizontal jump as well as one of the muscle strength tests namely the abdominal strength test. The vertical jump showed a high practical significant difference for the second testing episode. The tight five had better values for the bench press test, with a medium practical significant difference for the second testing episode.
- The backs outperformed the tight five in the agility and speed endurance tests with medium to high practical significant different values. The tight five were the better performers during the first testing episode with the aerobic endurance test, but the backs ended with better values; during this period there was a high practical significant difference.
- The backs outperformed the tight five in both the muscle endurance test (chin lifts) as well as the speed tests – except for the first testing episode of the 10m and 30m speed tests. All the speed tests showed a high practical significant difference in the second testing episodes and the chin lift test only in the first testing episode.

HALFBACKS vs. LOOSE FORWARDS

- The halfbacks outperformed the loose forwards in all the explosive tests as well as the muscle strength tests, with high practical significant differences, except for the abdominal strength which had only a medium practical significant difference in the second testing episode.
- The halfbacks outperformed the loose forwards in both the agility and endurance tests, with a medium to high (during the first testing episode only) practical significant difference. In other words, the halfbacks are more agile and have a greater aerobic and speed endurance than the loose forwards.
- The halfbacks outperformed the loose forwards in the muscle endurance (chin lifts) test, as well as all the speed tests (10m, 30m and 40m), except for the second 10m testing episode where the loose forwards were the faster group. There was an overall medium to high practical significant difference between these two groups.

LOOSE FORWARDS vs. TIGHT FIVE

- The loose forwards outperformed the tight five in both the muscle strength and explosive tests, except the second testing episodes of the abdominal strength and the vertical jump tests; even so there were only low practical significant differences between these two groups.
- The loose forwards were more agile than the tight five and had a greater aerobic endurance; with high practical significant values during the second testing episodes. As for speed endurance, both groups took a turn to outperform the other, with medium practical significant differences.
- The loose forwards outperformed the tight five in both the muscle endurance (chin lifts) test and the speed test (10m, 30m and 40m), with medium practical significant values in all the tests except the second 10m testing episode which had a high practical significant value.

HALFBACKS vs. TIGHT FIVE

- The halfbacks outperformed the tight five in both explosive tests, as well as with the abdominal strength test. The tight five showed better values in the bench press test. All of the above results had high practical significant differences.
- The halfbacks outperformed the tight five in both the endurance tests (speed and aerobic), as well as the agility test, with high practical significant different values only.
- The tight five outperformed the halfbacks in the muscle endurance (chin lifts) test, as well as the first 10m speed testing episode. There was a high practical significant difference in the 40m speed test, as well as the second testing episodes of the 30m and 10m speed tests. The chin lift test had a high practical significant difference in the first testing episode.

To conclude, physical and motor testing on this group revealed data on vertical and horizontal jump test, agility and speed endurance test, speed tests over 10m, 20m and 30m, bench press and chin lifts tests as well as abdominal curls tests (see Annexure 5). The first testing episode in October 2005 showed poorer values than in the compared literature, with values in July 2006 still lower. This concludes that there was little or no improvement of the group performance over the season in this category, even though they had been through months of intensive and professional coaching.

5.3.3 Aim three: To determine a profile for elite U/19 rugby players regarding Biomechanical and Postural evaluations

The specific profile of this group will be discussed, followed by a comparison of the profile of the different player positions. It is important to remember that this profile was set up according to once-off testing only.

The *biomechanical and postural evaluations* done on this elite U/19 group revealed the following:

- Firstly the right and left sides were treated as equal to one another, seeing that only two players of the whole group (n = 61) showed any difference at all between the two sides.
- Secondly, this BMPE was only compared to recordings of Hattingh (2003), seeing that up to date he is the composer of the BMPE and one of only three researchers to use this specific evaluation. The other researchers are Peens (2005), who used it in his study on the effectiveness of injury prevention strategies on injury epidemiology of elite cricket players; and Erasmus (2006) who used it in his study on the effect of a prevention programme on the rugby injuries of U/15 and U/16 schoolboys.
- Thirdly, a summary of the findings: The lower limb was overall dynamically loaded, but with relatively good postural alignment and the foot and ankle region tended to have a slight deviation from the normal. All the pelvic girdle region tests correlated well with those done by Hattingh (2003), showing some discrepancy, and can therefore be rendered as asymmetric and reasonably unstable, with a lack in core stability. In the spinal region, the dynamic mobility tests showed moderate mean values, indicating that it was closer to non-ideal; and as far as the postural assessments go, there was an overall low deviation from normal with no big anomalies. The upper limb region showed higher mean values, indicating poor regional positional stability and musculature.
- Finally, the neurodynamic tests showed an overall full ROM with no tension; in contrast with Hattingh (2003) who found high values here, indicating a lack of dynamic mobility.

<u>BACKS vs. LOOSE FORWARDS</u>

- In the lower limb region, under the dynamic mobility division, the backs tended to have more mean values closer to the ideal than the loose forwards, and there was only a medium practical significant difference in the illiopsoas test (part of the modified Thomas test). In the knee complex, the backs also outperformed the loose forwards, having more mean values closer to the ideal; and here were only low to no practical significant different values. In the ankle and foot complex the backs again

outperformed the loose forwards, having more mean values closer to the ideal; with a medium practical significant difference in the foot mobility test.

- In the pelvic girdle region, the loose forwards showed better core stability and symmetry than the backs, with high practical significant differences in the leg length discrepancy, ASIS, PSIS and pelvic rami positional tests.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further sub-divided into the coronal and sagittal axis. The loose forwards outperformed the backs in all the above mentioned tests, with only a high practical significant difference in the rotational dynamic mobility test.
- The loose forwards outperformed the backs in the upper limb regional tests, with only a medium practical significant difference in the shoulder winging positional test.
- In the neurodynamic tests, the loose forwards and backs had equal values, with low or no practical significant differences.

BACKS vs. HALFBACKS

- In the lower limb region, under the dynamic mobility division, the halfbacks tended to have more mean values closer to the ideal than the backs, and there was only a high practical significant difference in the TA test with a medium practical significant difference in the gluteus maximus test. In the knee complex the halfbacks also outperformed the backs, having more mean values closer to the ideal; with a high practical significant difference in the patella tilt test. In the ankle and foot complex, the halfbacks again outperformed the backs, having more mean values closer to the ideal; with a high and medium practical significant difference respectively in the transverse arch and the forefoot positional tests.
- In the pelvic girdle region, the halfbacks showed better core stability and symmetry than the backs, with medium practical significant differences in the leg length discrepancy and bilateral pelvic positional tests.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further

sub-divided into the coronal and sagittal axis. The halfbacks outperformed the backs in all the above mentioned tests, with only high practical significant differences in the functional flexion and side flexion as well as the rotational dynamic mobility tests.

- The halfbacks and backs had equal scores in the upper limb regional tests, with low or no practical significant differences between them.
- In the neurodynamic tests, the halfbacks had mean values closer to the ideal, with only a medium practical significant difference in the L3/4 prone knee bend test.

BACKS vs. TIGHT FIVE

- In the lower limb region, under the dynamic mobility division, the tight five tended to have more mean values closer to the ideal than the backs and there were high practical significant differences in the TA and adductor mobility tests. In the knee complex the tight five also outperformed the backs, having more mean values closer to the ideal; with medium practical significant differences in the q-angle, patella squint and patella tilt tests. In the ankle and foot complex the tight five again outperformed the backs, having more mean values closer to the ideal; with a medium practical significant difference in the rear foot lying test.
- In the pelvic girdle region, the tight five showed better core stability and symmetry than the backs, with high practical significant differences in the leg length discrepancy, ASIS, PSIS and pelvic rami positional tests.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further sub-divided into the coronal and sagittal axis. The halfbacks and backs were equal in the sagittal axis division of the positional alignment test but the halfbacks outperformed the backs in the other tests, with high practical significant differences only in the rotational and side flexion mobility tests.
- The tight five outperformed the backs in the upper limb regional tests, with only a medium practical significant difference in the shoulder winging positional test.
- In the neurodynamic tests, the backs and tight five had equal values, with a medium practical significant difference in the straight leg raise test.

LOOSE FORWARDS vs. HALFBACKS

- In the lower limb region, under the dynamic mobility division, the halfbacks tended to have more mean values closer to the ideal than the loose forwards and there was a high practical significant difference in the TA test and medium practical significant differences in the illiopsoas (part of the modified Thomas test) and the gluteus maximus tests. In the knee complex the halfbacks also outperformed the loose forwards, having more mean values closer to the ideal; with a medium practical significant difference in the patella tilt test. In the ankle and foot complex, the halfbacks again outperformed the loose forwards, having more mean values closer to the ideal; with high practical significant differences in the forefoot positional, transverse arch and foot mobility tests.
- In the pelvic girdle region, the loose forwards showed better core stability and symmetry than the halfbacks, with a medium practical significant difference in the pelvic rami positional test.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further sub-divided into the coronal and sagittal axis. The loose forwards and halfbacks were equal in the sagittal axis division of the positional alignment test, but the halfbacks outperformed the loose forwards in all the other mentioned tests, with medium practical significant differences in the functional flexion, extension and side flexion as well as the rotational mobility tests.
- The halfbacks and loose forwards had equal scores in the upper limb regional tests, with low or no practical significant differences.
- In the neurodynamic tests, the halfbacks outperformed the loose forwards, with a high practical significant difference in the L3/4 prone knee bend test.

LOOSE FORWARDS vs. TIGHT FIVE

- In the lower limb region, under the dynamic mobility division, the tight five tended to have more mean values closer to the ideal than the loose forwards and there is a high practical significant difference in the TA test and medium practical significant differences in the gluteus maximus and adductor mobility tests. In the

knee complex, the loose forwards outperformed the tight five, having more mean values closer to the ideal; with a medium practical significant difference in the q-angle test. In the foot and ankle complex the tight five outperformed the loose forwards, having more mean values closer to the ideal; with medium practical significant differences in the longitudinal arch, forefoot positional, rear foot standing and lying tests.

- In the pelvic girdle region, the tight five showed better core stability and symmetry than the loose forwards, with only low or no practical significant differences in all the tests.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further sub-divided into the coronal and sagittal axis. The tight five outperformed the loose forwards in all the above mentioned tests, with only low or no practical significant differences.
- The tight five outperformed the loose forwards in the upper limb regional tests, with only a medium practical significant difference in the shoulder outline composition test.
- In the neurodynamic tests, the tight five and the loose forwards had equal values, with only a medium practical significant difference in the straight leg raise test.

HALFBACKS vs. TIGHT FIVE

- In the lower limb region, under the dynamic mobility division, the halfbacks tended to have more mean values closer to the ideal than the tight five and there was a high and medium practical significant difference in the modified Thomas test (illiopsoas and quadriceps tests), as well as a medium practical significant difference in the adductor mobility test. In the knee complex, the halfbacks also outperformed the tight five, having more values closer to the ideal; with medium practical significant differences in the q-angle and patella squint tests. In the ankle and foot complex the halfbacks again outperformed the tight five, having more mean values

closer to the ideal; with high practical significant differences in the rear foot standing and lying tests.

- In the pelvic girdle region, the tight five showed better core stability and symmetry than the halfbacks, with medium practical significant differences in all the tests, except the sacroiliac cleft test which had a low practical significant difference.
- The spinal region is divided in the spinal dynamic mobility and the spinal positional alignment complex. The spinal positional alignment complex is further sub-divided into the coronal and sagittal axis. The tight five and halfbacks were equal in the sagittal axis division of the positional alignment test but the halfbacks outperformed the tight five in all the other mentioned tests, with medium practical significant differences in the TLF and functional flexion mobility tests.
- The tight five outperformed the halfbacks in the upper limb regional tests, with only a medium practical significant difference in the shoulder outline composition test.
- In the neurodynamic tests, the halfbacks outperformed the tight five, with a high and medium practical significant difference respectively in the straight leg raise and L3/4 prone knee bend tests.

To conclude, biomechanical and postural evaluations on this group revealed data which correlated well with other results in the literature (see Annexure 5). This data showed the group to be dynamically and mechanically overloaded with poor regional stability and musculature as far as the upper and lower limbs were concerned. The spinal and pelvic region also showed asymmetry and weak core stability. The neurodynamical tests were satisfying.

5.3.4 Aim four: To determine a profile for elite U/19 rugby players regarding injury epidemiology

The specific profile of this group will be discussed, followed by the different player positions.

The *injury epidemiology* done on this elite U/19 group during the season (2005/2006) revealed the following:

5.3.4.1 Injury incidence as occurred in various player positions of the elite rugby players:

A total of 184 injuries were reported during the 2006 season. The tight five (32,07%) was the player group most often injured, followed by the backs (26,63%), loose forwards (26,09%) and halfbacks (15,22%). The flanker (14,20%) was the most often injured player position in contrast with the lesser injured player position, the fly-half.

5.3.4.2 Anatomical regions and injury incidence of the elite U/19 rugby players:

The lower limbs (57,61%) were the anatomical region mostly injured, followed by the upper limbs (23,91%), spinal (17,39%) and head and face (1,09%) region. The body part mostly injured, was the knee (15,92%) and the less injured body parts the head, face and foot regions (1,09%). The tight five mainly injured the ankle (5,58%) and knee (4,56%) region. The loose forwards and backs mainly injured the shoulder (5,87% and 4,40%) and the knee (4,56% and 5,32%) respectively. The halfbacks mainly injured the arm (4,38%) and the lower leg (3,34%) region.

5.3.4.3 Type of injury as occurred for the elite U/19 player group

Ligament sprains (22,22%) and muscle strains (16,67%) were the injuries which occurred the most in this group. This together with biomechanical lumbar pain and disc lesions (12,04%) was the case in all the player groups.

5.3.4.4 Results of the clinical attendance records of the Institute for Sports Medicine, as for the elite U/19 rugby players:

The prevalence of injuries was the highest during the April to June 2005 period with a 52,96% rate. The January to March and July to September periods shared the rest of injury prevalence. There were also more acute (62,47%) than chronic (37,53%) injuries. Of all these injuries, 42,14% were referred for the opinion of a specialist, as well as specific assessments such as X-rays, sonars and isokinetic testing.

The injury epidemiology of this group revealed a huge amount of injuries, most probably due to the poor above mentioned values.

5.4 RECOMMENDATIONS AND SHORTCOMINGS OF THE STUDY

5.4.1 Recommendations of this study:

- The results identified in this study, can be used in future to evaluate upcoming U/19 rugby players. The coaches and management team can use this data to conduct similar tests on players and in this way identify potentially talented players.
- Conditioning programmes according to findings under anthropometrics, physical and motor variables should be designed by the sport scientists. Biomechanical and physical programmes are developed according to each individual player status by the medical staff and should form part of the conditioning programme.
- Biomechanical and postural evaluations should also be conducted in other sports to determine the effect of the correct handling of imbalances of injuries internationally.

5.4.2 Shortcomings of this study:

- The first testing episode involved all the players and a profile for elite players after their school career was determined. However, during the second episode only the first team was re-tested and a profile of elite U/19 players after their first year at the Rugby Institute was determined. The fact that different groups were tested, might question the practical significant difference.
- The preventative training programme remains untested and should be conducted in the future to determine its efficacy in improving the anthropometrical, physical and motor variables and therefore the performance of the players.
- Biomechanical and postural evaluations should be done at the beginning of the season and on a regular basis throughout the season, to be able to change the

training programmes of each individual accordingly and therefore help to prevent injury.

- The controlling of the training and or biomechanical programme used during the season were not followed up. This could have helped to determine where the problems were which had caused the low improvement of performance level and the high incidence of injuries.

To summarize, the study succeeded in developing a profile of the anthropometrical, physical and motor, biomechanical and injury epidemiological of elite Under 19 rugby players. It also expands the literature on the biomechanical and postural evaluations of players, seeing that so little research has been done on this particular topic up to now.

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ANNEXURE 3.1:

RUGBY INSTITUTE MEDICAL CLINIC QUESTIONAIRE

CLINIC DATE _____

NAME _____

POSITION _____ AGE GROUP _____

ANATOMICAL REGION INJURED _____

TYPE OF INJURY _____

INJURY OCCURRED DURING: MATCH _____ OR TRAINING _____

INJURY: ACUTE _____ OR CHRONIC _____

TIME: OF TRAINING _____ OF GAME _____

DIAGNOSIS _____

REFERRED TO:

PHYSIOTHERAPIST _____

BIOKINETICIST _____ SPECIAL TESTS _____

SPORT SCIENTIST _____

REVISIT _____ ON _____

COMMENTS _____

_____

ANNEXURE 3.2: **Biomechanical and Postural Evaluation (BMPE)**

PERSONAL INFORMATION

Name:
Age:
Player position:
Dominant hand:
Dominant foot:

MEDICAL HISTORY

Present:
Past:

LOWER LIMB

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
TA			30° +	20°-30°	20°
ITB			12H00	11H55 or 12H05	11H50 or 12h10
QUAD			50° +	30°-50°	30°
ILLIOPSOAS			30° +	15°-30°	15°
GLUT MUSCLES			90° +	60°-90°	60°
ADDUCTOR			120° +	100°-120°	100°
HIP INTERN ROT			30° +	15°-30°	15°
HIP EXT ROT			90° +	60°-90°	60°
KNEE Q- ANGLE			9° -	9° +	
KNEE SQUINT			9° -	9° +	
KNEE TILT			0°	0° +	
KNEE HEIGHT			Normaal	Anormalies	
VMO			Normaal	Anormalies	

FOOT

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
FOOT LONGITUDINAL			Flat	Normal	High
FOREFOOT			Normaal	Anormalies	
REAR FOOT STANDING			0°-9°	0° -	9° +
REAR FOOT LYING			0°-9°	0° -	9° +
TRANSVERSE			Normal	Flat	
MOBILITY			Hyper	Normal	Rigid
TOES			Normaal	Anormalies	

HIP GIRDLE

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
LEG LENGTH			Left =Right	1cm discrepancy	1cm + discrepancy
ASIS			Left =Right	Discrepancy	
PSIS			Left =Right	Discrepancy	
RAMI			Left =Right	Discrepancy	
CLEFT			Left =Right	Discrepancy	
PELVIS BILATERAL POSITION			2-3 cm	3-5 cm	5 cm +

SPINAL

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
THORACO LUME FASCIA			2 cm	4 cm	4 cm +
SACRUM RHYTH			Left = Right	Aberrant	
EXTENSION			Easy ROM	Limited ROM	Hyper
FLEXION			Easy ROM	Limited ROM	Hyper
ROTATION			Easy ROM	Limited ROM	Hyper
SIDE FLEXION			Easy ROM	Limited ROM	Hyper

CORONAL MID

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
HEAD POSITION			Normaal	Anormalies	
CERVICAL			Normaal	Anormalies	
THORASIO			Normaal	Anormalies	
LUMBAR			Normaal	Anormalies	

SAGITAL MID

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
HEAD POSITION			Normaal	Anormalies	
CERVICAL			Normaal	Anormalies	
THORASIO			Normaal	Anormalies	
LUMBAR			Normaal	Anormalies	

UPPER LIMB - SHOULDER

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
HAND BEHIND BACK			Left = Right	4 cm -	4 cm +
HAND BEHIND NECK			Left = Right	4 cm -	4 cm +
SHOULDER POSITION			Neutral	Two thirds	
WINGING			None	Winging	
OUTLINE			Muscular	Bony	
THROWING POSITION			Coronal mid +	Coronal mid -	

NEUROLOGICAL

AREA	GRADE		GRADE DETAIL		
	L	R	1	2	3
STRAIGHT LEG RAISE			90° +	70° +	70° -
UPPER LIMB TENSION TEST			180° - O° No tensio	180° - 0° With tension	180° - 0° +
L4			Full ROM No tensio	Full ROM With tensio	Not touching
SLUMP			FROM with DF with no t	OM with DF with tens	Limited ROM with tension

COMMENTS