A PREVENTION PROGRAMME FOR RUGBY INJURIES BASED ON AN ANALYSIS AMONG ADOLESCENT PLAYERS

JOHANNES HENDRIKUS BERNHARD HATTINGH

M.Sc. (Sport Science)

Thesis submitted for the degree Philosophiae Doctor in Educational Science (Teaching and Learning) at the Potchefstroomse Universiteit vir Christelike Hoër Onderwys

Promoter: Prof. E.J. Spamer (PU for CHE)

Co-Promoter: Prof. J.L. de K. Monteith (PU for CHE)

Assistant Promoter: Dr. C. van Rensburg (University of Pretoria)

2003

Potchefstroom

ACKNOWLEDGEMENTS

I wish to thank the following persons for their help and support in undertaking this study:

- My study leader, Professor Manie Spamer, for his encouragement and very capable guidance.
- Dr Christa van Rensburg of the Sports Medical School of the University of Pretoria, for providing valuable input, support and advise.
- Professor M. Monteith, for valuable input and support.
- The Leopard Rugby Union for allowing me to do this study on rugby teams under their jurisdiction.
- The PUK Rugby Institute for assisting me in the obtaining of valuable data, and studying rugby teams under their jurisdiction.
- Professor Steyn and his team, for the statistical data processing.
- Johan Blaauw, for his excellent advise on language and grammar.
- Professor Casper Lessing, for his technical advise.
- Elize Snyman, for her word processing and assistance.
- My office staff, for their assistance.

The aim of this study is to develop a prevention programme for rugby injuries, based on analysis among adolescent players, with reference to physical and motor, anthropometric and biomechanical and postural variables.

A further aim of this prevention programme will be to address and improve the physical and motor, anthropometric and biomechanical and postural standards of young school players, to be introduced at an early school level to curb injury epidemiology.

An analysis of literature resources was done by making use of electronic media, a library search and a search of sports and sports medicine journals. Databases such as Pubmed, EbscoHost (Academic Search Elite), Sciencedirect and Medline were used. Also, the chief medical officers of Wales, England, Scotland, Ireland, France, New Zealand and Australia, the seven major rugby-playing nations, were contacted via electronic media for input and assistance on the research topics.

Special consideration was given to rugby injury epidemiology, the physical and motor and anthropometric standards of elite senior secondary school and junior tertiary rugby players. A new approach involving the biomechanical make-up of players was also introduced.

In this study a total of a 331 elite rugby players were used. The players were chosen according to gratification of position and availability, and further divided into four age groups. The two junior groups consisted of 15- and 18-year-old elite provincial school players in the North West Province of South Africa, participating in the Craven week. The two senior teams comprised 19- and 20-year-old elite tertiary education level players of the Potchefstroom University Rugby Institute.

Once approval had been granted by the players, the North West Leopards Schools Rugby Union as well as the University of Potchefstroom Rugby Institute, the players were submitted to a test battery. Anthropometric and physical and motor tests were done mid-season. Proper steps were taken to address existing shortcomings identified in the test subjects. Re-tests were done (19- and 20-year-old) at the end of the season to re-evaluate the test subjects. Biomechanical testing of all four identified groups was done pre-season. Once results had been analyzed, the appropriate individual programmes were formulated, explained and implemented. This aim was to address the possible risk areas identified by the screening.

Results were statistically processed, recorded and compared with earlier literature studies.

A prevention programme was compiled:

- Pre-season preparation programme
- Start-of-season level 1: 6 week maintenance programme
- Start-of-season level 2: advanced maintenance programme
- Mid-season 1 week conditioning programme
- Mid-season level 3: most advanced conditioning programme
- Off-season maintenance programme

Recommendations were made, and shortcomings of this study identified.

OPSOMMING

Die doel van hierdie studie is die ontwikkeling van 'n voorkomingsprogram vir rugby beserings. Die studie is gebasseer op 'n ondersoek op jong volwasse spelers, met verwysing na fisiese en motoriese, antropometriese en biomeganiese en posturale komponente.

'n Verdere doel van hierdie voorkomingsprogram, is die verbetering van die fisiese en motoriese, antropometriese en biomeganiese en posturale komponent standaarde van jong skool spelers, asook die implimentering van hierdie voorkomingsprogram op 'n vroeë skool stadium vir die vermindering van beserings epidimiologie.

Met behulp van elektroniese media, biblioteek materiaal en sport en sport en medisyne joernale, is 'n ondersoek van literatuur studies gedoen. Data basisse soos Pubmed, EbscoHost (Academic Search Elite). Sciencedirect en Medline was gebruik. Hoof mediese beamptes van Wallis, Engeland, Skotland, Ierland, Frankryk, Nieuzeeland en Australië, die 7 hoof rugby-spelende nasies, is ook gekontak vir bydrae en bystand tot die studie.

Spesifieke aandag is gegee aan rugby beserings epidimiologie, die fisiese en motoriese en antropometriese standaarde van elite senior sekondêre skool en junior tersiêre rugby spelers. 'n Nuwe benadering tot die biomeganiese samestelling van die spelers is ook uitgelig.

In totaal is 331 elite ruby spelers vir hierdie studie gebruik. Spelers is gekies na aanleiding van gratifikasie van posisie en beskikbaarheid. Spelers is in 4 groepe verdeel, 15- en 18-jaar-oud elite Noord-wes provinsiale skool spelers soos aan Craven week deelgeneem, en die senior groep die 19- en 20-jaar-oud elite tersiêre spelers van die Potchefstroomse Universiteit Rugby Insituut.

Na goedkeuring van spelers, Noord-wes Luiperd skool rugby unie en Potchefstroomse Universiteit Rugby Instituut, is die spelers aan toetsbatterye onderwerp. Antropometriese, fisiese en motoriese toetse is mid-seisoen gedoen. Stappe is geneem om tekortkominge uitgewys, aan te spreek. Her-toetsings (19- en 20-jaar-oud) is aan einde van seisoen gedoen. Al 4 groepe is voor-seisoen biomeganies getoets.

Biomeganiese resultate is verwerk, en individuele programme is geskryf, verduidelik en geimplimenteer, met die doel om die geidentifiseerde risiko areas aan te spreek.

Resultate is statisties verwerk en genoteer en met vroëre literatuur studie vergelyk.

Voorkomingsprogram soos volg is daargestel:

- Voor-seisoen voorbereidingsprogram
- Begin van seisoen vlak 1: 6 weke onderhoudsprogram
- Begin van seisoen vlak 2: Gevorderde onderhoudsprogram
- Mid-seisoen 1 week kondisioneringsprogram
- Mid-seisoen vlak 3: Mees gevorderde kondisioneringsprogram
- Af-seisoen onderhoudsprogram

Aanbevelings is gemaak, en tekortkominge van hierdie studie is ook uitgewys.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

ACC Sport Smart 2000	Accident compensation corporation
CHIRPP	Canadian Hospitals Injury Reporting and Prevention Programme
SARFU	South African Rugby Football Union
SAS	Statistical Analysis System

Chapter 2

ACTRU	Australian Capital Territories Rugby Union
AFL	Australian Football League
CSRL	Croatian-Slovenian Rugby League
IRFB	International Rugby Football Board
NZRFU	New Zealand Rugby Football Union
RIPP	Rugby Injury and Performance Project
SRU	Scottish Rugby Union
UAR	Argentine Rugby Union

Chapter 3

ASIS	Anterior Superior ileac spine
Cd	Compact disc
cm	Centimeter
Ext	External
ITB	Iliotibial band
Intern	Internal
IRM	One repetition maximum
Kg	Kilogram
L	Left
m	Meter
PSIS	Posterior Superior ileac spine
Physio	Physiotherapist
PUK	Potchefstroom University for Christian Higher Education
Quad	Quadriceps
Q-angle	Quadriceps angle
ROM	Range of movement
R	Right

ROT	Rotation
SIJ	Sacroiliac joint
SLR	Straight leg raise
TA	Tendon Achilles
VMO-L	Vastus medialis obliques-lateralis

Chapter 4

BMPE	Biomechanical and postural evaluations
Min	Minimum
Max	Maximum
N	Number
s	Standard deviation
Sec	Second
TLF	Thoraco lumbar fascia
$\bar{x}$	Mean value

Bibliography

Mar	March
Jun	June
Ed	Edition/Editor
Eds	Editors
p	page
Nov	November
Sept	September
PU vir CHO	Potchefstroom University for Christian Higher Education
U.S.	United States
Aug	August
Dec	December
Apr	April
Oct	October
Ph.D	Philosophiae Doctor Degree
UCT	University of Cape Town
M.Phil	Magister Philosophiae
Feb	February

CHAPTER 1

PROBLEM STATEMENT AND SUBSTANTIATION, RESEARCH AIMS AND OBJECTIVES

1.1 INTRODUCTION AND PROBLEM STATEMENT

As we are progressing into the new millennium, participation in rugby in all its variations is being threatened by an onslaught from less physical and less dangerous sports types. A tremendous growth in soccer in the United States of America has been seen since the 1998 Soccer World Cup. Vast numbers of American youths have been moving away from gridiron football to soccer (Wilson, 2000). Unfortunately, if all the rugby types are taken into consideration, the black sheep of this family in terms of injury is Rugby Union. Frightening statistics are chalenging the future, the nature and the popularity of this sport.

A study done in Scotland in 1993/1994 at club level showed an incidence rate of 13,95 injuries per 1 000 playing hours (Garraway & Macleod, 1995). Using the same definition for injuries as in the 1993 study, a repeat was done at the same clubs in 1997/1998. A 94% increase in the injury rate was found (Garraway *et al.*, 2000). However, this is not the end of the nightmare. The most recent study using the same injury definition was done on professional rugby players in the 1999/2000 Super 12 season. An injury incidence rate of 86,4 per 1 000 player hours was recorded (Holtzhausen *et al.*, 2001), which according to a quick calculation is an increase of just over 620% in incidence rate. This makes Rugby Union by far the most dangerous of sports.

Since the change to professionalism in 1995 the game has undergone a virtual metamorphosis. Thomas & Nelson's (1985) statistics shows on average four times the amount of tackles and rucks per player in the modern-day game, thus making it far more dangerous and the players more liable to injury. New Zealand's statistics over the last 26 years has shown an increase in weight of 16-19 kg on average for the back-line. This increase in weight is predominantly lean body mass, which fits in with the modern-day era of the super-athlete.

Leuan Evans former Wales and British Lions winger after 10 years of international rugby stated: "...it used to be a far less physical game. It has changed from a contact sport to a collision sport where the body has to absorb a pounding from players twice my size" (Wilson, 2000).

The tackle area has evolved into a ferocious battle ground and it is mostly here that the game is won or lost, rather than at the scrum or lineout, as a generation ago, according to Wilson (2000). The modern game is played mostly in the second phase. The team that can physically dominate the tackle area by gaining the hard yards when attacking or forcing opponents back when defending is the team which wins the game regardless of first-phase possession. The nature of the tackle has also changed.

Players nowadays aim for the upper chest in order not only to stop the opponent but also to force the ball carrier backwards and, if violent enough, to make him lose ball control. Terminology like “big hit", "high shot” and even "multiple-direction tackles" are the order of the day (Wilson, 2000).

Fitness levels and dedication to the game as well as the complete commitment of players on the field is now being reflected in the hours spent improving fitness, strength and speed, according to David Young, former captain of Wales. When a survey was done on the Wales international rugby squad in 1990 by Lynn Davies, only 3 out of 30 players spent regular time in the gym (Wilson, 2000). Nowadays all players not only spend a substantial amount of time in the gym but very specific and advanced training programmes are being followed.

The last factor that essentially changes rugby from the old to the new is the number of games per season (Quarrie *et al.*, 2001). Gareth Edwards, former Wales and Lions player, played an average of 16,25 games over a 12-season period. In contrast, Dallaglio, former captain of England and the Lions, played an average of 35 games per season. This scenario is even worse for the modern player.

With all these facts on the table spelling gloom for Rugby Union, there are fortunately some positive aspects. The New Zealand Rugby Union over the last five years has conducted a reasonably successful study where 10 pointers were addressed and researched, and documented by them in their Accident compensation corporation sport smart: successful sports injury prevention document (Quarrie *et al.*, 2001).

- Screening
- Warm-up/cool-down

- Physical condition
- Technique
- Fair play
- Protective equipment
- Hydration and nutrition
- Injury surveillance
- Environmental factors
- Injury management

There was a reduction in injury rate of approximately 47% brought about by the implementation of the above so-called ACC Sport Smart (2000) programme. The fact that only three major studies have been done since 1995 on rugby injury epidemiology begs for further research. An additional fact that was pointed out by Holtzhausen (2001) is that in these three studies neither the study design nor the injury definition was up to standard.

In comparing school and club rugby Lee and Garraway (1996) report a practical significant difference in epidemiology between these two groups of players. Club players in 1996 were at a higher risk than their school counterparts due to the number of games, intensity of play and fitness levels.

In 1995 the Canadian Hospitals Injury Reporting and Prevention Programme (CHIRPP) ran a five-year study on school rugby players. Highest at risk injury-wise were the 15- to 19-year-old rugby players. According to this study 53,5% of injuries required advice only or minor treatment, 43,4% required medical follow-up after leaving the emergency department and 3,1% of the patients were admitted to hospital.

A study done during one 18-week season at 26 high schools by Roux *et al.* (1987) showed that 71% of injuries occurred during matches and 29% during practice. Injury was more common during the first four weeks of the season, and again in the same time period after the mid-season vacation. Of all injuries 55% occurred while the player was tackling or being tackled, and 18% during the loose scrum or maul. The ratio of body parts injured was as follows: lower limb 37%, head and neck 29%, and upper limb 20%. The ratio of types of injury was as follows: fractures 27%, ligament and tendon injuries 25%, and muscle injuries 17%.

These findings correlate well with similar studies done nationally and internationally on elite club players (Lee & Garraway, 1996). Unfortunately, as in the case of senior rugby, the same unacceptable rise in rugby injury epidemiology is seen post-1995 at school level. This is highlighted by the catastrophic 2001/2002 South African schools season, with so far no fewer than six school deaths resulting mainly from concussion and spinal injuries (Jakoet, 2002).

The question can be asked if the elite senior school player has the physical and motor, anthropometric and biomechanical make-up which is demanded by the changing game. More to the point, taking into consideration the above facts and findings, the question is whether the elite senior school player has the make-up to play safe rugby and to make the transformation to elite club level.

1.2 RESEARCH AIMS

The aim of this study is to develop a prevention programme for rugby injuries, based on analysis among adolescent players, with reference to physical and motor, anthropometric and biomechanical and postural variables.

A further aim of this prevention programme will be to address and improve the physical and motor, anthropometric and biomechanical and postural standards of young school players, to be introduced at an early school level to curb injury epidemiology.

1.3 METHOD OF INVESTIGATION

1.3.1 Review of literature sources

An analysis of literature resources was be done by making use of electronic media, a library search and a search of sports and sports medicine journals. Databases such as Pubmed, EbscoHost (Academic Search Elite), Sciencedirect and Medline were used. Also, the chief medical officers of Wales, England, Scotland, Ireland, France, New Zealand and Australia, the seven major rugby-playing nations, will be contacted via electronic media for input and assistance on the research topics. Special consideration was given to rugby injury epidemiology, the physical and motor and anthropometric standards of elite senior secondary school and junior tertiary rugby players. A new approach involving the biomechanical make-up of players was also be introduced.

1.3.2 Empirical investigation

1.3.2.1 Choice of participants

In this study a total of a 331 elite rugby players were used. Written consent was given by all players to take part in this study. The aim of this study was submitted and accepted by the North West Rugby Province as well as the Potchefstroom University Rugby Institute. The players were chosen according to gratification of position and availability, and further divided into four age groups consisting of 30 players each. The two junior groups consisted of 15- and 18-year-old elite provincial school players in the North West Province of South Africa, participating in the Craven week. The two senior teams comprised 19- and 20-year-old elite tertiary education level players of the Potchefstroom University Rugby Institute.

1.3.2.2 Test battery

A thorough study of the game of rugby in the literature has already been attempted in the pre-study. From the literature a range of tests, analyses and protocols have been obtained to identify and select important tests that have proven to be advantageous to high-level performance.

These tests can be divided into three main groups: a physical and motor, an anthropometric and a biomechanical group. Physical and motor tests can be subdivided into 10 different tests concentrating mainly on five specific areas, namely power, explosive power, speed, fitness and agility. The twelve tests selected were: the 30 metres dash for speed (Hazeldine & McNab, 1998), the Standard Bloomfield agility test (Bloomfield *et al.,* 1994), Illinois agility test (Kirby, 1991), vertical (Thomas & Nelson, 1985) and horizontal jumps (Kirby, 1991) for explosive power, the bleep test (Brewer *et al.*, 1988) for cardiovascular fitness, and for power, pull-ups (Turnbull *et al.*, 1995), abdominal curls (Kirby, 1991), bench presses and squats (Kirby, 1991).

In the anthropometric group, three standardised tests were selected: body fat percentage (Norton *et al.*, 1996) by using six skin folds, body length (Norton *et al.*, 1996) and body mass (Norton *et al.*, 1996).

The third assessment protocol can be classified under biomechanicals (Watson, 2002 & Kapandji, 1974). Here five different body zones were identified, classified and each compared to its counterpart and the rest of the anatomy. Factors like suppleness, balance, positioning and muscle mass were interpreted. The groups were the lower limb, the pelvic girdle, the spinal region, the upper limb, and neurodynamics.

1.3.2.3 Procedures and research methods

Once approval had been granted by the North West Leopards Schools Rugby Union as well as the University of Potchefstroom Rugby Institute, the testing procedures commenced as follows:

Anthropometric and physical and motor testing was done mid-season. Proper steps were taken to address existing shortcomings identified in the test subjects. Re-tests were done (19- and 20-year-old) at the end of the season to re-evaluate the test subjects.

As is the case with anthropometric, and physical and motor testing, biomechanical testing of all four identified groups was done pre-season. Once results had been analysed, the appropriate individual programmes were formulated, explained and implemented. This aim was to address the possible risk areas identified by the screening.

1.3.2.4 Statistical data processing

- Data was processed with the SAS System for Windows release 8.02 TS Level

  02M0 Copyright 1999-2001 by SAS Institute Inc., Cary, NC, USA

  software program. (SAS user's guide, 1985).

- Statistical and SAS software will be used for discrepancy analysis (SAS user's guide, 1985).

CHAPTER 2

LITERATURE SURVEY: RUGBY EPIDEMIOLOGY

2.1 INTRODUCTION

When assessing rugby union historically, 1995 can be seen as a turning point. The game as in the 1970s, 1980s and early 1990s, is hardly recognisable in comparison with the modern era (Wilson *et al.*, 1999). The main cause of this tendency is professionalism.

Sensational tackles, skilful ball handling and an amazing pace lead to an increase in spectator satisfaction. However, with the modern era not everything is as well as it seems, it appears as if the professionalism comes at an expensive price.

Literature has shown alarming increases in injury rates and, unfortunately, this impacts on playing life and injury incidence. Furthermore, a huge discrepancy between injury definition internationally in the past and in the present is apparent (Holtzhausen, 2001). This has an effect on research data on rugby injury epidemiology and makes comparison with previous studies extremely difficult and indecisive.

In this Chapter the historical background of rugby injury epidemiology will be discussed, spanning an era as far back as the medieval period in Great Britain up to the modern era. Secondly, what initially was defined as an injury and what the modern definitions are will be described. Thirdly, the possible reasons for injury incidence over this period, especially the year 1995, which can be seen as the turning point between the old and the new, will be discussed. Fourthly, the reporting of injury rates or injury incidence in all its forms up to the modern description of injury per 1 000 player hours will be reviewed. Lastly, the injury as such will be discussed, and when and where it occurs, the body parts mostly affected, the playing position and the phase of play during which the player is most at risk, will be emphasised.

2.2 HISTORICAL EPIDEMIOLOGY

Historically, the origin of ball games, whether rugby, soccer or hockey, can be traced back to medieval. English ancestry. In the so-called "game", village residents congregated at a convenient site halfway between their villages. Their objective was to propel a ball-like object (cow bladder) through the gateway of the opposite village leader. In some cases there were up to 300 competitors in a competition. The game started when the ball was thrown into the centre of the playing area. Thereafter it was likely that anything was acceptable since there were few, if any, rules governing the game. There were no restrictions on clothing, equipment, the number or age of the participants or modes of transport. Ambushes and drowning were common as rivals took the opportunity to settle private animosities and simmering feuds (Noakes & Du Plessis, 1996).

Later in the history the game became more socialised, it was introduced into the elite English school systems and specific fields began to be used. The school systems utilised these games to develop the physical side and masculinity of pupils and secondly to control disagreement and aggression. Owing to the variation in field sizes at the different schools, the game uniquely developed into either a ball handling or dribbling game. The first set of specific rules was introduced in the year 1846, and favoured the dribbling game. By 1863 the distinction between rugby and soccer had become somewhat clearer; the main difference was that in rugby, tackling, tripping and holding the player in possession of the ball were allowed (Noakes & Du Plessis, 1996).

Possibly, it is this historical development which gave rise to the famous quote, much favoured by rugby players, to the effect that rugby is a game for hooligans played by gentlemen, whereas soccer is the opposite.

The game rugby was therefore thus been played for more than almost a century before the first study on injury epidemiology was reported by O'Connell in 1954. O'Connell (1954) was an Irish orthopaedic surgeon working at St. Vincent's hospital, Dublin, Ireland. He published an article on rugby injuries and their prevention in which six hundred injury cases were reported. O'Connell (1954) suggested the following to reduce injury risk:

- Proper pre-season preparation and training;
- Protective devices to be used for the head and the face, padding for the shoulders and strapping or bracing of the ankles;
- On the field the use of flexible corner flags, padding of the goalposts and clearing the field of stones, animals and animal faeces.

- Lastly he suggested proper rehabilitation of injured players before returning to the game.

Remarkably, what this researcher (1954) suggested 50 years ago still applies in today's modern rugby.

The rugby world had to wait another two decades (the year 1974) before three studies of importance on rugby injury epidemiology were produced (Micheli & Riseborough, 1974; Roy, 1974; Weightman & Browne, 1974). The authors concluded that the high injury trend was unnecessary and could be reduced if the game was more properly regulated. This statement foresaw the injury crises (catastrophic spinal region injuries in the early 1980's), which engulf rugby a few years later. In 1975 a letter by Walkden (1975) published in the *Practitioner*, acknowledged for the first time medical concern regarding injuries in rugby, specifically involvement in tackles and collapsing of the scrum. Unfortunately it took more than a decade before rule changes were introduced in the first phase of play to protect and control the set pieces.

The first official scientific rugby injury paper was published in 1977. This showed an increase in cervical injuries and was done by Scher (1977) of the Spinal Unit at the Conradie Hospital in Cape Town. Scher (1977) identified two mechanisms leading to cervical spinal cord injuries – tackling injuries to either the tackler or the tackled player, and injuries in the scrum presumed to result from scrum collapse. He concluded that whereas tackling injuries causing spinal cord damage might not be preventable, prevention of the collapsing scrum should be achievable either by rule changes or by the more active intervention of referees.

After 1977 reports followed in succession. Burry and Gowland (1981:56) in New Zealand wrote that: "The 1978 rugby season in New Zealand was marred by an epidemic of fatal cervical cord injuries". This led to the New Zealand Rugby Union requesting an investigation into this matter. In the next decade reports and studies from all the major rugby-playing nations showed an increase in the incidence of these dreadful injuries.

In 1988 the International Rugby Football Board (IRFB) added to Law 20 a paragraph which stated: "In the interests of safety, each front row should touch on the upper arms and pause prior to engagement – in the sequence: crouch – touch – pause – engage."

This international law did not address wilful wheeling and movement of the scrum. It was only until somewhat later that Law 20 was further adjusted so that "a scrummage must not be wheeled beyond a position where the middle line becomes parallel to the touch line" (Badley, 1990:5).

In 1990 the IRFB added onto Law 26 (Note 3) that: "...tackling or attempting to tackle a player around the neck or head or above the line of the shoulders *must be punished severely and a penalty awarded in all such cases*" (Badley, 1990:6).

Rugby Union saw the introduction of the World Cup event in 1987. The competition is held once every four years and includes all the rugby-playing nations. This event can be seen as a rugby showpiece of the highest quality and standard available (Jakoet & Noakes, 1998). Unfortunately, with this high standard of competition a higher than normal injury rate is being observed.

In the year 1995, rugby union finally changed from an amateur to a professional sport. This was also the year of the third World Cup, which was held in South Africa. Jakoet and Noakes (1998) stated that frequency of injury in this competition was the highest yet recorded in any group of rugby players. The risk of rugby injury was therefore greatest in the best players in the game, challenging the view that superior fitness, skill and experience could reduce the risk of rugby injury.

In the Southern Hemisphere in 1996 the first fully professional rugby competition was held between South Africa, New Zealand and Australia. Ten regional teams competed, 4 from New Zealand, 4 from South Africa, and 2 from Australia and played in a "round robin" fashion. Targett (1998), in New Zealand, published an article on rugby injury epidemiology. He stated that injury rates increase with increase in competitive levels, supporting the Jakoet and Noakes (1998) findings. Targett (1998) recorded an overall injury incidence of 120 per 1 000 player hours. These statistics were the highest ever recorded in a competition and set a trend for a new era of frighteningly higher injury rates.

In conclusion, from the first scientific documented studies a steady increase in rugby injury incidence was reported. However, since the turn to full professionalism these rates accelerated tremendously.

2.3 INJURY DEFINITIONS

As stated previously, definitions of injuries in rugby union are controversial. Huge discrepancies are seen internationally, and it seems that even authors in the same country tend to manipulate definitions to suite their studies and results. Historically, furthermore, rugby union injury definitions differ when the professional era is compared with the old amateur.

When the bigger rugby family is addressed and injury definitions are researched, the literature produces the following: Mainly four major rugby contact types are contested worldwide. These can be stated as the very popular and well known American Football, also known as Grid Iron; Australian Rules, very popular especially in the South Seas; Rugby League, again popular in the western world and last but not least, Rugby Union Football, as we know it in South Africa.

American Football (Grid Iron) identifies a rugby injury as a game injury in any football-related ailment that occurred on the field during a game, keeping a player out of competition for the remainder of the game and requiring the attention of a physician, and it includes all concussion, dental, eye and nerve injuries. Severity of injury (based on time loss) is recorded as mild (no limitations expected and either no time loss or players expected to return to football within 3 days), moderate (athletes returned within 4 to 14 days), or severe (long-term sequelae expected, and athletes expected to be out of football longer than 14 days). Furthermore injury prevalence is expressed as the percentage of players injured during the entire season at each grade level. Injury incidence is expressed as injuries per 1 000 player games (Stuart *et al.*, 2002).

Australian Rules has no currently available injury definition in the literature.

The third major rugby type, as mentioned, Rugby League defines an injury as any physical or medical condition that prevents a player from participating in a regular season (home and away) match. The rationale for this definition is that club "senior lists" (players rosters) are kept relatively constant throughout the season and the central Australian Football League (AFL) administration keeps a "player movement" record for every "senior list" player during every round of the season. A player is considered to have recovered from an injury when he returns to playing matches. An injury is considered to be a "recurrence" if the player suffers an injury of the same type to the same body part, on the same side as earlier in the same season (Orchard & Seward, 2002; Gissane *et al.*, 2002).

The last of the four rugby types is Rugby Union Football. As previously mentioned, much discrepancy is seen in injury definition. To simplify this matter, literature was researched and divided in to a pre- and post-professional era, whith 1995 being the date of the change. One of the oldest documented series of studies found, was done by Davidson (1987) from 1969 to 1986, in Australia. This study was done on 11- to 18-year-old schoolboys during all Saturday interschool rugby matches at a private school. After the inception of the study, both the diagnosis and the early management were documented for every injury reported to the casualty station operating during all matches. Injuries were defined retrospectively as “severe” or “minor” on a clinical assessment. Those injuries that were graded as severe included concussions and most fractures and dislocations and comprised mainly those injuries that resulted in some degree of incapacity. The less severe injuries included some contusions, sprains, lacerations and some fractures and dislocations, such as those that involved the small bones of the hands and feet (Davidson, 1987).

In South Africa, at more or less the same period in time, Roy (1974) did research on players seen at his one-man practice in a university town, Stellenbosch. His study did not cover the total number of injuries occurring in Stellenbosch, nor was controlled. Patients were seen on a random basis and were completely unselected. Only patients who completed a survey form were included. The survey extended from February to October 1973. Most of the patients were students from Stellenbosch University, although some school pupils were also included. Roy (1974) defined an injury as one resulting in a player requesting private medical treatment. Injuries were graded as 1st, 2nd and 3rd degree, depending on severity – 1st degree was a minor tear with no loss of strength; 2nd degree was a definite tear with loss of strength, but no abnormal motion; 3rd degree meant a complete rupture.

Myers (1980) did an Australian study on injuries presenting in rugby union football. For this study no injury definition was used, however reporting to the duty medical officer was recorded. Follow-up information concerning progress and hospital management was obtained in many cases. Injuries were classified as trivial, minor, major and serious.

In South Africa, Nathan *et al.* (1983) did a study on schoolboy rugby players. As an initial step to determine the true incidence of the injuries, they chose to study all injuries that occurred during the 1982 season in one school, which fielded 31 rugby teams ranging in age from under 10 to under 19 years. For the purpose of this study, 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 occurred. The authors stated two reasons for using this definition: (i) they felt that the degree of injury would be easily identified by the particular survey methods they used, whereas less serious injuries which did not prevent the player from playing rugby for 7 days would almost certainly go undetected; and (ii) trivial or minor injuries were of little short- or long-term consequence, and could safely be ignored as their inclusion would overestimate the true risk of playing rugby.

In the late 1980s, again in South Africa, under the auspices of the Cape Education Department Roux *et al.* (1987) did a study over an 18-week period, in which 26 high schools played 3 350 rugby matches. The schools presented the following regions: Western Cape, Boland, South-Western Districts, Eastern Cape and Griqualand. In this study Roux *et al.* (1987) used a similar definition, but not identical to the study of Nathan *et al.* (1983). They defined an injury as severe enough when a player is prevented from returning to rugby for at least 7 days. Included was that all concussions had to be reported even if the player continued to play. The latter portion was different from the definition used by Nathan *et al.* (1983).

Addley and Farren (1988), in their Irish survey on rugby injuries at Dungannon football ground, defined an injury as the presence of pain, discomfort or disability arising during and as a result of playing in a rugby match. A questionnaire was used to record injury details. Injured players were interviewed immediately after the match and in order to eliminate observer bias the authors themselves completed each questionnaire.

When we come to the 1990s, the drought years on research material is finally over. Six major studies were done in the early 1990s.

Clark *et al.* (1990) in his prospective study on the incidence and nature of injuries to adult rugby players used a similar, but not exactly the same definition, to that of Nathan *et al.* (1983) and Roux *et al.* (1987). An injury was defined as an incidenct that prevented a player from playing rugby for at least 7 days or that requires medical or surgical treatment. All cases of concussion were reported as injuries, regardless of the length of time unable to play.

A retrospective survey of rugby injuries in the Leinster province of Ireland was done by O'Brien (1992:243). His criterion for inclusion of an injury was "an injury insult which prevented the player form playing or training for at least 7 days and which required a consultation with a medical professional".

In Argentina, Bottini *et al.* (2000) did a study from 1991 up to 1997 on any rugby club affiliated to the Argentine Rugby Union (UAR). Injuries occurring in rugby games of all categories played during a single weekend (Saturday and Sunday) in different provincial unions of Argentina were prospectively registered. For this study, Bottini *et al.* (2000) defined an injury as a lesion sustained on the field during a competitive official match, who required either temporary replacement of the player because of an open or bleeding wound, or permanent substitution for the rest of that game. No reference was made to injuries sustained off the field or injuries sustained during other rugby activities.

In New Zealand, 1993, Gerrard *et al.* (1994) initiated the Rugby Injury and Performance Project (RIPP). This was a prospective study by a multidisciplinary research group. The aim of the study was to identify the influence of a previous injury, the use of safety equipment and the availability and significance of medical advice. Gerrard *et al.* (1994) defined an injury as a circumstance that required either medical treatment or caused the player to miss at least one scheduled game or team practice. This was regardless of whether injury was sustained during a match, practice or any rugby related activities. In the same year in New Zealand, Alsop *et al.* (2000) did a study on the patterns in the frequency, nature and circumstance of injuries occurring among a cohort of 356 rugby players during a club season. The same definition as used by Gerrard *et al.* (1994) was used for this project.

Also in the year 1993, Garraway and Macleod (1995) did a study on epidemiology of rugby football injuries in the Northern Hemisphere. They reported the frequency, nature, circumstance, and outcome of rugby injuries in a prospective cohort consisting of virtually all players registered with senior rugby clubs in the South of Scotland District of the Scottish Rugby Union (SRU). An injury was defined by Garraway and Macleod (1995) as sustained on the field during a competitive match, during a practice game, or during other training activity directly associated with rugby football and preventing the player from training or playing rugby football from the time of the injury, or from the end of the match or 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 activities undertaken to achieve fitness). Injuries which necessitated leaving the field of play or practice and missing the remainder of the match or practice, but which did not cause the player to miss subsequent matches or practice for at least 7 days, were classified as transient.

Lee and Garraway (1996) compared epidemiological injuries in school and senior club rugby. Their objective was to determine the frequency, nature, circumstances and outcome of schoolboy rugby injuries and to compare these injuries with those occurring in senior rugby clubs. In this study Lee and Garraway (1996) used exactly the same injury definition as Garraway and Macleod (1995), as stated earlier.

The end of the amateur era in rugby union has finally arrived. Certain changes in the game, financial structures, marketing and finally presentation are being introduced. The year 1995 is not only seen as the start of the professional era, but also a very important World Cup year for rugby union. Jakoet and Noakes (1998) found it appropriate to analyse the frequency and nature of all injuries sustained during the competition and to compare the findings with the published literature. For the purpose of their study, they defined a rugby injury as a new injury that necessitated the player's leaving the field of play for the remainder of the game. All lacerations were included, whether or not the player returned to the same match. A standardised injury report form had to be completed, giving details on personal information, site and type of injury, phase of play and playing position.

The Jakoet and Noakes (1998) definition differs from that of Garraway & Macleod (1995) mainly in that the study concentrated on *new* injuries sustained, disregarding chronic or overuse injuries, which might cause the player to leave the field. Secondly, injuries sustained in training or in rugby related activities were not reported. However, they did include details on the site and type of injury, phase of play and playing position, which were good additional data.

In Croatia, Babic *et al.* (2001) under the auspices of the Croatian Rugby Union did a study on rugby epidemiology and other characteristics of injuries in the first Croatian-

Slovenian rugby league (CSRL). For the purpose of their study, Babic *et al.* (2001) used Garraway and Macleod's (1995) definition as stated earlier.

March 1996 saw the birth of the Super 10 (later to become the Super 12) competition played between the major rugby-playing "powerhouses" of the southern hemisphere. This was seen as the toughest regional rugby competition in the modern era (Holtzhausen, 2001). In 1997 Targett (1998) did a Super 12 study on injuries in professional Rugby Union. Again, the 1995 rugby injury definition was altered. Targett (1998) defined an injury as that which prevented a player from participating fully in two training sessions, from playing the next week or that required special medical treatment (such as suturing and special investigation).

In the 1997 – 1998 season Lee *et al.* (2001) did a study on the influence of preseason training, fitness and existing injury on subsequent rugby injury. The authors used and implemented the same definition as in the 1993-1994 studies of Garraway & Macleod (1995) who also participated in this study. In short, a rugby injury was defined as an injury sustained on the field during a competitive match or during training that prevented the player from playing or training from the time of injury or from the end of the match or training session during which the injury was sustained.

One of the more recent major studies in Rugby Football Union was done in South Africa. Holtzhausen (2001) researched the incidence and nature of injuries in South African rugby teams during the 1999 Rugby Super 12 competition. For the purpose of their study, an injury was defined as one that prevented a player from playing or participating in squad training, or one that required special medical treatment (medication, suturing and radiographs). All cases of concussion were recorded. Acute and chronic overuse injuries were included if these criteria were met (Holtzhausen *et al.*, 2001). The severity of an injury was assessed by recording the number of games and training sessions missed. Injuries were classified as minor if three or fewer sessions were missed, intermediate if four to nine sessions were missed (less than three weeks) and serious if 10 or more sessions were missed (more than three weeks). Holtzhausen (2001) used this definition to allow comparison with a study on injuries to first-grade players in the Australian Capital Territories Rugby Union (ACTRU) competition (Hughes & Fricker, 1994).

The Holtzhausen (2001) definition is similar to Targett's (1998) as applied to the Super 12 competition, but not the same, the main difference being the number of days missed from training. The Holtzhausen (2001) study can be seen as more sensitive in respect of injury classification. A player missing any squad activity or training was seen as injured, where as in the Targett (1998) study the player had to miss at least two training sessions before being classified.

As can be seen from the literature, the definition of rugby injuries has varied tremendously through time. A less sensitive definition, with an obvious lower injury rate and incidence, was seen and used in the second half of the previous century. In modern times, with definitions like those used by Targett (1998) and Holtzhausen (2001), a more sensitive and detailed definition has come to light. This being one of the possible contributing factors towards higher incidence and injury rates as seen in the latest research. For the purpose of this study, the definition as described by Garraway & Macleod (1995)was used. A rugby injury is defined as an injury sustained on the field during a competitive match, during a practice game or during other training activity directly associated with rugby football and which prevented the player from training or playing rugby football from the time of the injury or from the end of the match or 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 activities undertaken to achieve fitness). Injuries that necessitated leaving the field of play or practice and missing the remainder of the match or practice but which did not cause the player to miss subsequent matches or practice for longer than 7 days were classified as transient. Injuries were classified according to time elapsed to resumption of playing or training: within 28 days, mild; 29-84 days, moderate; more than 84 days, severe.

2.4 REASONS FOR HIGH INJURY RATES

Since the earliest literature on injury epidemiology, authors and researchers attempted to explain the possible reasons for the so-called injury problem.

O'Connell (1954) in the first article on rugby football union injuries identified the following aspects as playing a role in injuries:

- Improper pre-season preparation of players.

- Improper protection of certain body parts (strapping, padding etc.).
- Rigid corner flags and unpadded goalposts.
- Debris on field of play (stones and animal faeces).
- Lastly, improper rehabilitation of injured players before returning to the game.

These were remarkable observations for their time. O'Connell (1954) concluded that rugby football union is an amateur game and that players should accept the knocks that are going with the spirit of the sport. However, without any undue interference in the spirit or the rules of the game, protection against many avoidable injuries could be achieved.

An article on the nature and frequency of rugby injuries in Stellenbosch, South Africa was published by Roy (1974). Three hundred reported injuries were statistically analysed. Roy (1974) identified four possible reasons for the high injury incidence. Foul play and improper refereeing during the game were the cause of unnecessary hardship and pain. Based on the large number of lower limb injuries seen in his study, Roy (1974) assumed that boot design played a major role. Lastly, the lack of proper medical and first aid protocols to be followed by on duty medical personnel attending matches also contributed. Roy (1974) concluded that much could be done by improving medical attendance at matches and training, thereby making rugby a safer game without necessarily sacrificing the features which make it, when played properly, so attractive to so many.

In Ballymore, Brisbane, Myers (1980) published his article on "injuries presenting from rugby union football". The aim of his survey was to document adult rugby union injuries as they presented to the medical officer at a major ground and to classify these injuries. During the 1979 rugby union season, 221 club and representative matches were played at Ballymore grounds. From these matches, 271 players reported injured. The author found an injury rate of 0,032 injuries per player hour. Myers (1980) suggested the following reasons for injury statistics:

- A significantly increasing trend was seen from lower to higher levels of play.
- Site, nature and severity of injury could be related to position and the level of play.

- Collapse of the scrum leading to neck muscle strain and costochondral joint injury.

- Players with the highest level of fitness also had the highest injury rate. According to the author, increased vigour, determination, speed of play and possible malice were culprits.

In contrast to popular belief, Myers (1980:19) stated in his study that "collapse of the scrum produced no cervical spinal injuries". He finally concluded that in injury prevention it was the more serious injuries that should be addressed.

The article "Rugby football injuries, 1980-1983" (Sparks, 1985) was done by the former medical officer on school rugby played at Rugby, England. Injuries sustained were recorded and analysed recording to age, experience, position, phase, and duration of the game and phase of the season. A high injury incidence was seen in the earlier weeks of the season Sparks (1985) blamed this phenomenon on unfitness and excessive keenness on the side of the players. He further found an increased incidence when comparing the younger with the more mature groups, except for the under fifteens where musculo-skeletal development gave the players little time to adapt. Lastly, he concluded that the tackle was predominantly the most injury prone phase, followed at a distance behind by the rucks and set scrums. This was an interesting statement made by the author, considering the year and the fact that law changes on set pieces were only introduced in the year 1988. It was concluded by Sparks (1985) that his survey did not pretend to offer any firm views on the prevention and management of rugby football injuries.

Addley and Farren (1988) did an injury survey on all rugby played on the Dungannon rugby ground in the season 1986-1987, Ireland. The data was categorised according to time of injury, phase of play, team position, and nature of injury. In total 84 players presented with injuries. During the eight-month season 40 matches were studied giving a total of 1 200 player appearances. Injuries were correlated with the various phases of play, which occur during a game. Eighty-seven per cent were sustained in player-to-player contact whilst a further 13% were associated with non-body contact, thus running. It was further suggested that match fatigue played a major role in the injury incidence. As regards the phases of play, tackling and second-phase ball handling were found to be the most dangerous. Fix phases, like the scrum, played a much smaller role in injuries, although severe spinal region injuries could occur during this phase. The authors concluded that although the incidence of serious injuries was low in Ireland, a major lack of comprehensive data collection existed.

In South Africa, Clark *et al.* (1990) in their study on the incidence and nature of injuries to adult rugby players compared results with two similar studies done on South African schoolboys (Nathan *et al.*, 1983; Roux *et al.*, 1987). Eight first-division senior rugby teams from clubs in the Cape Peninsula were selected and before the rugby season began, contact persons were informed on the aims and methods of the research. Seventy-eight players suffered a total of 114 injuries during the 1988 season. The researchers found that injuries most often occurred during the tackle, open play and loose scrum, and that 85% of injuries occurred during matches and the rest during training. Clark *et al.* (1990) concluded that senior club players suffered similar injuries than their schoolboy counterparts. However, differences existed between these two groups in respect of skills, aggression, attitude and commitment.

A Canadian study published by Badley (1990) on rugby football injuries researched the type and frequency of injuries, in which phase of play they had occured and whether additional law changes might reduce incidence. It was found that existing laws governing scrum collapse and mauls, with the new International Rugby Football Board (IRFB) amendments of laws relating to engagement of scrummage and the definition of dangerous tackles, should have been sufficient to reduce injuries. Strict enforcement of rugby laws should be the responsibility of the referees, by which means they could control the safety of the players. Appropriate attitudes of players and proper skills and techniques in the game should be provocated by coaches.

O'Brien (1992:243) hypothesised that "Rugby Union Football is a high-speed contact sport and has a significant incidence of injury". He did a retrospective survey of rugby injuries in the Leinster province of Ireland for the period 1987-1989. A questionnaire was completed by 50 senior rugby players, which presented 23% of the rugby-playing population. Details on the type and site of injury sustained during the previous three seasons had to be reported. A total of 120 injuries were reported, giving an injury incidence of one in 31 appearances. This is more than double the figure quoted by O'Connell (1954) in his study. O'Brien (1992) blamed this phenomenon on the faster, stronger and fitter player of the modern era. Secondly, there were law changes in rugby union allowing:

- the differential penalty leading to running and the 'Garry Owen-kicking' of the bal; and.

- running of the fullback and three-quarters from defence in counterattack, leading to an increase in 'open-field' injuries.

The author concluded on the basis of the above that rugby football was a high-speed contact sport with significant incidence of injuries.

In New Zealand in 1993 Gerrard *et al.* (1994) launched the Rugby Injury and Performance Project II (RIPP II) to identify previous injury experience of a rugby-playing cohort. The initial phase of data collection in this study involved a pre-season questionnaire which, among other things, sought to establish variables relating to the past injury experience of players. The influence of previous injury, the use of safety equipment and the availability and significance of medical advice were among the variables identified by individual questionnaires. The RIPP study found that due to the robust nature of the sport, a rugby player was likely to suffer at least one significant injury in the course of the season. This was alarmingly high for 1993. Due to the nature of the game, a significant number of players could be expected to carry the lingering consequences of previous trauma to the following season. The RIPP pre-season data showed that player keenness resulted in their returning for trial games and selection opportunities despite inadequate rehabilitation. Gerrard *et al.* (1994) found it reasonable to assume that players were unwilling to jeopardise selection by identifying pre-season injury. A last statement emphasized by the authors highlighted the inappropriateness of pressure being exerted by coaches on players for premature return to the game.

Gerrard *et al.* (1994) often linked chronic injury to the lack of use of safety measures such as headgear, mouth guards and prophylactic strapping. This once again accentuated the inappropriate rehabilitation and treatment of chronic and overuse injuries, also the lack of regard for the use of protective equipment. The authors found a disturbing 39% player refusal to adhere to popular medical opinion. According to the survey, this opinion was seen as representing the conservative end of the therapeutic spectrum. This fact highlighted the need for trained, experienced and specialised medical personnel in the sport.

During the same period as Gerrard *et al.* (1994), Bird *et al.* (1998) launched the fifth Rugby Injury and Performance Project (RIPP) on injury epidemiology during a season of rugby. A prospective cohort study followed 356 male and female rugby players throughout the competitive club season. Players were interviewed by telephone each week to obtain information on the amount of rugby played and the injury experienced. Bird *et al.* (1998) stated that despite the vigorous nature of the game, it was of concern that such a large proportion of players reported injury per season, especially injury with the potential risk of long-term musculo-skeletal effect and the cumulative effects of trauma to the head. In their study, an injury incidence of 16 per 1 000 player hours was reported. Rates examined within player groups showed higher proportional injury rates for senior grades. The possible reasons for this were blamed on higher level of skills, fitness, experience, and intensity. These findings correlated with the Gerrard *et al.* (1994) study. Williams and Blake (Bird *et al.*, 1998) have offered several possible explanations for this increased rate, including the increased size and strength of players, the higher level of competitiveness, increased vigour, increased aggression, more foul play and more matches during the season. The authors stated that physiological fatigue might also be a further contributing factor.

In the same year as the RIPP II study, Lee & Garraway (1996) in Scotland did a prospective cohort study on epidemiological comparison of injuries between school and senior clubs. Their objective was to determine the frequency, nature, circumstances and outcome of injuries. This study was the first of its kind to compare injuries in schoolboy versus senior club rugby in Britain. The following facts were found at school level:

- An increase in school rugby injury prevalence associated with age. The older the player, the higher the incidence. This correlated with the findings of Bird *et al.* (1998).
- The smaller size and lower strength of younger boys resulted in fewer injuries.
- Due to the compulsory attendance at younger levels, the enthusiasm and competitiveness of younger boys were less than that of older pupils who had the choice to choose rugby from among other sports.
- More dedicated players had a greater risk of injury than their peers.

- When comparing school with club level, the following were found:

- Senior club players were generally more committed to rugby, which lead to an earlier return to play despite injury. The proportion of players completing the game or training session in which they were injured further highlighted this phenomenon.

- Schoolboys had a much higher rate of upper limb and concussion injuries than their club counterparts. The authors attributed this to inexperience.

- In conclusion, it was stated that schoolboy rugby was much safer than rugby at senior club level.

Wekesa *et al.* (1996) did an injury survey during the qualifying tournament for the 1995 Rugby World Cup in Kenya. In this study all injuries that led to temporary stoppage of the game or to the substitution of a player during a match were recorded. Forty-seven injuries occurred, giving an injury rate of 8% per match. The authors experienced an injury decrease from 38,3% in the opening matches to 23,4% in the final rounds. This phenomenon was blamed on the decrease in enthusiasm by the participants. Secondly, the authors found more injuries occurred in the defensive half of the field of play than in the offensive half. The time of the injuries showed that only 38,3% of injuries occurred during the first half of the match, while 61,1% of injuries occurred during the second half. Specific situations of the game such as set scrums, rucks and mauls, led to heavy bodily contact and injuries. Wekesa *et al.* (1996) concluded that protective equipment should be introduced to minimise the number and seriousness of injuries.

Jakoet and Noakes (1998), in the 1995 World Cup, did a study on injury rate. The study was an analysis of all new injuries requiring medical attention during the competition. Data were collected by the duty match doctors at each of the venues. The authors found that the larger size, greater speed and superior competitiveness and commitment of the best rugby players in the world were reasons for the higher injury rates. The overall incidence in this study was 32 injuries per 1 000 player hours. However, in the final matches there was an injury incidence of 43 per 1 000 player hours. The Jakoet and Noakes's study supported the findings of Bird *et al.* (1998) and the Lee and Garraway (1996) studies, which concluded that a higher level of competitiveness leads to a higher injury incidence.

In the same period (1995), Edgar (1995) did an article on rugby tackle injuries. He quoted Garraway and Macleod (1995), stating that rugby is the sport with the highest injury risk per player hour. From the late 1970s the increasing numbers of rugby injuries in general and broken necks in particular raised concern among medical officers. As a result, strong medical representations in several countries influenced the International Rugby Football Board to adopt new rules, which was agreed on in 1986. The new laws targeted the following three areas: collapse of the scrum, prolonged rucks or mauls, and spear or high tackles. At school level, players were to be matched for experience and size, rather than for age. These changes brought about a safer environment in the first phase of play, as a bonus, a more fluent and spectacular pleasing play.

Alsop *et al.* (2000) did a study on temporal patterns in the frequency, nature and circumstances of injuries occurring among a cohort of 356 rugby players during a club season in New Zealand. In their study they found an overall reduction in injury rate. However, this was more pronounced in certain research categories. Although this supported findings in the Jakoet and Noakes (1998) study, the finding was controversial for the period, compared to other popular literature. This study showed a sharp peak in injury incidence at the end of the season, the possible reason of which according to the authors, could be blamed on the intensity of competition finals.

Bottini *et al.* (2000) studied the incidence of the most commonly sustained injuries in Argentinean rugby and analysed them according to type, position and age of the players, and phase and time of play. This was a study done over the period 1991 to 1997, except for the year 1996, on different provincial unions. Their data were collected during a randomly chosen whole weekend each year, between the months June and July. All their information gathered during these six years was subjected to statistical analyses. Players were divided into age groups, namely a junior (8 – 21 years of age) and a senior category (adults above 21). Their study specifically amplified different age injury tendencies. It was found that the junior players statistically had a three times greater risk of suffering either muscular or ligament injuries of the cervical column. The position at highest risk was hookers. Possible reasons for this tendency were stated as a lack of game skills and experience.

On the contrary, senior players experienced four times the amount of lacerations and lesions to the facial area. This confirmed that more playing experience does not necessarily reduce the risk of injury to this area, and could be linked to a more aggressive attitude to the game.

Bottini *et al.* (2000) also addressed the phase of play as a reason for injury. He stated that speed, tackle, and counterattack were key tactical features in modern rugby, so it is no wonder that the most common mechanism of injury was the loose play. This finding supported the Bird *et al.* (1998) and Jakoet and Noakes (1998) studies.

Lee *et al.* (2001) did a study to examine the influence of preseason fitness, existing injury, and preseason rugby training on subsequent injury in the Border Reivers District of the Scottish Rugby Union (SRU) during the 1997-1998 season. These three factors were evaluated as possible culprits for their influence on injury rates. Apart from a presentation of a preliminary study to the Fourth World Congress of Science and Football in 1999, this was the first report to examine preseason physical activity, fitness, and injury, and to relate the former to the injury. In this study 675 injury episodes occurred to 423 (53%) players during training or in matches. Lee *et al.* (2001) found that there was a 3,9% increase in injury rate for each additional preseason training week attended, and a 61% relative increase for those players who had been injured or were carrying an injury at the end of the previous season. Injury risk was more likely to be related to rugby training than to overall player fitness.

Wilson *et al.* (1999) published an article on the nature and circumstances of tackle injuries in rugby union, thus, assessing the possible reasons in the tackle that causes injury. They used RIPP (Gerrard *et al.*, 1994) data and supplementary information from analysis of the New Zealand Rugby Football Union (NZRFU) videotape on tackle injury events. Their results were as follows:

- Seventy percent of injuries occurred when the player was running or diving/falling to the ground. The authors did not find this phenomenon strange and blamed it on the physical characteristics of the game. The injury mechanisms most frequently observed in the tackle were impact with other players (61%), ground impact (21%) and interpersonal impact (twisting or torsion) (18%).

- The authors found that 30% of injuries occurred with the player stationary on the ground. They explained this phenomenon as due to holding in the tackle, falling or stepping on the grounded player.

- Wilson *et al.* (1999) found that front-on tackles had a 300% higher injury incidence than either side-on or tackles from behind.

- They further compared trunk tackles (57%) with tackles below the hips (43%), and found that the high trunk tackle played a much larger role in the injury incident.

- The falling phase in the tackle was mostly associated with the injury, however 'going with the impact' or 'turning in the tackle' reduced injury incidence.

- Lastly, it was found that the supporting player, helping with the tackle or the freeing of the ball, played a 21% role in the injury incidents.

Lee and Garraway (2000) wrote an article on the influence of environmental factors on rugby football injuries. The aim of their study was to establish the influence of weather and pitch conditions on the frequency and nature of rugby injuries. In their results they found that environmental conditions could significantly affect how players perform, and affect the frequency of injuries. They further stated the importance of understanding the hazards of exercise under different environmental conditions if injury frequency was to be reduced. This factor was more important in team sports, where participants' involvement on the field of play may be infrequent, and when the sport was played in adverse weather conditions. Furthermore, Lee and Garraway (2000) found that the state of the pitch did not appear to influence the risk of injury. The authors did not use any objective means to establish pitch conditions and there may have been inter-observer variations in subjective judgements made by the different physiotherapists involved.

According to Davies and Gibson (1978) 40% of injuries occurred on hard playing surfaces, and the remainder of injuries took place on very soft and wet pitches. Inglis and Stewart, in 1981 quoted by Noakes & Du Plessis (1996), attributed an equal amount of injuries to hard and soft surfaces. In South Africa Van Heerden reported similar findings (quoted by Noakes & Du Plessis, 1996). Roy (1974) in South Africa found that 57% of knee injuries occurred in the first three months of the season, March to May. This is the time of year when the grass on the fields is heavy and thick, with a firm root system. He hypothesised the entanglement of the boots stuts with the roots, with consequent vulnerability of the knee joint. He further found a substantial decrease of injuries in this area after the first winter rains, in the Western Cape province. In 1984 a study done by Williams (quoted by Noakes & du Plessis, 1996) found similar results on pitch quality to Inglis and Stewart (quoted by Noakes & Du Plessis, 1996). However, Williams found the type of injury sustained on a hard versus a soft surface varied.

At the start of the new millennium Babic *et al.* (2001), under the auspices of the Croatian Rugby Union, did a study on rugby injuries in a country where this sport is not particularly popular. Their aim was to analyse the epidemiology and other characteristics of injuries in the first Croatian-Slovenian rugby league (CSRL). Factors taken into consideration were anthropometric statistics and body composition. The authors found that:

- Croatian rugby had more than double the amount of match injuries when compared with the so-called more developed rugby played in Scotland.

- There were no statistically significant differences in anthropometric characteristics, body composition or the constitution of injured and uninjured players. However, the authors found that heavier and bigger players with higher fat percentages had a 2,5 times greater risk of being injured. This compares well with the New Zealand study of Bird *et al.* (1998).

- Lastly, it was found that players in lower divisions (less experienced) had a higher risk of injury than their counterparts. This correlates with the inexperience phenomenon described earlier by Bottini *et al.* (2000) and Lee and Garraway (1996).

- Targett (1998) in his Rugby Super 12 study, focused on the reasons causing high injury rates during the tournament and aimed to establish a pilot study for further research. The author found that:

- A higher grade and intensity of rugby leads to a higher injury incidence. This correlated with the Jakoet and Noakes (1998) study.

- Due to the nature of the Super 12 competition rugby activities are now spread over a 12-month period. This include pre-season and in season activities, and leaves the players without a break.

- Time zone travel, due to geographical settings in the competition, was unavoidable and further constituted a stressor to the players.

- Lastly, altitude differences had to be overcome. This was a problem in al three countries but particularly in South Africa.

Garraway *et al.* (2000) published an article on the impact of professionalism on injuries in rugby union. The objective of their study was to measure the frequency and nature of injuries occurring in competitive matches since professionalism has been introduced. A cohort study previously conducted in the Scottish Borders in the 1993-1994 seasons was repeated in the year 1997-1998. The same definition, outcome criteria, and method of calculating playing hours were used. Garraway *et al.* (2000) found that in the professional era players sustained twice the number of injuries that the amateur group did. This phenomenon was explained as over-training and an inadequate preseason rest period found similarly in the Targett (1998) Super 12 study. The authors further found that the professional era players had a shorter time off period post-injury. Two possible reasons for this were hypothesised, namely monetary involvement and more professionalism in medical support. Lastly, changes in the laws since the first survey were seen as aggravating factors in the increase of injury incidence.

In South Africa, Holtzhausen (2001) did the second Super 12 study on rugby epidemiology. The aim of his study was to document the incidence, nature and risk factors associated with injuries during the 1999 Super 12 rugby competition. As with the studies of Garraway *et al.* (2000) and Targett (1998), they found that insufficient preseason break, over-training and early return to play after injury were the reasons for the high incidence of recurrent injuries.

From 1994 to 2000, Bathgate *et al.* (2002) did an Australian study on elite Wallaby rugby players. Their objective was to assess injury patterns and incidence and to compare this with lesser rugby-playing levels. The study found that the injury rate increased at higher levels of play. This contradicted the findings of Babic *et al.* (2001), but supported those of Bird *et al.* (1998) and Jakoet and Noakes (1998). Secondly, it was found that rugby injury rates had increased significantly post-1995, which was the year in which professionalism was introduced.

In conclusion, fifteen reasons (See Table 2.1) for the increased tendency in rugby epidemiology have been discussed in the literature above. The year 1995, when rugby union became a professional sport, can be seen as the turning point not only from amateur to professionalism but also low injury incidence to the modern high rates seen today.

Since the change to professionalism in 1995 the game has undergone a virtual metamorphosis. Statistics shows on average four times the number of tackles and rucks per player in the modern-day game,. thus making it far more dangerous and the players more liable to injury.

New Zealand's statistics over the last 26 years has shown a weight increase of 16-19 kg on average for a back line player. This consits of predominantly lean body mass, and fits in with the modern-day era of the so-called super-athlete: stronger, faster, bigger and better.

Leuan Evans former Wales and British Lions winger after 10 years of international rugby, stated: "...rugby used to be a far less physical game. It has changed from a contact sport to a collision sport where my body has to absorb a pounding from players twice my size" (Wilson, 2000).

According to Wilson (2000) the tackle area has evolved into a ferocious battleground and it is mostly here that the game is won or lost, rather than at the scrum or lineout, as a generation ago. The modern game is played mostly in the second phase. The team that can physically dominate the tackle area by gaining the hard yards when attacking or forcing opponents back when defending is the team that wins the game regardless of first-phase possession. The nature of the tackle has also changed. Players nowadays aim for the upper chest in order not only to stop the opponent but also to force the ball carrier backwards and, if violent enough, to make him lose ball control. Terminology like "big hit", "high shot" and even "multiple-direction tackles" are the order of the day (Wilson, 2000).

Fitness levels and dedication to the game as well as the complete commitment of players on the field is now being reflected in the hours spent improving fitness, strength and speed, according to David Young, former captain of Wales. When a survey was done on the Wales international rugby squad in 1990 by Lynn Davies, only 3 out of 30 players spent regular time in the gym (Wilson, 2000). Nowadays all players not only spend a substantial amount of time in the gym, but very specific and advanced training programmes are being followed.

The last factor that essentially changes rugby from the old to the new is the number of games per season (Quarrie *et al.*, 2001). Gareth Edwards, former Wales and Lions player, played an average of 16,25 games over a 12 month period. In contrast, Dallaglio, former captain of England and the Lions, played an average of 35 games per season.

In summary according to literature, speed, momentum and size are the major contributing factors to rugby injuries.

Table 2.1: Major factors contributing to reasons for injury incidence not rugby?

Factors	Reference
Foul play	Roy (1974); Bird et al. (1998)
Level of competitiveness	Myers (1980); Lee & Garraway (1996); Bird *et al.* (1998); Jakoet & Noakes (1998); Targett (1998); Alsop *et al.* (2000); Babic *et al.* (2001); Bathgate *et al.*, (2002).
The tackle	Sparks (1985); Wilson *et al.* (1999); Bottini *et al.* (2000).
Size of the player	Lee & Garraway (1996); Bird *et al.* (1998); Jakoet & Noakes (1998); Babic *et al.* (2001).
Professionalism	Garraway *et al.* (2000); Bathgate *et al.* (2002).
Number of games per person	Bird *et al.* (1998).
Age / Experience	Sparks (1985); Lee & Garraway (1996); Bird *et al.* (1998); Bottini *et al.* (2000); Bathgate *et al.* (2002).
Preseason preparation	O'Connell (1954); Myers (1980); Sparks (1985); Bird *et al.* (1998); Targett (1998); Garraway *et al.* (2000); Holtzhausen (2001); Lee *et al.* (2001).
Protective equipment	O'Connell (1954); Gerrard *et al.* (1994).
Environmental factors	O'Connell (1954); Roy (1974); Lee & Garraway (1996).
Carrying injury	O'Connell (1954); Gerrard *et al.* (1994); Lee *et al.* (2001).
Medical regimes & refereeing	Roy (1974); Gerrard *et al.* (1994).
Attitude	Myers (1980); Sparks (1985); Lee & Garraway (1996); Jakoet & Noakes (1998).
Skills	Badley (1990); Bird *et al.* (1998); Bottini *et al.* (2000).
Law changes	Badley (1990); Edgar (1995).

2.5 INJURY INCIDENCE

As set out in paragraph 2.3 above dealing with injury definition, injury incidence in rugby has seen its fair amount of change. The earliest available literature on injury incidence can be found in medieval times. It has been stated: "The game commenced when the ball or similar object was thrown into the centre of the assembled villagers; thereafter it is likely that anything was acceptable since there were few, if any, rules governing the game... Ambushes and drowning were common as rivals took the opportunity to settle private animosities and simmering feuds" (Noakes & Du Plessis, 1996:10). It is clear that in this period injury or injury incidence was seen as and associated with gross disablement and sometimes unfortunate death.

Many decades later when the sport was popularly played at English public schools, a few rules were introduced, with the aim of reducing injury and make the game safer. Rules which agreed upon specifically banned tripping, running with the ball and especially hacking, an offensive technique which allowed the shins of an opponent to be kicked anywhere between the knee and ankle provided he was facing his aggressor and was not held at the time. Historically in 1863 rule changes finally differentiated between the game of soccer (dribbling game) and of rugby (handling game).

The first study of injuries to rugby union players in 1954 was that of O'Connell (1954). No injury definition or injury per player-hour rate existed during those times. However, certain recommendations, as discussed earlier, were made to make the game safer and to control injury risks. His recommendations were remarkable, considering the period of time.

In 1973 Roy (1974) did a study on the nature and frequency of rugby injuries. The aim of the study was threefold:

- To determine the pattern of injury and associated factors;
- To determine the role of late tackles, foul play and equipment; and
- To identify dangerous phases in the game.

Roy (1974:2321) stated that: "Few will deny that rugby is a dangerous sport". Widespread participation in South Africa in that period of time meant thousands of injuries were occuring without being scientifically monitored or reported.

Roy (1974) divided the training and match period into quarters, comparing the likelihood of injury in these various periods. He found that injury rate was fairly consistent throughout, though slightly more injuries occurred during the third quarter. He further found that the total number of injuries in any one-month appeared to be more related to the amount of rugby played than any other factor. Roy (1974), however, did not define the incidence as injury per 1 000 player hours, which makes comparison with later studies difficult.

Myers (1980) published an article called "Injuries presenting from rugby union football" on injuries experienced in Ballymore during the 1979 rugby season. A total of 271 players reported injured to the duty medical officer. Myers (1980) reported an injury rate of 0,032 per player-hour, or alternatively 1,23 injuries per game, or 0,041 injuries per player appearance. He further found a significant increase in injuries from the lower to the higher level. Suggestions were made on improved player, coach and referee awareness of the injury-prone phases of play. He finally commented that the risk element of contact sports could not be eliminated for it was this which "mixed with the elements of activity, skill and competition makes the right prescription for so many men" (Weightman & Browne, 1974).

In the period 1980-1983, Sparks (1985) in the town Rugby, studied the injuries sustained by players at one English public school. He analysed his documented injuries by age, experience, position, phase, and duration of the game and of phase of the season. The author found an injury incidence of 194/10 000 player hours, thus 0,019 per hour. A large proportion of these presented early in the season. He further stated that injuries increased with age, due to physical maturation. Unfortunately injury definition was not quantified or clarified by the author.

The study of Nathan *et al.* (1983) on the incidence and nature of rugby injuries experience at one school during the 1982 rugby season specified the amount of time spent on matches and rugby training during the season as 31 185 hours. A total amount of 79 injuries was recorded, 29 of which occurred during practice and 50 during matches. Nathan *et al.* (1983) expressed their incidence as the number of injuries per boy-hours of rugby (15 boys playing for 1 hour equals 15 boy-hours of rugby). One injury for every 395 boy-hours of rugby was reported. If this is transformed to the modern injury per 1 000 player hour, an incidence of 2,53 injuries per 1 000 player hours was seen. In this study injury statistics were further divided into primary and secondary school. A substantial difference could be seen between these groups when injury incidence was considered: the secondary school had an incidence of 1/243 boy-hours and the primary school 1/1044 boy-hours.

A study on the epidemiology of schoolboy rugby injuries (Roux *et al.*, 1987) was done during one 18-week season, in which players from 26 high schools played 3350 rugby matches. The authors reported 495 injuries, of which 353 occurred during matches and 142 during practices. A total amount of 3350 matches were played. The overall injury incidence was 1 injury for every 142 boy-hours in match play, and during practices 1/1 825. The pattern of incidence was found to be low among the under-14 age groups and gradually rose during higher age groups. It was specifically high for the under-19 age group, which amounted for 20% of all the injuries. Roux *et al.* (1987), as in the case of Nathan *et al.* (1983), highlighted the difference in injury incidence between matches and practice sessions.

Davidson (1987) published an article on schoolboy rugby injuries during the period 1969 to 1986. For this period a casualty station operated during all Saturday interschool rugby matches at a private school. All presenting injuries were documented, and for the first time classified as mild, moderate or severe. In the mentioned period 1 444 boys were seen, of whom 116 sustained injuries that were classified as being severe. A further two injuries were classified as serious, being a scull fracture and a fracture-dislocation of the cervical spine. Davidson (1987) in his study reported an incidence of 176/10 000 player-hours, or 1,56/100 player-games, this incidence being substantially higher than in the Nathan *et al.*, (1983) study. Furthermore, Davidson (1987:120) did not found an increase in incidence through the 18-year period and stated that: "There is no evidence to suggest that the game has been played more violently in recent years".

During the 1986-1987 Irish rugby union season, Addley and Farren (1988) did their survey on all rugby played at the Dungannon football club. In this 8-month period, forty matches were studied giving a total of 1 200 player appearances. A total of 84 injuries were documented, giving an injury incidence of 1 per 14 appearances. In conclusion Addley and Farren (1988) felt that there was a lack of comprehensive data relating to rugby injuries in Ireland and suggested further specific research to solve this problem.

In Canada in the 1990s, Badley (1990) wrote an article which was prompted by the Refereeing and Laws Committee of the Canadian Rugby Union. They established a Safety Committee whose charge was to determine the type and frequency of injuries in Canadian rugby, furthermore to identify the dangerous phases of play, and to consider whether additional law changes might be necessary to reduce *injuries.* The author collected data on all participating Canadian rugby clubs in a one-week period. During the specific week 111 participating teams engaged in 135 games and 224 practices. Senior teams were involved in 254 of these events, 30 junior teams reported on 99 events, and the remaining six events involved women's teams. In total 100 injuries were reported, 75 senior and 20 junior during match play, a further five senior injuries were sustained in practice. Badley (1990) expressed this injury incidence rate as losing a player every 1,42 games, or alternatively an individual player presenting with an injury every 21,3 games. He identified definition criteria in previous studies to be lacking in standardisation and classification of 'what is an injury'.

Clark *et al.* (1990) in his prospective study of the incidence and nature of injuries to adult players used a similar definition than that used by Nathan *et al.* (1983) and Roux *et al.* (1987) a few years earlier. The authors found an overall injury incidence rate of 1/171-player hours, with 1 for every 60 player hours during matches and 1/780 during practice. The authors further found a higher injury incidence for senior players when compared to junior groups. Seventy-eight players suffered 114 injuries during the season. Ninety-seven injuries (85%) occurred in matches and 17 (15%) during practices. The majority of the match injuries (88%) occurred during league fixtures as opposed to friendlies (6%) and other matches (12%). Clark *et al.* (1990) concluded that although there are some similarities in injury distribution between adults and school players, some definite differences exist:

- adult players have a higher injury rate (65%);
- adult injuries are more severe (13% prevent further participation for the season);
- schoolboy training injury incidence is higher than in the case of adult players;
- adult hookers are more at risk than their schoolboy counterparts; and
- schoolboy players are at higher risk in the tackle.

Gerrard *et al.* (1994) in their RIPP II study in New Zealand used a pre-season questionnaire, which related to the previous 12-month injury experience. Three hundred and fifty-six rugby union players, according to Gerrard *et al.* (1994), would sustain at least one substantial injury during the season. The number of rugby injuries during a full season experienced by any one player during the 1992 rugby season might range form

0 to 11 different injuries. A cumulative total of 583 rugby-related injuries were reported, with an incidence of 1,4 injuries per player season.

Garraway and Macleod (1995:1485) stated that with the exception of spinal cord injuries, the frequency and consequences of rugby injuries are not clearly understood. They consequently did a study on epidemiology of rugby football injuries, which was published in the *Lancet* in 1995. The authors did a prospective cohort study involving all the senior rugby clubs in the Scottish Borders. All personal details and information of 1 169 eligible players were reported over a 12-month period. Information on acute and recurrent injuries were collected on a weekly basis. In total 361 players experienced 584 injuries in 512 injury episodes, and 84% of these injuries arose during match play. Garraway and Macleod (1995) had a period prevalence of 13,95 per 1 000 player hours. This is the equivalent of an injury episode every 1,8 rugby matches. They conclude that: "Rugby injuries are an important source of morbidity in young men. They need to be better understood if their frequency and consequences are to be reduced".

In the same period of time Lee and Garraway (1996) did a comparative study on injury incidence between schoolboy and senior club rugby, also in Scotland. The study was a cohort study conducted on 1 705 players from nine Edinburgh schools and 1 169 players from all 26 senior Scottish Rugby Union clubs. Hundred-and-fifty-four school players (9%) experienced 210 separate injuries in 186 episodes, 80% of which arose in matches. The authors expressed the incidence rate as 73,9/1 000 player-seasons. Senior club match injury incidence was 160,4/1 000 player-seasons. These statistics showed four times the amount of injuries at senior club level when compared to their school counterparts. The authors concluded that schoolboy rugby was much safer than senior club rugby and the outcome of injuries occurred were less disruptive.

Bird *et al.* (1998) in the year 1993 used RIPP data (Gerrard *et al.*, 1994) and wrote an article on epidemiology of a season of rugby injury. Their objective was to describe the incidence, nature and circumstances of injury experience by a cohort of rugby union players during a full competitive club season. Information on 4 403 player-game and 8 653 player-practices was collected. A total of 671 injury events were reported, of which 569 were rugby related. The authors found higher injury rates for games when compared with practices. Males, at 10,9 injuries per 100 player-games, had a higher injury incidence than their female counterparts at 6,1 injuries per 100 player-games. In conclusion the study revealed that rugby injuries were common among the study subjects and differed according to grade and gender.

With the third Rugby World Cup held in South Africa in 1995, Jakoet and Noakes (1998) did their study on the rate of injury during the competition. Their objective was to determine the frequency and nature of injuries sustained by 416 players from the 16 participating countries. Forty-eight preliminary and seven final-round matches were played. A total of 70 injuries were sustained, 58 of which occured during the preliminary matches. The frequency for this part of the competition was 32 injuries per 1 000 player hours. In the last 7 final-round matches the frequency increased to 43. Overall injury frequency was 1 injury every 0,8 matches during the preliminary and 1 every 0,6 matches during the final rounds. Jakoet and Noakes (1998) found that the injury incidence in this competition was the highest ever recorded. They concluded that the risk of injury was therefore greatest in the best players in the game, challenging the view that superior fitness, skill and experience can reduce the risk of injury.

Targett (1998) in the first Rugby Super 12 competition article, concentrated on documenting injury rates in professional rugby players and to act as a future pilot study. He found an incidence rate of 120/1 000 player-hours, with the significant injuries at 45. These were identified as being significant if they made the player invikved miss 7 days of training or the next match. He concluded that injury rates increased with the increasing level of rugby (supporting the Jakoet and Noakes (1998) study). Furthermore, there is a pressing need for the collection of accurate ongoing standardised epidemiological data on injuries in rugby.

Garraway *et al.* (2000) did a study on the impact of professionalism on injuries in rugby union in Scotland. The aim of their study was to measure the frequency and nature of injuries occurring in competitive matches since the advent of professionalism. They found that, when comparing their 1993-1994 study with the 1997-1998 season, there was a 100% increase in rugby injury incidence, despite a 7% reduction in the rugby-playing population. This translated into an injury episode every 3,4 matches in 1993-1994, rising to one in every 2,0 matches in 1997-1998. An injury episode occurred in a professional team for every 59 minutes of competitive play. Garraway *et al.* (2000) concluded that the introduction of professionalism in rugby union coincided with an increase in injuries to both professional and amateur players.

An Argentinean study was done by Bottini *et al.* (2000) in the period 1991 to 1997. In their study they researched the incidence of the most commonly sustained injuries and analysed them according to type, position and age of the players, and phase and time of play. A total of 924 injuries were registered in 1 296 rugby games, involving 38 933 players. Bottini *et al.* (2000) found a mean incidence of 2,4 % per rugby-playing weekend. Furthermore in contrast with popular data, Garraway *et al.* (2000) and Bottini *et al.* (2000) in their studies did not find a remarkable increase in injury incidence in Argentine rugby post-1995. The authors concluded that injuries are the cause of significant morbidity among rugby players in Argentina. This is similar to the statement made by Garraway and Macleod (1995). They further suggested that a more thorough investigation and a greater understanding of the mechanisms are crucial in order to update the rugby laws and reduce this high injury incidence.

In the year 2001 Babic *et al.* (2001) published their article on Croatian rugby injuries. They found an injury incidence of 28,22 per 1 000 player hours during matches and 1,24 during training. These statistical findings fitted in well with the earlier Jakoet and Noakes (1998) study. However, Babic *et al.* (2001) found that clubs in Croatia playing at a lower level were at higher risk of injury than their more advanced peers. This is in contrast to the work of Lee and Garraway (1996); Bird *et al.* (1998); Jakoet and Noakes (1998); Targett (1998) and Garraway *et al.* (2000).

Holtzhausen *et al.* (2001) did an injury epidemiological study on the South African teams participating in the professional Rugby Super 12 competition. In their study a total of 740 player game hours and 4 900 player training hours were recorded. Their overall injury incidence was 55,4 injuries/1 000 player game hours, and 4,3 injuries/1 000 player training hours. Twenty-four per cent of injuries were sustained during training, and chronic overuse injuries accounted for 10%. The authors concluded that they found a high injury incidence during the competition; however, a large proportion of these injuries were classified as minor.

The most recent literature published on rugby injury epidemiology was done by Bathgate *et al.* (2002). This was a prospective study from 1994 up to 2000, in Australia. The aim of their study was discussed earlier in the chapter under *Reasons* paragraph 2.4. A total of 143 injuries were recorded from 91 matches. In their study an overall injury incidence rate of 69/1 000 player hours were recorded. When comparing pre-professional with professional era, incidences of 47/1 000 player hours versus 74/1 000 player hours were documented. The authors concluded that injury rates increased at higher levels of play, supporting the findings of Lee and Garraway (1996), Bird *et al.* (1998), Jakoet and Noakes (1998), Targett (1998), Garraway *et al.* (2000) and Holtzhausen *et al.* (2001). Injury rates in rugby have almost doubled since the inception of the professional era. Furthermore, most injuries are now seen in the third quarter of the game, supporting Roy (1974). Lastly, the authors suggested the need for standardisation of data collection in rugby union.

With all the information on rugby incidence discussed, a strong tendency can be followed from the earliest to the most modern literature. Slowly but surely, the incidence rate increased with a sharp acceleration after the introduction of professionalism, and a further increase in the late 1990s with the introduction with the fully professional competitions.

2.6 THE INJURY AS SUCH

As can be seen with the historical mutation of rugby, the epidemiology, and more specifically the injury, has changed, especially since the professional era in 1995. Under this section the type, the anatomical region and the player at risk, will be focused upon.

O'Connell (1954) in his article on rugby football injuries and their prevention, stated "apart from risks arising from inherent defects in the player or his equipment, most injuries arise from physical contact with:

- other players,
- the playing field, goal posts and touch flags,
- ...the ball".

He further identified four phases of play, which mainly contributed to injuries.

- The scrum: The front row was identified as a high-risk area in the scrumming manoeuvre, and particularly the hooker. Violent impact and scrum collapse were responsible for the more serious injuries (fractures and dislocations in the head and neck). The second and third row had a particular high risk in the shoulder and ear cartilage areas.

- The tackle: O'Connell (1954) stated that the tackle, to the inexperienced eye, was the most spectacular and seemingly the most dangerous phase of play. However, he remarked that when the players were trained and conditioned it was not necessarily so. But he blamed the high tackle and "hand-tripping" for dislocations, lacerations and fractures of the facial and upper-limb area.

- The loose play: Here players were mostly injured when kicked, trodden and fallen on. The head and knees were the body parts that were mostly at risk.

- Line-out: Barging from shoves in the back or shouldering on the players way up were blamed for most of the injuries. He identified the player as being unsafe once he had possession of the ball. Most common injuries were to the ankle and knee joints.

In *Figure* 2.1 the body parts most often injured in the O'Connell (1954) study are represented, the head and shoulder areas being at highest risk.

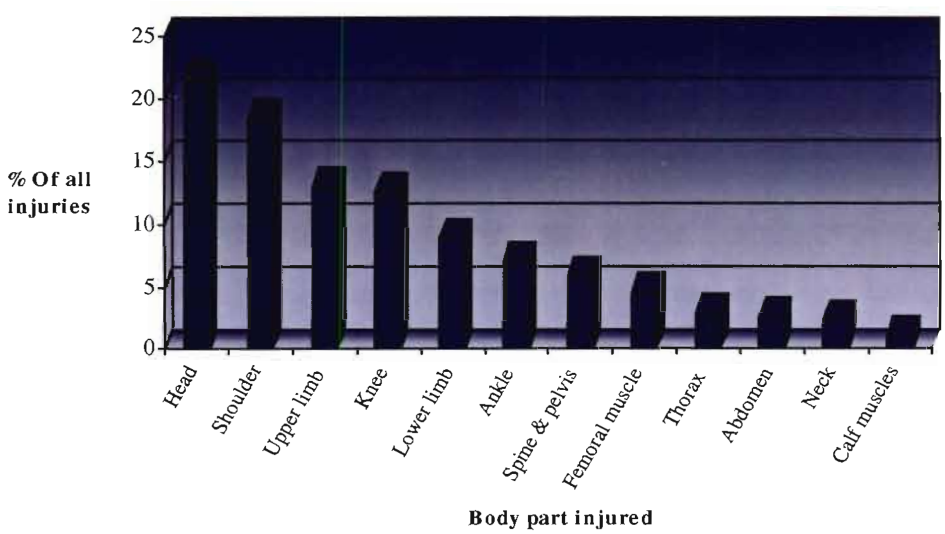


Figure 2.1: General analysis of all injuries (O'Connel, 1954)

A pilot study in Stellenbosch done by Roy (1974) researched the nature and frequency of rugby injuries. The author did not discuss phase of play when considering the injury. However, he did identify tackling without the ball, loose-scrum and foul play for causing 34% of all injuries, 35% of these being ankle injuries, and 29% knee injuries. Sixty-one per cent of facial injuries occurred without ball possession. Of this, 48% was due to deliberate foul play. The author further discussed player position at risk. In *Figure* 2.2 a summary of injury percentage per player position is given. Highest at risk was the eighth man, with the safest position being the scrumhalf.

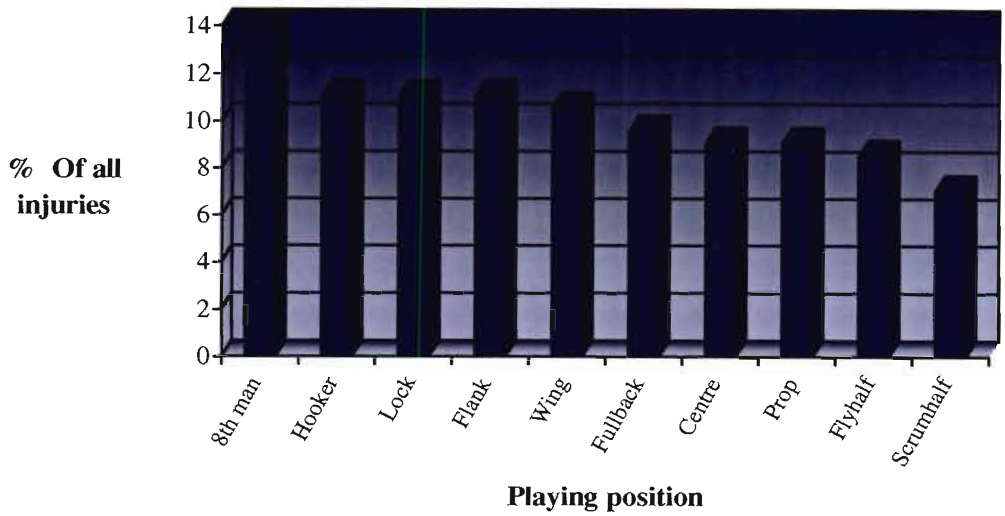


Figure 2.2: Injury frequency by position (Roy, 1974)

The author (Roy, 1974) identified rupture of the spleen, prolonged concussion, temporary brachial plexus palsy and hyperflexion of the thoracic spine as the more serious injuries in his study, excluding injury to the long bones and joints.

Walkden (1975:201) in his study on the medical hazards of rugby football stated that "the rugby player utilises the basic motives of rivalry by combining the ethics of sporting competition with instinctual aggression; he takes part for the sake of his own enjoyment; indeed this is one of the axioms of Rugby Football Union. Once the player crosses the touch-line he is prepared to undergo sporting risks on the playing field. A certain number of injuries are inevitable; if injuries can be reduced enjoyment will be increased". He analysed all injuries necessitating medical attention from 1964 up to 1975 occurring at Twickenham. On average 30 matches were played and a 1 000 rugby players were involved per season. He further found an incidence of 100 injuries per season, with a gradual increase since 1970. The author identified:

- 1,7% of injuries as being serious. (the rest being either mild or moderate). Of these serious injuries, 5,7% were fractures, 54% in the facial area predominantly among backs.

- Head injuries comprised 6,5% of the total, 30% of these being sustained by the full-back.

- 20% of all injuries sustained were joint-related. 30% were to the ankle joint and 70% of these were again sustained by the backs. In the shoulder (20%) and knee (20%) joints, there was no difference in injury between the forwards and backs.

- Musculotendonous lesions comprised 25% of injuries. 50% of these were haematomas, and they were more prevalent among the backs.

- Miscellaneous group of injuries comprising of 30,8%

- According to the author the cutaneous injuries were the main culprit for the increase in injury epidemiology seen from 1970. Suturing was required for 53% of lacerations, and of these 70% were to the facial area and 75% of all suturing was done on forwards.

Walkden (1975) concluded that injury incidence varies according to player position and that the player in the so-called 'hot-seat' was the scrumhalf, contradicting Roy's (1974) findings.

Injuries to the cervical spinal cord covered 20 injury cases admitted to the Conradie Hospital, Cape Town (Scher, 1977). Eight players (40%) were injured during the scrum and a further 12 (60%) during the tackling phase. All of the scrumming cervical injuries sustained were fracture dislocations, 7 of which had bilateral and 1 unilateral locking. According to the author the bilateral locking caused severe disruption and severance of the cord, leading mostly to death. In scrumming, cervical flexion plus scrum collapse with continuing forward pressure amount to an ideal situation for cervical cord disruption, a fact that is supported by Torg *et al.* (1990). Scher (1977) did not found a particular pattern of injury during the tackle phase. However, he identified 3 major components contributing to cervical cord injuries:

- Flexion-rotation violence: In this mechanism, as with scrumming, either unilateral or bilateral facet locking can occur.

- Vertical compression forces: This mechanism leads to compression or burst compression fractures of the vertebral body.

- Hyperextension forces: Due to the mechanism, fracture of the spinous process and neural arch of C2 (axis) may occur.

In the study by Scher (1977) six (30%) of the 20 players died shortly after injury. In five cases death could be attributed to respiratory complications, while 1 patient died under anaesthesia. Scher (1977) concluded that although these injuries were fortunately not common, they were absolutely devastating, leaving the unfortunate player, if not dead, then at best paralysed, with a high risk of further complications and a poor long-term outlook on life.

Hoskins (1979) did a similar study on rugby injuries to the cervical spine in English schoolboys. For his study the author contacted all spinal injury units in the United Kingdom. Information from medical officers and headmasters of rugby-playing schools was gathered. Thirty-three injuries leading to tetraplegia or death were reported over a 36-year period (1942-1978), as seen in Table 2.2. The author identified scrumming, loose-play and the tackle to be contributors. As with Scher (1977), it was found that scrummaging played a role in 40% of these injuries, with the rest (60%) being attributed to loose-play and tackles.

Time span	Injury incidence
1942 – 1968	5
1973 – 1978	12
1971 – 1978	16
36 years	**33**

Table 2.2: Occurrence of cervical spinal region injuries

Hoskins (1979) concluded that there was no doubt that an increase in schoolboy cervical spine injuries was evident. The essential differences between adult and schoolboys were as follow:

- Schoolboys were not at liberty to choose whether to participate in this sport or not.
- Few boys playing were covered by accident insurance, which left the player with an enormous financial burden and a lifetime of tetraplegia.

In the Myers (1980) article on 'injuries presenting from rugby union football' the author reported that the head and neck was the most frequently injured anatomical region with 146 injuries (52%) (*Figure* 2.3). The types of injuries that presented in this region were lacerations, followed by unconsciousness, fractured nose, soft tissue injuries, neck injuries, fractured mandible, and lastly cauliflower ear. The second most common injured region was the lower limb, with 57 injuries, contributing to 21% of the total. The body parts most often injured were the knee, followed by the ankle and hip, with lastly some types of soft tissue contusions. The upper limb region at 51 injuries contributed to 19% of the total, anatomical sites injured were the acromioclavicular joint, shoulder, forearm, and lastly the hand. In these regions the most common types of injuries presented were fractures, dislocations, subluxations, sprains and lacerations. Lastly, the trunk region followed with 23 injuries (8%), and this region was subdivided into chest wall, abdominal and visceral areas. The major portion of these injuries presented in the chest wall area, these being fractures, strains and sprains.

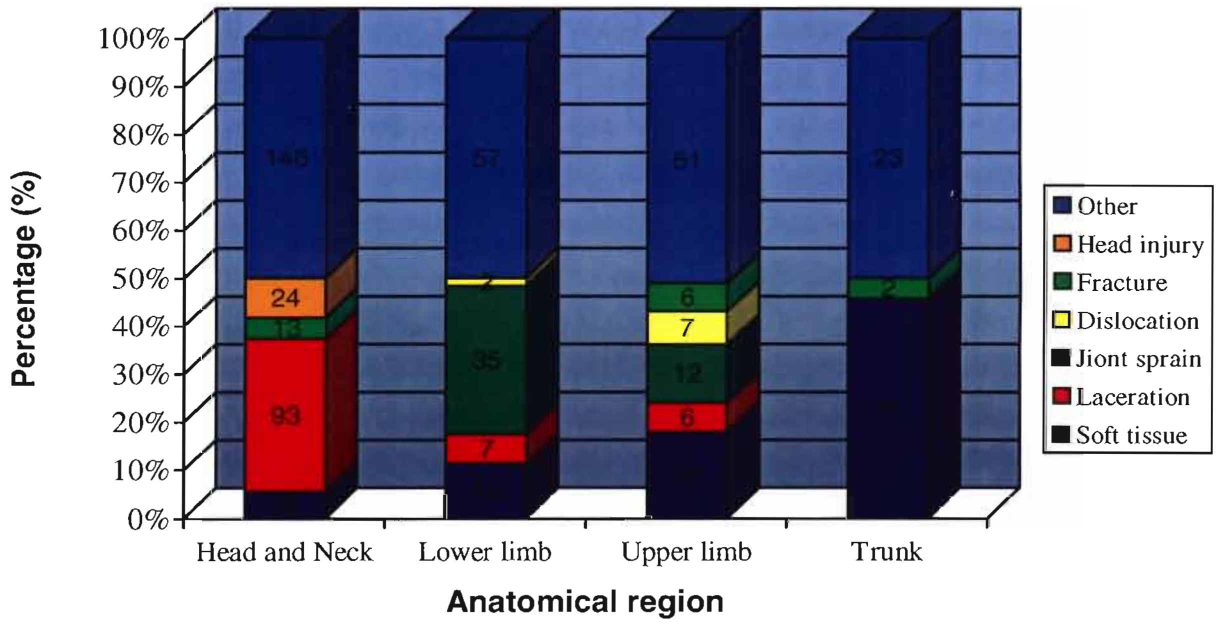


Figure 2.3: Anatomical regions injured (Myers, 1980)

Myers (1980) found that the position of fullback closely followed by flank/tight forward (scrum-half) and halfback were the highest at risk, supporting the Davidson (1987) study. Forwards and backs sustained more or less the same number of injuries, but varied in pattern in his study.

Burry and Gowland (1981) in their 6-year New Zealand survey on cervical injuries stated that there was no evidence of an increase in injury incidence. This contradicted the 36-year survey of Hoskins (1979) done on English schoolboy rugby. The authors recorded 5 deaths, 11 permanent severe spinal insults, 9 temporary quadriplegia and 29 minor to moderate injuries. When considering all rugby played in New Zealand a cervical incident will occur once in every 333 000 exposures.

As with the Hoskins (1979) study the authors identified the scrum, more particularly the formation of the scrum, as the danger phase, with the young player more at risk. The ruck and maul was identified as a further danger area. Burry and Gowland (1981), with reference to the scrumming manoeuvre, identified the front row, and particularly the hooker, to be the positions at risk. In loose play, the front row and backs were identical in injury incidence. In conclusion, the authors felt that proper selection and coaching would reduce such hideous injuries, furthermore that very necessary rule changes should be introduced in the fixed phases of the game to protect players.

Nathan *et al.* (1983) in their study on the incidence and nature of rugby injuries experienced at one school during the 1982 rugby season in South Africa found that the months of April and July had the highest injury incidence of the season. They blamed this phenomenon on improper pre-season preparation on the players, and more particularly on the July mid-winter break.

As did Myers (1980), the authors found the hooker (31,6%), full-back (14,7%), eighth man (12,6%), scrum-half (10,5%) and fly-half (8,4%) to be the playing positions most at risk. Anatomical regions parts mostly affected were (*Figure* 2.4):

- Upper limb, in total 23 injuries (29%);
- Lower limb, in total 20 injuries (25%);
- Head and face, in total 20 injuries (25%);
- Neck, in total 10 injuries (13%); and
- Trunk, in total 6 injuries (8%).

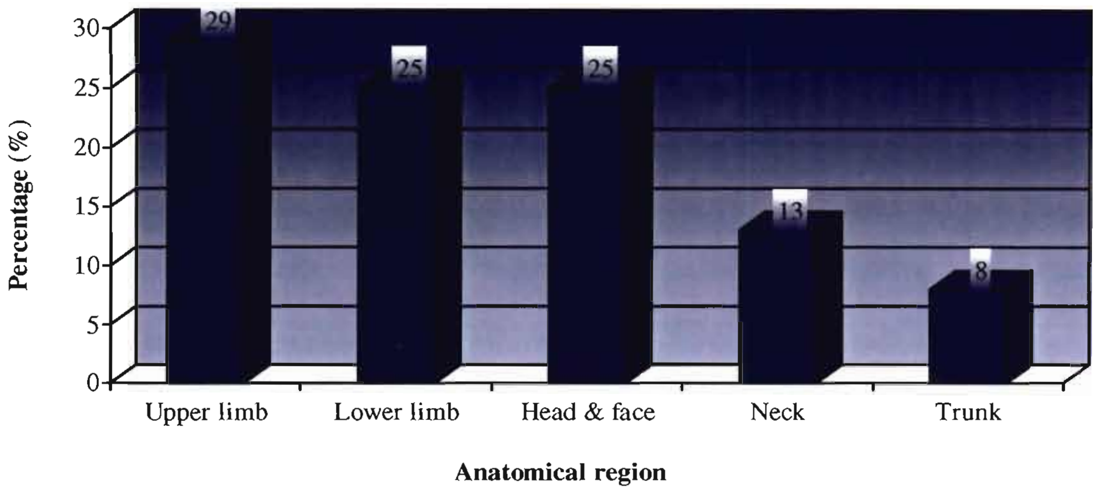


Figure 2.4: Percentage of anatomical regions injured (Nathan et al., 1983)

These regions compares well with the Myers (1980) findings. Nathan *et al.* (1983) found the most common types of injuries to be concussions, muscular and ligamentous injuries.

Sparks (1985) in his study on rugby injuries found the prop (13,3%), wing three quarter (13,0%), lock (12,8%) and flanker (12,1%) to be the player positions most at risk. The rest of the positions followed at more or less the same ratio (7,7%). Concerning the phase of play the tackle (39,6%) was identified as the most dangerous, correlating well with Myers (1980) and Nathan *et al.* (1983). This was followed by the ruck and maul (25,6%), tight scrum (11,9%), open play (9,7%), and lineout (1,4%) (*Figure* 2.5). The author further divided the game into four quarters, identifying the first and last to be the most injury prone. The anatomical region most commonly affected was the lower limb (36,3%). This differs marginally from the Myers (1980) and Nathan *et al.* (1983) findings. The upper limb and 'head and neck' regions followed at 26,5% and 26,8%, respectively. Lastly, trunk injuries presented at 10,4%.

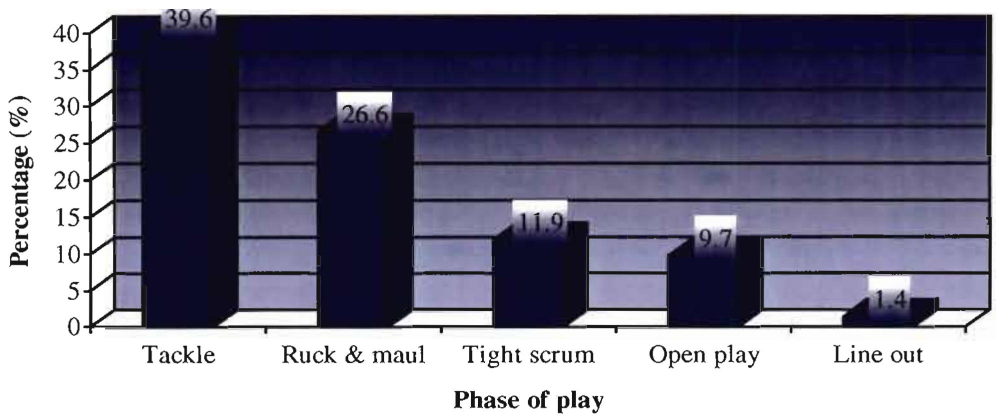


Figure 2.5: Injury occurrence in phase of play (Sparks, 1985)

As with the Hoskins (1979) and Nathan *et al.* (1983) studies, Roux *et al.* (1987) did a study on schoolboy rugby epidemiology, in South Africa. They found injury incidence to be higher for the months April and July, correlating well with the Nathan *et al.* (1983) and Clark *et al.* (1990) surveys, but contradicting the work of Davidson (1987). Secondly, they found the eighth man to be the most dangerous playing position, supporting Roy's (1974) findings. Safest positions were tight-forward and scrum-half, contradicting Walkden (1975) and Burry and Gowland (1981).

When phase of play is considered, tackling (55%) and the loose scrum and maul (18%) were the most dangerous (*Figure* 2.6), comparing well with Sparks' (1985) findings. Body parts highest at risk were firstly the lower limb (37%), followed by head and neck (29%) and upper limb (20%), correlating with Sparks (1985), but contradicting Myers (1980) and Nathan *et al.* (1983). Lastly, the most common types of injuries were fractures (27%), ligament/tendon injuries (25%) and muscle injuries (17%), with underreporting of concussions. This differs from Nathan *et al.* (1983) where concussions (22%), muscle injuries (22%) and ligament injuries (18%) were the main contributors.

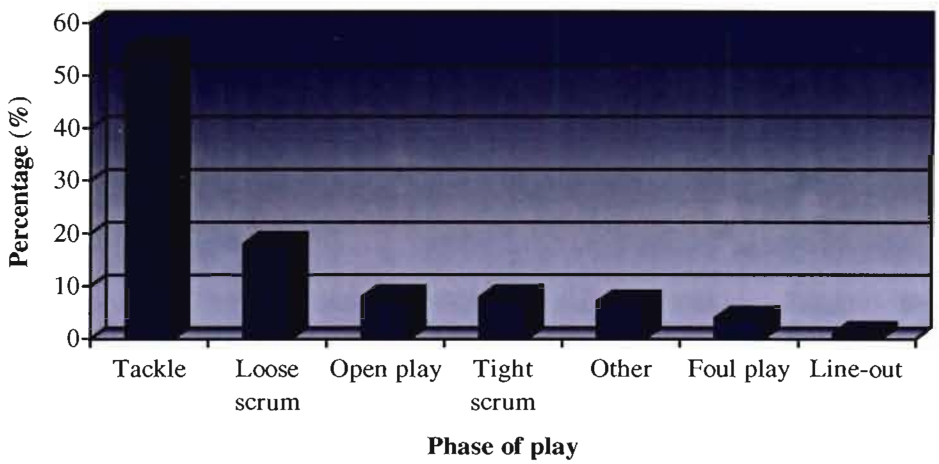


Figure 2.6: Injury occurrence in phase of play (Roux et al., 1987)

Addley and Farren (1988) in their Irish injury survey found the second and fourth quarters during competition to have the highest injury incidence. This was similar but not exactly the same as the Sparks (1985) findings. The authors divided injuries into contact and non-contact phases, with the first contributing to 87% and the latter to 13% of incidence. Player position is further divided into forwards and backs, with the forwards attributing to 60,5% of injuries (*Figure* 2.7). The authors identified the most dangerous playing position to be open-side wing forward (flanker). Anatomical body part most commonly injured (lower limb) correlated well with the Roux *et al.* (1987) and O'Brien (1992) studies, but differs from Sparks (1985), Walkden (1975), Roy (1974) and Myers (1980), who found the head and neck area to be the most commonly affected site. Lastly, the type of injuries recorded by the authors correlated well with the findings of Roux *et al.* (1987) , these being muscle/tendon strain, ligament/joint sprain and bruising.

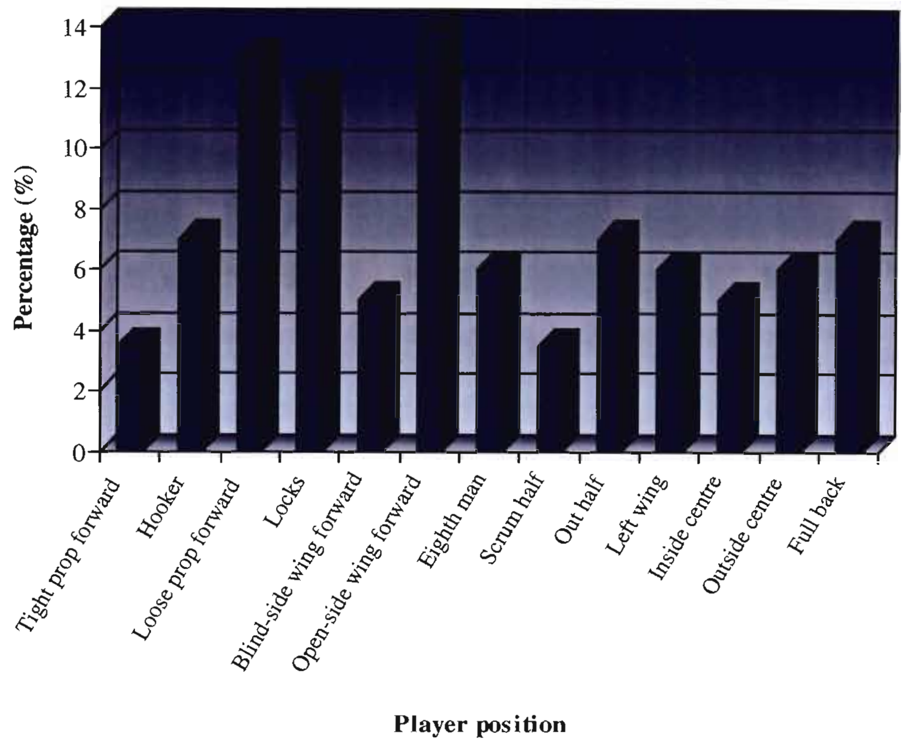


Figure 2.7: Player positions mostly at risk (Addley & Farren, 1988)

Clark *et al.* (1990) in their study on rugby injury incidence in South Africa found that hookers, wings, fullbacks and centres were the most commonly injured players (*Figure* 2.8). This compares to a degree with the work of Sparks (1985) and Myers (1980). The phases of play that largely contributed to injury incidence were identified as tackling, open play and loose scrum. These findings generally support the above-mentioned studies. Muscles (33%) and ligaments (32%) were the anatomical structures most often injured. The authors concluded that adult rugby players sustained more serious injuries and are more often injured. They are less likely to be injured in training and are not as highly at risk than their schoolboy counterparts in the scrum.

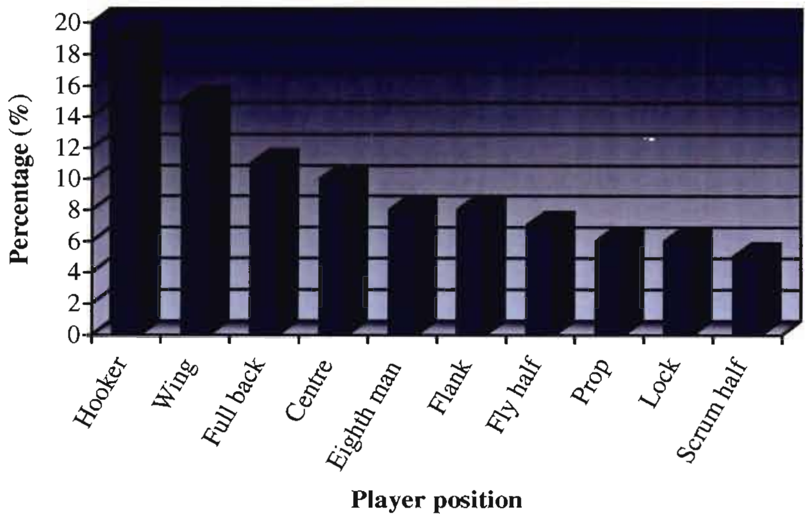


Figure 2.8: Player positions mostly at risk (Clark et al., 1990)

Badley (1990:7) in his Canadian study hypothesised that "existing laws that govern the collapse of scrums and mauls, (introduced in March 1988) together with the newly introduced IRFB amendments of laws relating to engagement of the scrummage and the more precise definition of dangerous tackles, should be sufficient to reduce injuries in these areas, provided that they are consistently applied". However, when considering phase of play, player position and type of injury no substantial difference was seen statistically when compared with the literature. He finally remarked that despite certain law changes to decrease injury rate, a high incidence still prevailed, and that further law changes were necessary.

Scher (1991), in his publication on spinal cord rugby injuries, remarked that although a decrease in injuries was seen in Europe and New Zealand (since the 1988 law changes), the same tendency did not show in South Africa. In his study he found the tackle phase to be responsible for the majority of region injuries and not the scrum as in the past. The high tackle (foul play) and the diving action were blamed for these catastrophic spinal region injuries in South Africa. This finding supported the work of Noakes *et al.* (1999).

O'Brien (1992) stated that law changes had ensured a faster, more spectacular game where the full back and three-quarters run out of defence in counterattack. This led to an increase in 'open-field' and tackling injuries, supporting Scher's (1991) hypothesis.

Gerrard *et al.* (1994) in the RIPP II study found that the forward players were at higher risk than their back-line counterparts, with a ratio of 2,2:1,8 injuries per player season. Anatomical sites affected correlated well with the work done by Roux *et al.* (1987) and O'Brien (1992). In *Figure* 2.9 types of injuries are displayed, the majority being attributed to muscular strains and sprains. This differs from earlier work, where cutaneous lacerations and abrasions were in the majority (Roy, 1974; Myers, 1980; Sparks, 1985).

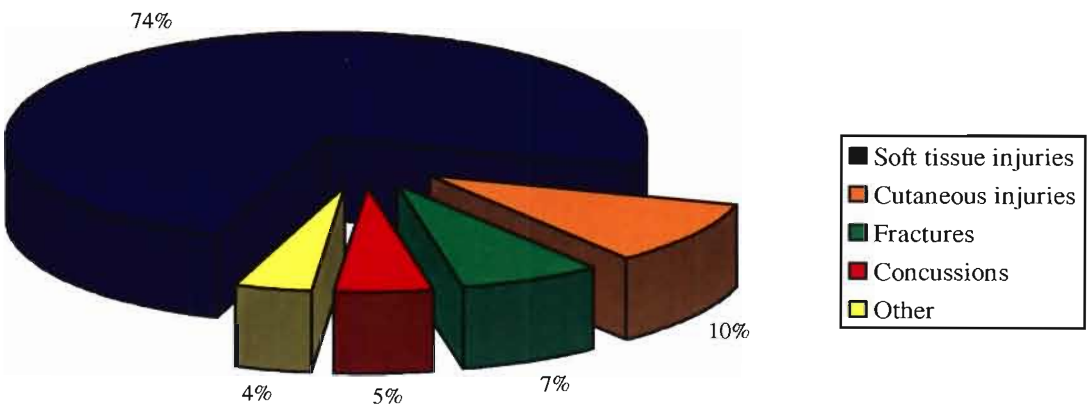


Figure 2.9: Distribution of type of injury

Garraway and Macleod (1995:1485) stated that "with the exception of spinal cord injuries, the frequency and consequences of rugby injuries are not clearly understood". They defined the tackle as being the most dangerous phase of play (49%), contributing to the more severe types of injuries (fractures, dislocations, strains and sprains). In their study the authors found the spring (September-October) and autumn periods (March-April) to be particularly high in injury incidence. The most often affected anatomical site, as with earlier authors, was the lower limb. Garraway and Macleod (1995) did not find any significant difference in player position when the injury was considered. However, forwards sustained three times more trunk injuries than backs. They concluded that more should be known about the tackle, the mechanism and the risks. Recent law changes (1988) were blamed for the increased incidence in tackle injuries, supporting Scher's (1991) findings. They concluded that "the challenge now is to sustain the popularity of the game while lessening the hazard of high-velocity contact in the tackle" (Garraway & Macleod, 1995:1487).

Lee and Garraway (1996) in their comparative study on injury incidence between schoolboy and senior club rugby found that 64% of schoolboy rugby injuries were associated with the tackle. The authors defined the tackle as tackling or being tackled. They further found that 33,3% of schoolboy injuries occurred in the month of September. Senior club players had higher match injury prevalence for all types of injuries. The scrum, ruck and particularly the tackle were identified as risk phases for senior players. When considering player position, schoolboys like their senior club counterparts had an equal distribution of injuries between forwards and backs. However, the type of injury distribution differed. Schoolboy forwards sustained more upper limb strains, sprains and dislocations, whereas the back-line sustained all the reported lower limb fractures (*Figure* 2.10). Senior club forwards, on the other hand, sustained 70% of fractures to the head, neck and face areas, whereas senior backs had more upper limb dislocations, strains and sprains (*Figure* 2.11). The authors concluded that rugby played at school level was safer than that played at senior clubs, injuries were not as serious and less time off was lost.

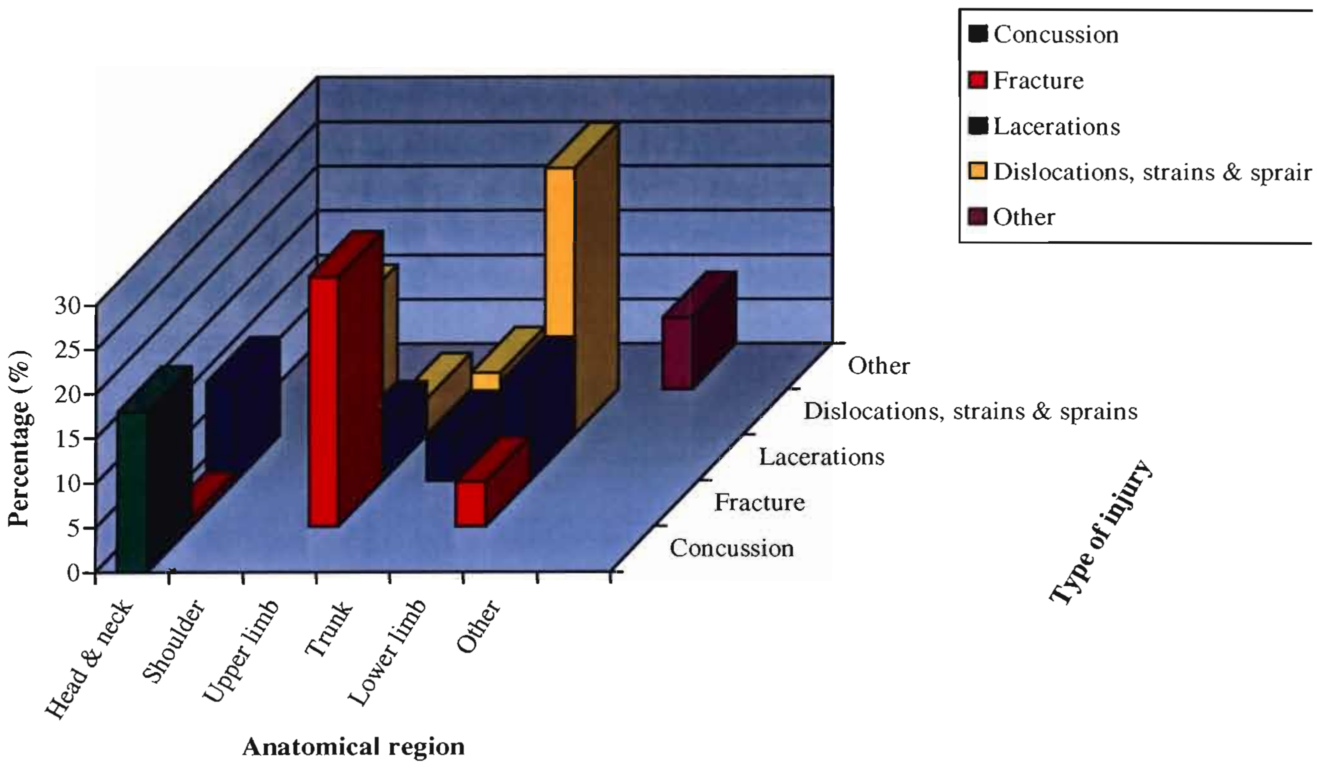


Figure 2.10: Distribution of anatomical region injuries and the type of injuries in school rugby (Lee & Garraway, 1996)

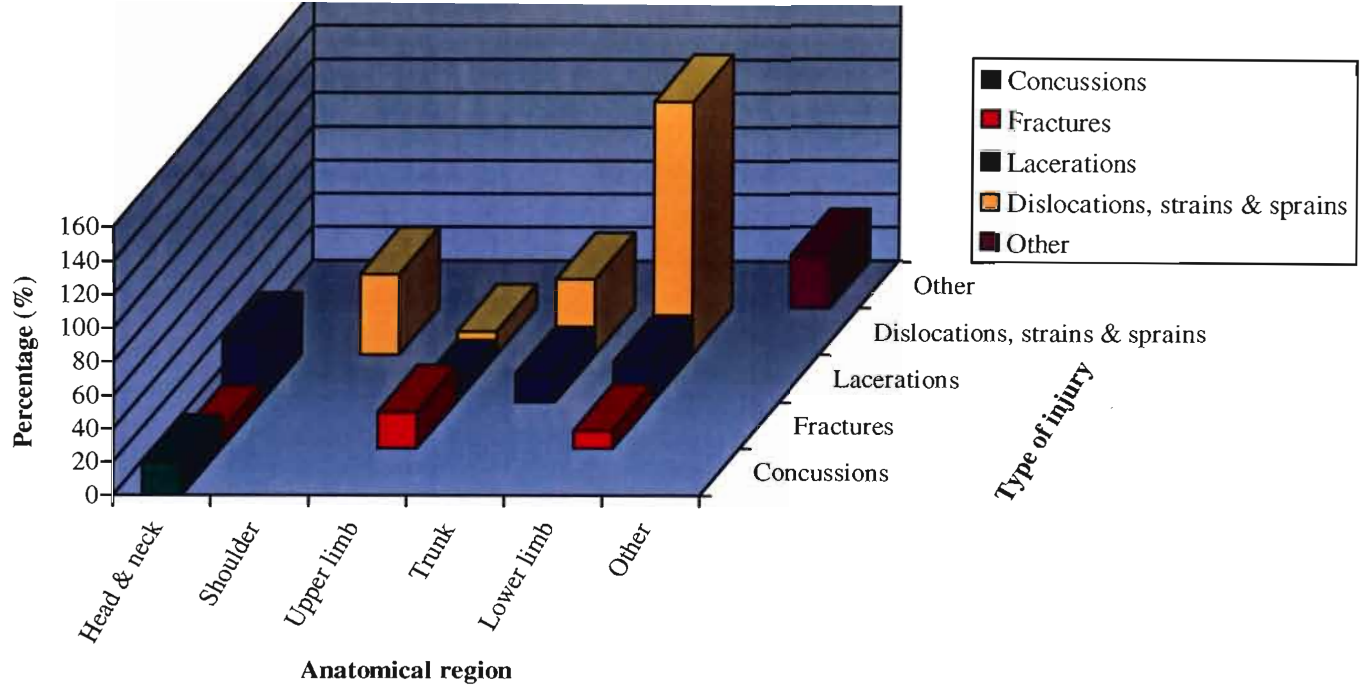


Figure 2.11: Distribution of anatomical region injured and the type of injuries in senior club rugby (Lee & Garraway, 1996)

Bird *et al.* (1998) in their study on a season of rugby injuries in New Zeeland found the following:

- injury rate was higher during matches (8,3:1) when compared with training;
- the player position most often injured was the lock (13 per 100 player-games);
- the anatomical region most commonly injured was the lower limb; 42,5% during games and 58,4% during training;
- most common type of injury were strains and sprains, both for match and training;
- the tackle was responsible for 40% of match injuries.

Lastly, Bird *et al.* (1998) found that foul play was responsible for 13% of all injuries during matches. These findings were similar to that mentioned in previous studies, except for the high incidence of injuries of the lock position.

Jakoet and Noakes (1998) in their study on injuries during the 1995 Rugby World Cup found that 71% of injuries sustained were either ligamentous or muscular, or consisted of lacerations. As in previous research it was found the most common anatomical site affected was the lower limb (42%). The tackle phase (56%), followed by the ruck and maul (23%), were the most dangerous. Interestingly, the scrum and line-out (fix phases) only contributed to 1% of injuries. According to Jakoet and Noakes (1998) the most dangerous player positions during the 1995 World Cup was that of loose forwards (25%), followed by centres and wings at 20%. The authors attributed these controversial findings to "the way in which the game is played at international level" (Jakoet & Noakes, 1998:47). In conclusion, it was found that the best rugby players were at highest risk; experience, skill and superior fitness do not necessarily decrease rugby injury incidence.

Targett (1998) in his study on professional rugby found a fairly equal distributed injury incidence throughout the season. As discussed earlier in paragraph 2.3, he classified injuries as mild, moderate and severe. As far as moderate and severe injuries were considered the pre-season and post 8th week (recess) periods saw the highest injury incidence. He found that 65% of injuries were sustained by forwards and (35%) by backs. Player position most at risk was identified as the eighthman, correlating well with the earlier work of Roy (1974). The anatomical region most commonly affected was the head and neck area, followed by the lower limb. The majority of injuries were musculo-tendinous strains, sprains and contusions, contributing to 61% of all injuries, regardless of grade. Phase of play most often associated with injury was the open play and the tackle (36%), followed closely by ruck and maul (27%). Unfortunately, foul play contributed to a large proportion of all injuries (5% to 33%), depending on the injury grade.

Bottini *et al.* (2000) in his Argentinean study stated that senior players had a 1,53:1 injury ratio compared to their schoolboy counterparts. The lower limb was the most commonly affected anatomical site (42,6%), followed closely by the head and neck areas. This correlates well with the modern Targett (1998) findings. Player injuries, as in earlier studies, showed a dominance in forwards (57,3%) versus backs (42,6%). However, the players most often injured were the flanker among the forwards (15,5%) and the full-back in the back-line (11,1%). The authors identified open play as the main contributor to injuries (33%) and stated that foul play was a minor role player in the total injuries (2%). Lastly, Bottini *et al.* (2000) found that there was a slight dominance in injuries during the second half (54%) of the game when compared with the first (46%).

Garraway *et al.* (2000) did a research project in Scotland on the impact of professionalism on injuries in rugby union, where the professional (post-1995) was compared to the amateur era (pre 1995). This work was one of the only comparative studies done at this level that was found in the literature. The injury definition used for both the amateur and the professional era was discussed earlier in the Chapter in paragraph 2.3 above. In the amateur era a total of 373 injury episodes were reported, versus 576 in the professional. The period prevalence injury rates rose in all age groups, and more particularly in the younger player. This translated into an injury every 3,4 matches in the 1993-1994 season, rising to one in every 2,0 matches in 1997-1998. In simple terms every 59 minutes during match an injury presented in the professional era. In the amateur period the months of April and September recorded higher injury incident rates, however, the authors found a much higher recurrent injury tendency in the professional era, particularly during the pre-season. These findings were discussed earlier in paragraph 2.4 under *reasons*. When anatomical site is considered, a total of 56% of match days lost were attributed to musculo-tendinous, ligaments and joint injuries in the lower limb regions (professional era). However, the presenting types of injuries did not differ when comparing the old to the new. Changes in the laws of rugby union in recent years have been designed to encourage more open play. This has resulted in more tackles involving a higher degree of momentum and the use of greater force. High-speed tackles have recently been highlighted as an important factor in injuries occurring in rugby union (48%).

In conclusion, the authors found a strong increase in injury incidence. Recent rugby law changes have changed the game into a more fluent and spectacular performance, unfortunately resulting in more tackle injuries.

Alsop *et al.* (2000) in their New Zealand study found that higher rates of injury occurred at the start of the rugby season and decreased over time. The types and severity of injury remained relatively constant, but the proportion of injuries occurring in the back-line fell significantly. The authors also found that the site of injury was more concentrated on the body and trunk areas as the season progressed. Finally, trends in injury rate were found to be constant during the rugby season.

Holtzhausen (2001) in his study on the incidence and nature of injuries in South African rugby players found centres and fullbacks to be the most commonly injured player positions. It was found that the back-line, which comprises of 47% of players, sustained 56% of injuries, a result that differs from the earlier work of Addley and Farren (1988). Furthermore, of the 38 intermediate and serious injuries 55% were sustained by the back-line. Holtzhausen (2001) found that 50% of all injuries recorded were either ligament sprains or musculo-tendinous strains. *Figure* 2.12 displays a rundown on the types of injuries and the frequency with which they occurred (Holtzhausen, 2001).

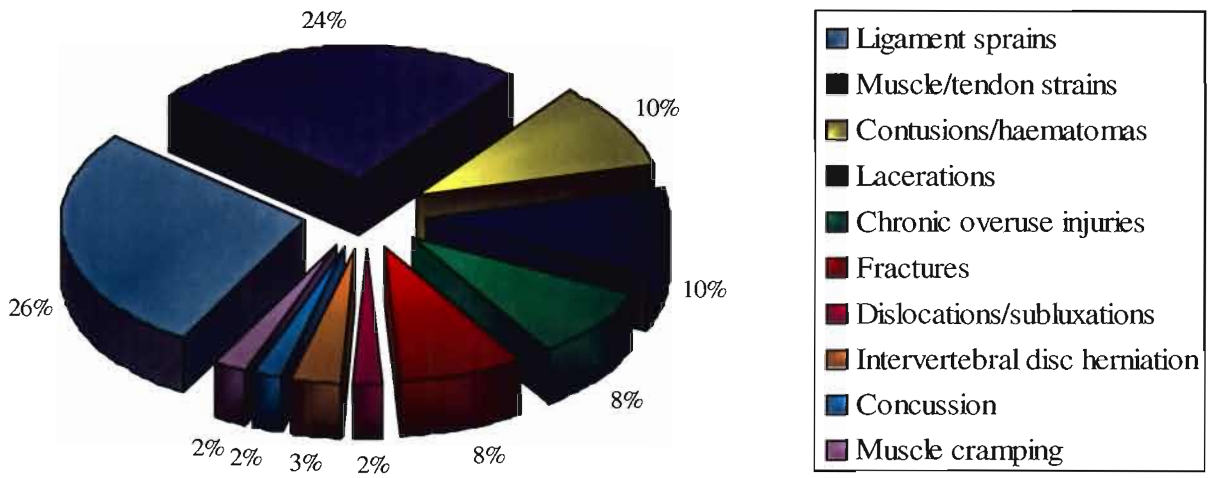


Figure 2.12: Frequency of the type of injuries sustained (Holtzhausen et al., 2001)

When anatomical region is considered, the authors found the pelvic and hip area (19%) to be the most commonly injured region. These were followed closely by the head (13%) and knee (13%) (*Figure* 2.13).

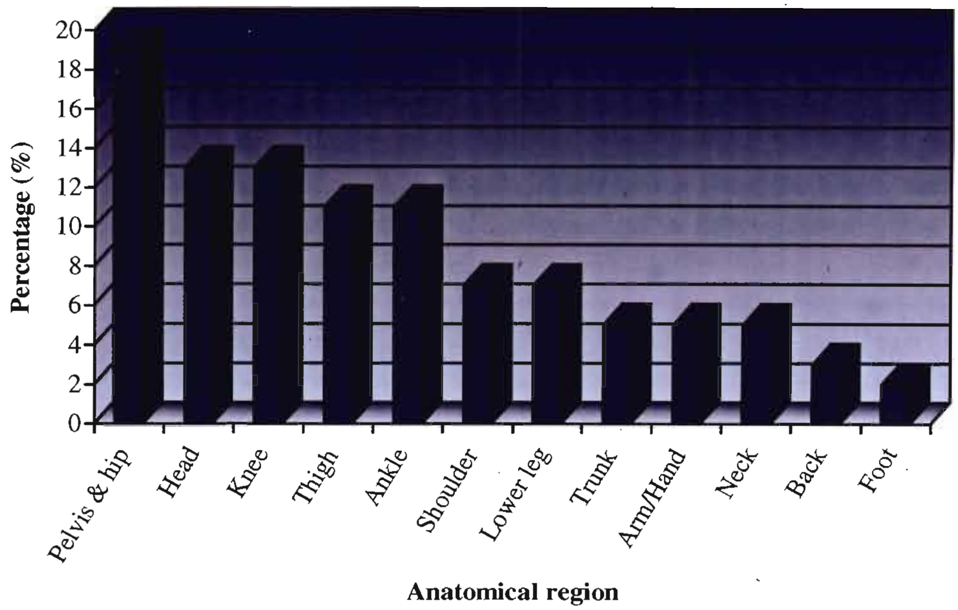


Figure 2.13: Anatomical region and injury occurrence (Holtzhausen et al., 2001)

When considering the severity of injury the pelvic and ankle areas were responsible for the majority of incidences. In open play the contact phase contributed to most of the injuries (65%). Fifty eight per cent of these were classified as either intermediate or serious. The most dangerous phase of play during matches was *being tackled* (46%). The majority of these injuries were either intermediate or serious in nature (56%). The authors found the rucks and mauls to be responsible for 17% of injuries and *tackling* at a low 15%. These findings differ vastly from earlier work done by Jakoet and Noakes (1998) and Targett (1998). The second (37%) and third (32%) quarters of the game were identified as being high risk, with the first quarter being the safest at 2%. Lastly, the authors recorded an incidence rate of 133/1 000 player hours for pre-competition preparatory matches. This fortunately levelled out to 44 injuries per 1 000 player hours during competition. This phenomenon was discussed and outlined under *reasons* earlier in paragraph 2.4 above.

Bathgate *et al.* (2002) produced the most recent epidemiological study found in the literature. The study was done on elite Australian rugby union players. As mentioned earlier in paragraph 2.4, he compared amateur rugby players with professional players since 1995. They reported an injury incidence rate of 47 versus 74/1 000 player hours when comparing the old to the new. The injuries presented (as defined in the *definition* earlier, paragraph 2.3) in the amateur period were classified as 63% mild, 26%

moderate and 11% severe. In the professional era they found 64% mild, 12% moderate and 24% severe (*Figure* 2.14). This statistics showed a 120% increase in the severe group in the professional era.

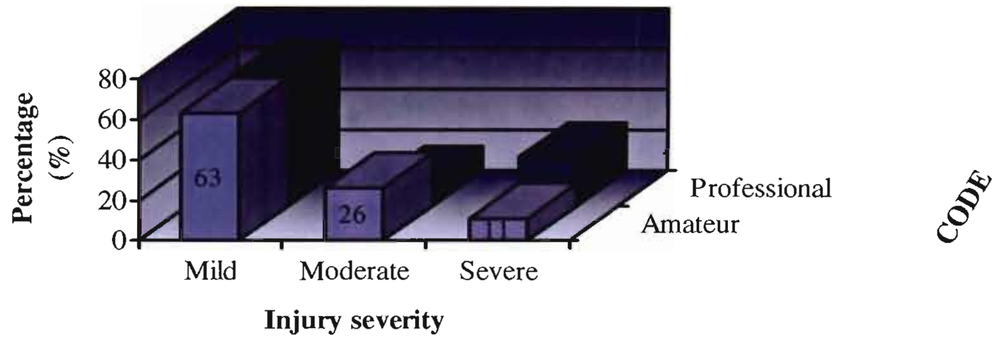


Figure 2.14: Comparison of amateur with professional rugby in regard to injury severity (Bathgate et al., 2002)

The authors recorded that 55% of injuries sustained were soft tissue (closed injuries). The anatomical sites most commonly injured were the head (25,1%), knee (14%), and thigh (13,6%), followed by the ankle at 10,5%. When player position is considered, in the amateur era the prop and centre were the most commonly injured. In the professional era, the lock forward and again the centre were at highest risk. On average, backs sustained 40,8% and forwards 59,4% of all injuries, this correlates well with Addley and Farren (1988). In phase of play, as with all modern findings, the tackle was identified as the most dangerous (58,7%), causing 66% of all severe injuries, followed by the open play (19,6%), causing 19% of severe injuries, and lastly the ruck and maul (14,7%), causing 9% of the severe injuries. The set phases in total caused 2,1% of injuries, not one classified as severe. Foul play was responsible for 3,5% of injuries; this is considerably lower when compared with other literature findings. The standard of refereeing at this high level must be the main contributing factor. The quarter responsible for most injuries during the game was the third, at 40%. Yet again, the safest period on the field was the first quarter, with an injury rate of 9%. This correlates well with other modern findings in the literature. Finally, Bathgate *et al.* (2002) found that 88% of injuries presented during the game and the rest during training.

As with injury definition, the injury itself, how it presented and its causes changed with the evolution of rugby. The sensitivity of injury recording have improved vastly when early works from the 1970s are compared with the modern era. Very necessary law changes introduced in the late 1980s brought about a shift in injury prevalence from the fix phase to the more open play and tackle. Fortunately decreases in catastrophic spinal region injuries followed, especially among school participants. The introduction of the professional era post-1995 introduced an increase in injury incidence, a trend that has continued right to the latest documented studies. Severity and intensity of injuries unfortunately follow the same pattern. When comparing schoolboy with senior club rugby, the literature shows a difference in the type of injury and the anatomical region injured. These tendencies are due to skill and attitude differences between these groups. Since the start of the modern era, post-1996, a lack of documented schoolboy rugby injury research has been experienced. Unfortunately, in the year 2002 a sudden increase in catastrophic cervical spine injuries and deaths among school players (in South Africa) highlighted this shortcoming. A taskforce was charged by the South African Rugby Football Union (SARFU) to research and to deal with this disconcerting new trend.

In conclusion with the evolution of rugby through the centuries, the definition (what is an injury), reason (cause of injury), incidence (injuries presenting per 1 000 player hours) and lastly the injury itself, have changed. "The Definition" developed into a more sensitive and structured defining system throughout the years. The causes of injury, as mentioned in paragraph 2.4, changed with the introduction of certain law changes, and particularly with professionalism in the sport. The dramatic increase in injury incidence and injury can be attributed to a more sensitive definition system, certain law changes and, last but not least, professionalism.

CHAPTER 3

EMPIRICAL INVESTIGATION: MATERIALS AND METHODS

3.1 INTRODUCTION

When rugby injury epidemiology is researched, six strongly contributing factors crystallise from the literature over a period of time. The first of these is the *evolution of the game*, from the origination of the ball game in medieval Britain to its development in the late 1800s into three different sports, namely rugby, hockey and soccer. The game of rugby continued to prosper and develop in the different colonial settlements to the modern era, where four similar, but very different, contact games are played, namely Rugby Union, Rugby League, Australian Rules and American Gridiron. In Rugby Union the first major 'overhaul' in rules and regulations were made in March 1988. This was necessitated to stamp out the hideous cervical spine injuries and deaths that were associated with first phase play. Similar law changes followed, with their emphasis being to minimise and to protect the playing participants.

The late 1980s also saw the introduction of the Rugby World Cup competition, bringing a new era of grandeur and splendour to Rugby Union. The year 1996 saw the introduction of the first fully professional rugby competition. The Tri-Nations was a competition held between South Africa, New Zealand and Australia from the month of March to the month of June.

The second phenomenon concerns the *definition of the concept of injury*. (See par. 2.3 p. 11) As with the historic evolution of the game, the definition of the injury concept had its share of change from being very crude and insensitive up to the modern detailed descriptions, defining types of injuries, regional representation (anatomical site), grade of injury, phase of play and even when sustained.

As with the previous two factors, *injury reasons* (See par. 2.4 p. 17) followed a similar pattern, with the first remarkable documented series done almost half a century ago. Certain injury reasons continued to present throughout rugby evolution, namely foul play, aggression, attitude and type of contact. Very necessary law changes in March 1988 curbed certain more serious and severe spinal region injuries at the time, especially among schoolboys. These rules changed the character of the game, making the tackle phase the highest-risk phase. Lastly, in the modern era reasons like length of season, monetary involvement and inappropriate rest and rehabilitation are seen as the main contributing factors.

The last two factors of injury epidemiology can be discussed in combination as *injury incidence* (See par. 2.5 p. 30) and the *injury itself* (See par. 2.6 p. 38). As previously discussed in paragraph 2.5, the tremendous increase in injury incidence is not only threatening rugby union, but the greater rugby family itself. Historically, a steady increase in injuries was seen, with a fortunate temporary arrest of cervical spine injuries and deaths since the inception of law changes in March 1988. The 1995 World Cup scattered the belief that injury incidence was lower among the best players in the business. This competition produced historically the highest *ever* recorded injury incidence up to the year 1995 (30 per 1 000 player hours). The introduction of professionalism, unfortunately, further worsened the scenario to staggering recorded rates of 150 injuries per 1 000 player hours (Holtzhausen, 2001). Finally, the 2002 South African rugby season was marred by a series of catastrophic injuries and deaths among the schoolboy rugby-playing population. This is necessitating urgent further research into this matter, and steps towards possible prevention.

In this Chapter the following materials and methods used will be discussed: anthropometric, physical-and-motor, biomechanical and postural status will be determined for all participants. A previous injury history questionnaire was completed by all participants to determine injury status. Lastly, due to availability of junior elite club players, an injury record throughout the 2002 season was kept and injuries classified according to the definition of Lee and Garraway (1996). The sample selection, which consisted of two main groups, namely elite school players and elite junior club players, is analysed, followed by a discussion of the test battery used. The battery of tests can be divided into anthropometric and physical-and-motor components. The measuring protocols as advocated by the International Body on Kinanthropometrics were used in this researched study (Ross & Marfell-Jones, 1991:224) An *injury history questionnaire,* (Annexure 3.1) which was completed by each of the participants, was then explained. Clinical records kept on attending PUK Rugby Institute rugby players throughout the 2002 rugby season are described and explained. Finally, biomechanical assessments (Annexure 3.3) which were done *once* throughout the season on all subjects are discussed and compared with regard to lower limb, pelvic girdle, spinal region, upper limb and neurological factors.

3.2 SELECTION OF SAMPLE

Two distinct rugby-playing groups were selected to participate in this study. The first was elite school players consisting of two age groups, namely 15-year- and 18-year-olds. All players who were invited to participate in the *final* trials for the North West Leopard Provincial teams selection were analysed in late May 2002. The participants were exposed to a once-off series of anthropometric, physical-and-motor and biomechanical-and-postural assessments. The anthropometric and physical-and-motor tests were performed by qualified sports scientists at the PUK Rugby Institute. The biomechanical tests were performed by two trained medical officers. Individual long-term programmes were issued for the positional (core stability) and dynamic (mobility) shortcomings identified by the biomechanical and postural tests. Finally, an up to date injury history questionnaire (Annexure 3.1) was completed by each player. This identified previous injuries as well as the current injury status of the players. Unfortunately, due to the period of the competition (June/July) and the geological representation (North West province) of players this group could not attend the sports-medical clinics which were held throughout the 2002 season.

The second group consisted of elite junior club-player age-groupers (19 and 20 years old). All players were selected institute students attending the PUK Rugby Institute. The two age groups were the 19-year-olds (freshmen) players, and secondly the 20-year-old (seasoned) playing students. The institute players were submitted to a series of anthropometric and physical-and-motor assessments. Due to player availability and the consistency of this group, pre-season (January), mid-season (May) and end of season (August) tests were performed. As with the school group the biomechanical assessments were only introduced once (late May). Long-term biomechanical and postural programmes were issued to address identified postural (core stability) and dynamic (mobility) shortcomings. All institute players had to complete an injury-history questionnaire to determine previous injury status. Finally, an injury incidence record (Annexure 3.2) was kept on all institute players reported injured throughout the 2002 rugby season. These clinics were held twice weekly at the institute and manned by sport physicians, physiotherapists, biokineticists and sport scientists. Unfortunately, due to a short competitive season of school players and regional representation these group could not attend the clinics. Injuries were classified as mild, moderate or severe, according to injury definition. (Lee & Garraway, 1996). Furthermore information was kept on the following: most commonly injured position, anatomical region, type of injury, period prevalence (when during season it occurred), when it occurred (match play or training), and lastly whether the injury was acute or of the chronic overuse type.

3.3 BATTERY OF TESTS

3.3.1 Anthropometric variables

The measuring protocols (body mass, body length and body fat percentage), as advocated by the International Body on Kinanthropometrics, were used in this research study (Ross & Marfell-Jones, 1991).

3.3.1.1 Terminology

- **Anatomical position**

This is where the participant is in the erect position, arms next to the side, palms and feet facing forward (Ross & Marfell-Jones, 1991).

- **The Frankfort level**

On measuring body length the head was held in the Frankfort level. The head position is in the Frankfort level when a horizontal line can be drawn from the orbital to the trachion . The orbital is the inferior border of the eye socket and the trachion is the indentation above the tragus of the ear (Ross & Marfell-Jones, 1991).

- **Vertex**

When the head is positioned in the Frankfort level, the vertex is the highest position on the skull (Ross & Marfell-Jones, 1991).

- **The acromion landmark**

This landmark is the highest point on the superior lateral aspect of the acromion when a subject is standing erect with arms relaxed (Ross & Marfell-Jones, 1991).

- **The iliospinal landmark**

This is a point on the anterior portion of the ilium exactly on the anterior superior ileac spine (Ross & Marfell-Jones, 1991).

3.3.1.2 Variables, measuring methods and apparatus

The measured variables, as well as the measuring methods and apparatus used, are discussed in this paragraph. All kinanthropometrists in this study were *right-handed* (dominant). The measuring protocol was introduced and used as prescribed by the International Body on Kinanthropometrics (Ross & Marfell-Jones, 1991).

3.3.1.3 Body mass

Apparatus: A calibrated, electronical mass meter.

Technique: The subjects were measured while dressed in rugby shorts, standing erect on the middle of the mass meter with weight equally distributed. The subject had to be still with eyes facing forward and arms relaxed for measurement (anatomical position). Body mass was recorded to the nearest digital tenth of a kilogram.

3.3.1.4 Body length

Apparatus: A portable Holtain-stadiometer.

Technique: With this measurement the maximum distance between the standing surface and the vertex of the skull were obtained. The measurement was taken with the subject standing erect, barefoot with heels together, body weight equally distributed and arms relaxed. In the standing (erect) posture the heels, buttocks, upper trunk and back of the skull had to touch the measuring apparatus before measurement. The head was held at the Frankfort level. Finally, before measuring, the subject was instructed to inhale and to elongate himself without lifting his heels from the platform. Firm contact was made between the index meter and the vertex of the skull for measurement. The body length was recorded to the nearest millimetre.

3.3.1.5 Skinfold measurements (Body fat percentage)

Apparatus: Harpenden skinfold measuring apparatus with a constant pressure of $10g/mm^2$.

Technique: The sites where the measurements had to be taken were clearly identified and marked. For the measurement, a double layer of skin with its underlying adipose tissue were firmly gripped on the marked area between the index finger and thumb. The skinfold was then pulled away from the underlying musculature and the mouth of the measuring apparatus was applied approximately 1 cm below the fingers of the gripping hand and 1 cm deep into the fold. The apparatus was placed at the prescribed angle and the trigger was completely released. A firm grip was kept on the skinfold throughout the measurement (Norton, *et al.*, 1996)

Enough time was allowed (2–3 seconds) throughout the procedure for full pressure measurement to take place. Two measurements of each skinfold were taken and when a discrepancy of more than 1 mm occurred, a third measurement was obtained. The different skinfold measurements were taken in a specific pre-planned rotational manner. All measurements were rounded digitally to the nearest 0,2 mm. The six skinfolds measured were as follow:

- *Triceps skinfold*

A vertical fold halfway between the acromion and radial landmarks on the posterior surface of the triceps.

- *Subscapular skinfold*

Lateral caudate fold taken at 45° to the horizontal, starting directly inferior to the lower angle of the scapula.

- *Supraspinal skinfold*

A diagonal fold taken in a downward and medial direction at an angle of 45° to the horizontal. The measurement is taken approximately 7 cm above the anterior superior ileac spine on an imaginary line to the anterior aspect of the axilla.

- *Abdominal skinfold*

Vertical folds taken approximately 2–3 cm lateral to the umbilicus. All measurements were taken on the left side.

- *Thigh skinfold*

A vertical fold taken halfway between the superior aspect of the patella and the inguinal fold on the anterior aspect of the thigh. The subject was measured standing with the knee at 90° and the forefoot supported on a stool.

- *Calf skinfold*

A vertical fold measured on the medial aspect at the point of largest circumference of the calf muscle. The subject was measured standing with the knee at 90° and the foot supported on a stool.

3.3.2 Physical and motor variables

3.3.2.1 Speed over time over a 30 m distance

Apparatus: 30 m tape measure; Brower-time-light system.

Test procedure: Subjects were submitted to a maximum speed test measured at 30 m. From a standing position with one foot behind the starting line, two attempts were performed with the Brower system measuring time at 30 m. The best result was recorded and rounded digitally to 0,01 seconds (Kirby, 1991).

3.3.2.2 Bloomfield Agility test

Apparatus: 12 markers; 5 assistants, stopwatch; rugby ball.

Test procedure: In the starting position the subject lay supine with his head towards marker A (Figure 3.1). At the word "go!" he ran around markers B, C and D. Between markers D and E a shoulder roll was performed. At marker E a rugby ball stationed there was collected, and the subject then ran with it around markers F and G. Finally, the subject ran in "zigzag" fashion around markers H, I, J, K and L to cross the finish line. Two attempts were allowed, with the best being recorded. Time was rounded off to the nearest digital tenth of a second (Bloomfield *et al*, 1994).

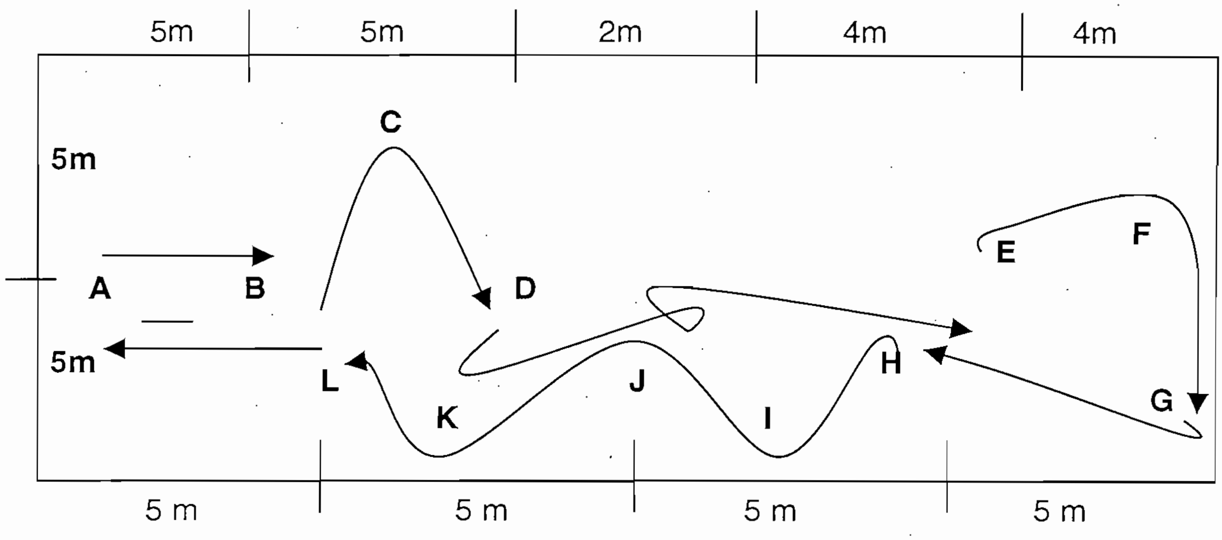


Figure 3.1 : Graphic description of the Bloomfield agility test (Bloomfield *et al.*, 1994)

3.3.2.3 Illinois agility test

Apparatus: 9 markers; stopwatch; tape measure.

Test procedure: Subject starts running from marker A (Figure 3.2), around marker B, towards marker C, zig-zagging through obstacles to marker D and zig-zagging back to marker C, continuing to marker E and ending at marker F, all in the shortest period of time. Time is measured and rounded off to the nearest 0,1 second. (Kirby, 1991)

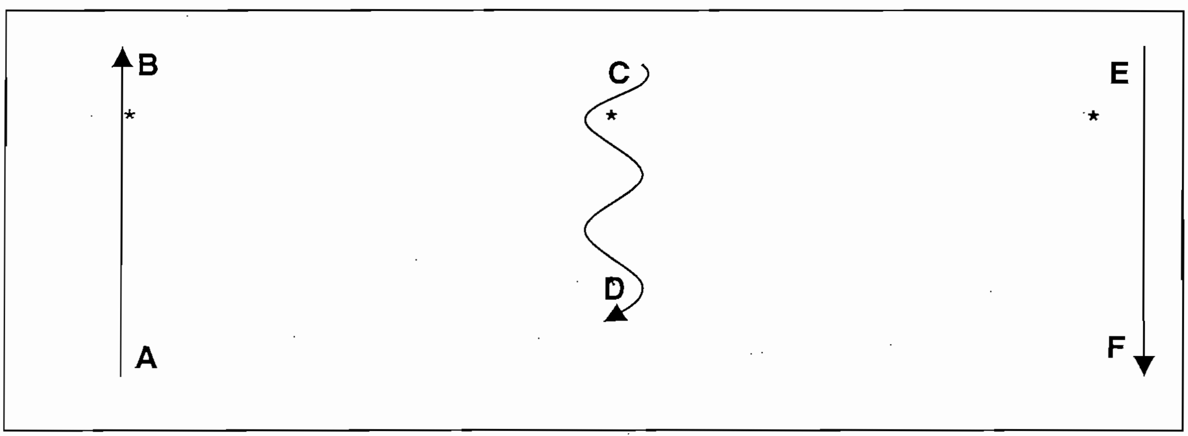


Figure 3.2: Graphic description of the Illinois agility test (Kirby, 1991)

3.3.2.4 Vertical jump

Apparatus: Magnesium powder; tape measure.

Test procedure: The subject was positioned standing with his side against a wall, with the arm nearest the wall stretched out vertically. The subject was then ordered to semi-crouch and to jump maximally (marking the highest point with magnesium powder applied to the middle finger; three jump attempts were allowed.) The highest achieved point was measured. (Thomas & Nelson, 1985).

3.3.2.5 Horizontal jump

Apparatus: Tape measure.

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 were rounded to the nearest centimetre (Kirby, 1991).

3.3.2.6 Abdominal curls

This test is designed to determine the absolute strength of the abdominal muscle groups.

Apparatus: Exercise mat; loose weights: 2,5 kg and 5 kg.

Test procedure: This test protocol has seven levels; to continue with the next level, the subject has to perform the previous level successfully.

- Subject laid supine, with both knees at an angle of 90°. Throughout the test procedure both feet remained in contact with the floor and the legs were kept together. The subject attempted a sit-up with extended elbows, touched the outside of the knees with both wrists and returned to the stationary position. This completed level one.

- Position as for level 1. With elbows extended a sit-up was attempted, the outside of the knees were touched with the elbows and the subject then returned to the resting position. This completed level 2.

- Position as for level 2. Palms of the hands were on the temporal area of the skull, and a sit-up was attempted; both knees were touched with the elbows and the subject then returned to the resting position. This completed level 3.

- Position as for level 3. Arms were now crossed on chest. Sit-up was attempted; forearms had to successfully touch thighs and the subject then returned to the resting position. This completed level 4.

- Position as for level 4. Arms crossed behind neck, sit-up was attempted; chest had to successfully touch thighs. The subject returned to the resting position. This completed level 5.

- Position as for level 5, with subject holding 2,5 kg loose weight in hands; a sit-up was attempted, with the chest touching the thighs, and the subject returned to the resting position. This completed level 6.

- Position as for level 6, with subject holding 5 kg in hands. A sit-up was attempted, with the chest touching the thighs, and the subject returned to the resting position. This completed level 7 (Kirby, 1991).

3.3.2.7 Pull-ups

Apparatus: A fixed horizontal bar at 2,5 m from the ground.

Test procedure: Subject started by hanging from the bar with palms facing away. At the order to start, he lifted himself until his chin was clearly above the bar. He was then allowed to lower himself until his arms were fully stretched. This represented one pull-up. This activity was allowed until failure. During the activity no stoppage for longer than 2 seconds was allowed, nor were unnecessary swinging and kicking. The testing personnel counted out loud each successful repetition. In failure to lift the chin clearly above the bar or failure to stretch the arms fully upon lowering himself, the particular attempt was disallowed (Thomas & Nelson, 1985).

3.3.2.8 Bench press (one repetition maximum)

Apparatus: One proper weight lifting bar; weight set; Bench press rack; one trained assistant.

Test procedure: The subject was on the bench press apparatus as for the bench press (bar positioned forehead). Hands were placed on bar just wider than shoulder grip on grip area, palms facing caudate, at this stage elbows slightly bent. Subject inhaled (approximately ¾ breath). Elbows were extended and locked, he was now fully loaded with bars and weights in midline of chest, then fully exhaled and re-inhaled before lowering the bar down to touching the point on the chest surface. With an explosive contraction, bar with weights were lifted from the chest vertically until elbows were in locked position. This represented one bench press. Throughout the procedure the assistant was monitoring and controlling this exercise (Biofitness systems Inc., 2002).

To determine the one repetition maximum (1RM), the following procedure was followed:

- Subject warmed up with light weigh, bench presses as set out above;
- Bar was increasingly loaded;
- Finally, the optimum weight at which only one repetition could be successfully performed was recorded. This was noted as the 1RM for the subject.

3.3.2.9 Squat

Apparatus: One proper weight lifting bar; weight set; *squat* rack and at least one strong, trained assistant.

Test procedure: The subject stood with feet shoulder width, facing the *squat* rack. Slight step forward with necessary flexion to load shoulders, arms spread out for stability. At all times during this procedure, the spine was kept in the extended (erect) position. In a controlled manner (fully loaded) the subject was allowed to bend his hips and knees (towards the ground) until both thighs were parallel to the horizontal axis. From this position the subject was ordered to rise strongly, pushing with the thighs and buttocks, back to the starting position. This represented one *squat* repetition. Throughout the procedure the subject was ordered to exhale on the way down and inhale on the way up.

To reach the one repetition maximal effort, the same procedure was followed as that discussed under bench press, the only difference being the warm-up exercise, which was squatting (Anon, 2002).

3.3.2.10 Bleep test

Apparatus: Compact disk player; compact disk (CD); markers; tape measure.

Test procedure: Two markers were placed 20 m apart on a level grass surface. Before the test procedure was carried out, proper instructions about the test protocol were given to participants. The subject started running from the first towards the second marker on the first audible "bleep", aiming to reach this at the sounding of the second "bleep". This procedure was continued, until failure by the participant. The last completed level and stage were then recorded (Leger & Lambert, 1982, Ramsbottom *et al.*, 1988 and McArdle *et al.*, 1991).

3.3.2.11 Speed endurance test

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

Test procedure: Three markers positioned ten metres apart in a straight line (Figure 3.3). With one assistant positioned at the middle marker A the test is started. The test subject at a given signal will proceed from marker A to marker B, turning and proceeding to marker C, returning and ending at marker A. Assistant will start stopwatch at the signal (to go) and will stop it once the subject has completed the full test (passing marker A from marker C). Time is noted.

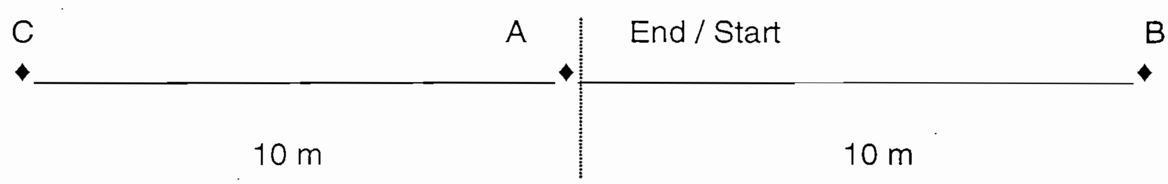


Figure 3.3: Graphic description of the Speed endurance test (Hazeldine & McNab, 1999)

The second assistant starts his 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. (Hazeldine & McNab, 1999). All six test episodes are noted and speed endurance calculated as follows:

1. $[(X1 + X2)/2]$ - $[(Y1 + Y2)/2]$ $= Z$

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

- $X1 + X2 \div 2$ = average X (where X1 and X2 are the slowest recorded time)
- $Y1 + Y2 \div 2$ = average Y (where Y1 and Y2 are the fastest recorded time)
- Average Y – Average X = Z
- $Z \div$ average Y x 100 = % decrease in speed endurance

3.3.3 Injury history questionnaire

All participating *schoolboy* subjects were required to complete a previous-injury questionnaire. (Annexure 3.1) The questionnaire (on the previous twelve months' injuries) was completed in early spring (August) before any anthropometric, physical-and-motor and biomechanical-and-postural testing was performed. The questionnaires were completed under the supervision of test personnel.

The questionnaires distinctly inquired into all *substantial* previous injuries. Here a injury was defined as being severe enough to cause the player to leave the field of play or training session, and secondly, to prevent the subject from participating in a subsequent rugby match and in training.

In response to the questionnaire, information on the *type of injury* and *body part affected* had to be given. Further data on the current status of the mentioned conditions were obtained, i.e. whether any signs or symptoms might still prevail or whether the respondent fully recovered. Information was also obtained on whether medical consultation had been required and if rehabilitation of the condition had taken place. Finally, data was obtained on whether any protective or prophylactic strapping or bracing had been used, and if so, to which body parts. All subjects were urged to complete this questionnaire as reliably as possible.

3.3.4 Institute sports medical clinic attendance records

For all institute elite junior rugby players a *free* sports-medical clinic was run throughout the year from the first week of February to the last week of October 2002. The sports clinic was run from a fixed location in Potchefstroom and was held twice weekly on Mondays and Wednesdays. These clinics were manned by two qualified or trainee sports physicians, as well as three qualified or trainee physiotherapists specialising in sport, and finally four biokineticists and four sports scientists (fitness conditioning coaches). All of the latter were either honours or master's students, in training at the Human Movement Sciences Department at the Potchefstroom University.

The function of the sports clinics were purely to diagnose, refer and programme all players who reported injured. Information on individual player status was communicated in writing as well as orally twice weekly to the head of coaching at the institute. (Annexure 3.2)

Before an institute 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,
- age group,
- anatomical region injured,
- when the injury had occurred (match or training),
- phase of play, and
- whether an acute or chronic injury.

The medical team from their side, after full screening of the subject, had to complete the following:

- correct diagnosis of injury,
- time off training, and secondly off playing,
- references:
    - physiotherapy with number of treatments

- biokinetics (testing)

- specialised test procedures or referrals,

3.3.5 Biomechanical and postural analysis

For test procedures, subjects were dressed in 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. (Annexure 3.3)

3.3.5.1 Lower limb region: Achilles tendon suppleness test (TA-test)

Apparatus: Long-arm goniometer ; one plinth.

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 the dorsiflexion position. Pressure of approximately 30 kg was applied. Degrees of forced plantar flexion was 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, a range of 30° or more (ideal); 2, between 10° and 30° (non-ideal); and 3, less than 10° (highly unsatisfactory) (Kapandji, 1970; McPoil & Brocato, 1990).

3.3.5.2 Lower limb region: Modified Thomas test:

Apparatus: One plinth; one marker; long-arm goniometer .

Test procedure: For the modified Thomas test three lower limb mobility measurements were assessed. This test was used as a functional combination test for all three measurements.

- Subjects stood at the end of the plinth, with posterior aspect 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.

✓ *Iliopsoas 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, >30° (ideal); 2, 15°–30° (non-ideal); and 3, <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, >50° (ideal); 2, 30°–50° (non-ideal); and 3, <30° (highly unsatisfactory).

✓ *Iliotibial band mobility (ITB)*

The anterior aspect of the ankle joint was clearly marked. With the long-arm 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, neutral / 0°–10° of deviation (ideal); 2, 10°–30° of deviation (non-ideal); and 3, more than 30° (highly unsatisfactory) (Hunt, 1990; Kapandji, 1970; Saudek, 1990).

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

3.3.5.3 Lower limb region: Gluteus maximus mobility test (short hip extensor mechanism mobility test)

Apparatus: Plinth; long-arm goniometer ; 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 position 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, >90° (ideal); 2, 60°–90° (non-ideal); and 3, <60° (highly unsatisfactory) (Hoppenfeld, 1976 and Kapandji, 1970).

3.3.5.4 Lower limb region: Adductor mobility test

Apparatus: Plinth; 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 stabilised and rotation controlled by the observer. The limb closest to the examiner was abducted, 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, >120° (ideal); 2, 100°–120° (non-ideal); and 3, <100° (highly unsatisfactory) (Hoppenfeld, 1976 and Kapandji, 1970).

3.3.5.5 Lower limb region: Hip joint

✓ *External rotation mobility test*

Apparatus: Plinth; long-arm goniometer ; marker.

Test procedure: Subject standing at end of 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 stabilised 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 three categories: 1, >90° (ideal); 2, 60°–90° (non-ideal); and 3, >60° (highly unsatisfactory) (Hoppenfeld, 1976; Kapandji, 1970).

✓ *Internal rotation mobility test*

Apparatus: Plinth, long-arm goniometer, marker.

Test procedure: The subject was positioned exactly as for the *external rotational mobility test*, except that the ROM now tested for internal rotation, and was measured. Measurements were classified into three categories: 1, >30° (ideal); 2, 15°–30° (non-ideal); and 3, <15° (highly unsatisfactory) (Hoppenfeld, 1976; Kapandji, 1970).

3.3.5.6 Lower limb region: Knee complex

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

Apparatus: Plinth, goniometer, marker; tape measure.

Test procedure: The subject lay relaxed, supine on the 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 two categories: 1, <9° (ideal); and 2, 9° and less (non-ideal) (Derman & Scwhellnus, 2001; Gilleard *et al.* 1998; Kapandji, 1970; McConnel, 1986).

✓ *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 one: 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 categorised as 1, not tilted (ideal state)

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

The procedure was then repeated on the opposite knee. (McConell, 1999).

✓ *Patella squint test*

Apparatus: One plinth; marker; tape measure.

Test procedure: The subject was positioned as for 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 categorised the amount of patella squint (rotation) in comparison with the mid-limb sagittal line. 1, <10° (ideal); and 2, >10° (non-ideal) (McConnell, 1999).

✓ *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 2 categories: 1, no apparent difference (ideal); and 2, apparent difference (non-ideal) (McConnell, 1999 and Wallace *et al.*, 1990).

3.3.5.7 Lower limb region: The foot

✓ *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, resisted movement (dropped arch/hypermobile); 2, easily inserted index finger (ideal); and 3, excessive play between plantar aspect and ground (high arch/hypomobile) (Hunt, 1990).

✓ *Forefoot positional test*

Apparatus: Marker; goniometer .

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, 10°–0° of deviation from Z axis (ideal); and 2, more than 10° of deviation from Z axis (non-ideal) (Derman & Schwellnus, 2001; Hunt, 1990).

✓ *Rear foot standing test*

Apparatus: One plinth; goniometer ; marker; tape measure; 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 calcaneus was marked. With the index finger and thumb of the left hand on either side of the calcaneus, the mid-position of the posterior calcaneus was marked. A line bisecting the calcaneus 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, >9° (rear foot pronation); 2, 0°–9° (ideal); and 3, <0° (rear foot supination) (McPoil & Brocato, 1990).

✓ *Rear foot lying test*

Apparatus: One plinth; goniometer ; 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 (Kapandji, 1970 and McPoil & Brocato, 1990).

✓ *Transverse arch area comparison test*

Apparatus: One plinth.

Test procedure: Subject 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, normal plantar aspect with slight transverse arch (ideal); and 2, callus plantar aspect with flat arch (non-ideal) (Kapandji, 1970 and McPoil & Brocato, 1990).

✓ *Foot mobility test*

Apparatus: One plinth.

Test procedure: The subject and the 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 categorised into 1, hypermobile; 2, ideal; and 3, hypomobile (Kapandji, 1970).

✓ *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 categorised: 1, ideal position (no valgus, rotation or deviation); and 2, non-ideal (valgus/rotation/deviation present) (Hoppenfeld, 1976).

3.3.5.8 Pelvic girdle region: Leg length discrepancy test

Apparatus: One plinth.

Test procedure: The subject was positioned supine on the plinth with the heels just over the edge. The examiner ensured the symmetrical positioning of the subject. Placed at the end of 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 categorised into 1, medial malleoli height left equals right (ideal); 2, <1 cm discrepancy (slightly displaced) non-ideal; and 3, >1 cm discrepancy highly unsatisfactory (Hoppenfeld, 1976; Peers, 1994; Rocabado, 2000).

3.3.5.9 Pelvic girdle region: Anterior superior ileac spine (ASIS) comparison test

Apparatus: One plinth; marker.

Test procedure: The was subject 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 categorised as follows: 1, symmetrical (ideal); and 2, asymmetrical (non-ideal) (Hoppenfeld, 1976; Peers, 1994; Rocabado, 2000).

3.3.5.10 Pelvic girdle region: Posterior superior ileac spine (PSIS) comparison test

Apparatus: One plinth; 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 categorised as follows: 1, symmetrical (ideal); and 2, asymmetrical (non-ideal) (Hoppenfeld, 1976; Peers, 1994; Porterfield & DeRosa, 1990; Rocabado, 2000).

3.3.5.11 Pelvic girdle region: Pelvic rami positional test

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 medial rami. The area was assessed for asymmetry. Status was categorised as follows: 1, symmetrical (ideal); and 2, asymmetrical (non-ideal) (Hoppenfeld, 1976; Peers, 1994; Rocabado, 2000).

3.3.5.12 Pelvic girdle region: Sacroiliac cleft test

Apparatus: One plinth.

Test procedure: The subject was positioned as for the *posterior superior ileac spine comparison test.* The examiner carefully exposed the sacroiliac joint (SIJ) area. He then placed the thumbs on the joint margin and assessed for cleft asymmetry. Status was categorised as follows: 1, symmetrical (ideal); and 2, asymmetrical (non-ideal) (Porterfield & DeRosa, 1990).

3.3.5.13 Pelvic girdle region: Bilateral pelvic positional test

Apparatus: Tape measure; marker; 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 categorised into the following: 1, 2–3 cm discrepancy (ideal); 2, 3–5 cm discrepancy (non-ideal); and 3, >5 cm discrepancy (highly unsatisfactory) (Kapandji, 1974).

3.3.5.14 Spinal region: Thoraco-lumbar fascia mobility test

Apparatus: One plinth; tape measure.

Test procedure: The subject was placed in side-lying position with head placed at 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 edge of 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 categorised into the following: 1, 1 cm and less (ideal); 2, 1–3 cm (non-ideal); and 3, >3 cm (highly unsatisfactory) (Kapandji, 1974).

3.3.5.15 Spinal region: Sacral rhythm test

Apparatus: One plinth.

Test procedure: Subject in prone position on plinth with head close to 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 categorised into the following: 1, symmetrical movement (ideal); and 2, asymmetrical movement (non-ideal) (Gould III, 1990).

3.3.5.16 Spinal region: Functional extension mobility test

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 categorised into: 1, 1 cm and less (ideal); 2, 2–3 cm (non-ideal); and 3, >3 cm (highly unsatisfactory) (Gould III, 1990).

3.3.5.17 Spinal region: Functional flexion mobility test

Apparatus: None.

Test procedure: The subject stood erect and relaxed, with feet at shoulder width. Without bending the 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, of possible. Flexion was categorised into: 1, palms placed flat on ground (ideal); 2, fingers touching ground (non-ideal); and 3, unable (highly unsatisfactory) (Kapandji, 1974).

3.3.5.18 Spinal region: Rotational mobility test

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 places his hands on the subject's shoulders and rotated the trunk to the end of its range. The range was noted and categorised as follows: 1, rotation 90° and more (ideal); 2, rotation at 70° and 90° (non-ideal); and 3, rotation less than 70° (highly unsatisfactory) (Kapandji, 1974).

3.3.5.19 Spinal region: Side flexion mobility test

Apparatus: One plinth.

Test procedure: The subject was positioned as for *rotational mobility test*. With both hands on shoulders relaxed. Examiner, from the rear, stabilised 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 to the left side. The range was categorised as follows: 1, easy elbow contact with plinth without stretching sensation and resistance (ideal); 2, contact with stretching sensation and resistance (non-ideal); and 3, unable to touch surface (highly unsatisfactory) (Gould III, 1990; Kapandji, 1974).

3.3.5.20 Coronal axis

Apparatus: One high stool.

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 spinal regions were positionally categorised: cranium (head), cervical, thoracic and lumbar. Regions were identified as: 1, ideal (within acceptable anatomical postural limits close to the coronal axis); and 2, non-ideal (exceeding acceptable limits) (Kapandji, 1974).

3.3.5.21 Sagittal axis

The subject was positioned as for the coronal evaluation, with the examiner positioned posteriorly 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 categorised: cranium (head), cervical, thoracic and lumbar. Regions were identified as: 1, ideal (within acceptable anatomical postural limits close to sagittal axis); and 2, non-ideal (deviating from axis) (Kapandji, 1974).

3.3.5.22 Upper limb region: Hand behind back ROM test

Apparatus: One marker; tape measure.

Test procedure: The subject stood erect, relaxed, feet at shoulder width, with examiner positioned posteriorly. 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 categorised into: 1, distance between two marks equal or less than 1 cm (ideal); 2, 1–3 cm (non-ideal); and 3, >3 cm (highly unsatisfactory) (Kapandji, 1970).

3.3.5.23 Upper limb region: Hand behind neck ROM test

Apparatus: One marker; 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 categorised into: 1, distance equal or less than 1 cm (ideal); 2, 1–3 cm (non-ideal); and 3, >3 cm (highly unsatisfactory) (Brukner & Khan, 2000 and Kapandji, 1970).

3.3.5.24 Upper limb region: Shoulder coronal positional test

Apparatus: One high stool.

Test procedure: The subject stood erect, relaxed, feet at shoulder width, with 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 categorised as: 1, anterior displacement of shoulder less than two thirds (ideal); and 2, anterior displacement more than two thirds (non-ideal) (Brukner & Khan, 2000 and Kapandji, 1970).

3.3.5.25 Upper limb region: Winging positional test

Apparatus: One high stool; marker.

Test procedure: Subject stood erect, relaxed, feet at shoulder width, with examiner positioned posteriorly seated on high stool. Inferior medial margins of both scapulae were carefully marked, as well as the spinous process of T9. Distances between the spinous process (T9) and the inferior medial margins were noted and recorded. Measurements were categorised as:

- Distance equal with no winging (ideal), both categorised as 1.
- Discrepancy more than 1 cm. Winging on larger measurement side, categorised as 2 (non-ideal). Contra-lateral side, no winging, categorised as 1.

Equal distance (larger) plus winging, non-ideal, both categorised as 2 (Brukner & Khan, 2000, Hallbach & Tank, 1990 and Kapandji, 1970).

3.3.5.26 Upper limb region: Shoulder outline composition

Apparatus: One high stool.

Test procedure: Subject stood erect, relaxed, feet at shoulder width, with examiner positioned laterally. Shoulder outline was categorised into: 1, predominantly muscular with very few to no *visible* bony landmarks (ideal); and 2, less muscular with prominent bony landmarks *well visible* (non-ideal) (Halbach & Tank, 1990; Brukner & Khan, 2000).

3.3.5.27 Upper limb region: Throwing ROM test

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 stabilised the trunk and passively flexed the shoulder to the end of its range. Using an imaginary coronal axis passing through the midline of the subject (line of gravity), the examiner noted the range. Subjects were categorised as: 1, exceeding coronal midline (ideal); and 2, short of coronal midline (non-ideal) (Mullin, 1999).

3.3.5.28 Neurodynamics: Straight leg raise (SLR)

The subject was positioned supine on the plinth, closest to the examiner. Trunk and hips were in a neutral position. The examiner places one hand under the Achilles tendon and the other above the knee. The leg is lifted perpendicular to the plinth, with the hand above the knee preventing any knee flexion. The limb is lifted as a solid lever moving at a fixed point in the hip joint. The limb is 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 a standard long-arm goniometer (with the apex of the trochanter as midpoint). The range of movement was noted and categorised as follows: 1, 90° and more (ideal); 2, 70°–90° (non-ideal); and 3, less than 70° (highly unsatisfactory) (Butler, 1991; Saunders, 1990;).

3.3.5.29 Neurodynamics: Upper limb tension test

1. 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 upper left arm resting on thigh.

2. The left shoulder girdle was depressed by the examiner with his left hand, ensuring maintenance of the neutral position of the girdle. The glenohumeral joint was abducted to 110° in the coronal plane.

3. With this position maintained, the forearm was supinated and the wrist and fingers extended.

4. The shoulder was rotated laterally.

5. The elbow was slowly extended.

6. 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, 180°–0° with slight symptoms (ideal); 2, 180°–10° with symptoms (non-ideal); and 3, 180° to more than 10°, with symptoms (highly unsatisfactory) (Butler, 1991 and Halbach & Tank, 1990).

3.3.5.30 Neurodynamics: L3,4 nerve suppleness test (prone knee bend)

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. Range was noted. Subjects were here classified into three categories: 1: heel touching gluteus area with little resistance (ideal); 2: heel touching gluteus area with strong resistance (non-ideal); and 3: heel not touching (highly unsatisfactory) (Butler, 1991 and Gould III, 1990).

3.3.5.31 Neurodynamics: Slump test

1. Subject was positioned well back with legs over the side of the plinth (knee crease at edge). Both hands were linked in a relaxed position behind the back.

2. Subject was ordered to slump with cervical spine in extension. The examiner now applied overpressure to thoracic and lumbar spine. This position was maintained.

3. The order was now given to flex the cervical spine and to press chin to chest, again with gentle overpressure by the examiner.

4. With this position held, the subject was now ordered to extend the knees, first the left, then the right. Range and discomfort was noted.

5. With position as in 4, dorsiflexion of the ankle and foot were carefully added. Range and discomfort were noted.

6. With position held as in 5, neck flexion was carefully released. Signs and symptoms were noted.

7. The test was repeated on the opposite side.

8. Finally, with subject in slump position with overpressure, both knees were extended. Discomfort and range were noted.

Subjects were classified into 3 categories: 1, Full range, with dorsiflexion, asymptomatic (ideal); 2, Full range, with dorsiflexion, and discomfort (non-ideal); and 3, limited range with tension (highly unsatisfactory) (Gould III, 1990).

In summary – testing batteries discussed were performed on all the age-groupers. Results with tendencies will be discussed in the next Chapter, with a discussion and conclusion in the last Chapter.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The aim of this study was to develop a prevention programme for rugby injuries, based on an analysis among adolescent players, with reference to anthropometric, physical and motor, and biomechanical and postural variables.

To achieve this aim, the research was categorised as follows:

- *Firstly,* by identifying the anthropometric, physical and motor and biomechanical and postural variables of *four elite rugby-playing age-groupers*.
- *Secondly*, by determining the differences in anthropometric, physical and motor and biomechanical and postural variables according to *forward and back-line players within each age group*.
- *Thirdly*, by comparing anthropometric, physical and motor and biomechanical and postural variables between *elite 15- and 18-year-old school* and *19- and 20-year-old elite club rugby players*, *as well as comparisons within each group*.
- *Fourthly*, by determining previous injury status of *each age group* according to injury history questionnaires, and by comparing this data among age-groupers.
- *Finally*, by revealing data on clinic attendance records by elite *club rugby players* and comparing data with information from the injury history questionnaire.

4.2 INDIVIDUAL AGE-GROUPER STATUS

The school rugby-playing groups were assessed and tested in the month of May 2002. Testing protocols for these age groups were done once off, due to the competition period for provincial teams and availability of players. Club rugby players were tested on three different occasions (January, May and August 2002) as far as anthropometrical, physical and motor variables are concerned. Biomechanical and postural evaluations (BMPE) were done once off as with the school rugby players during early May 2002.

When comparing the 15- and 18-year-old elite school rugby players, descriptive statistics were mostly used ($\bar{x}$,s, maximum and minimum values). With the 19- and 20-year-old elite club rugby players, descriptive and inferential statistics (d-values) were used. Because these groups were compared more than once, it was possible to obtain meaningful comparisons.

Due to player availability during the 2002 season, 19- and 20-year-old club rugby players underwent three testing episodes for anthropometric and physical and motor data. D-values are used to indicate practically significant differences between the different testing episodes, where d-values equal to or greater than 0,2 indicate a small practically significant difference, values equal to or greater than 0,5 a moderate practical significance, and values of 0,8 and greater a strong practical significance.

4.2.1 15-year-old elite school rugby players

4.2.1.1 Anthropometric, physical and motor variables

Table 4.1 displays all anthropometric, physical and motor data on the 15-year-old elite school rugby players tested. The anthropometric test for body mass displayed a mean value of 71,31 kg (with min. 51,0 kg and max. 99,0 kg) comparing well with the findings of Hare (1999) in his elite 15-year-old rugby-playing study group ($\bar{x}$ = 71,60 kg). The mean length was measured at 173,69 cm (with min. 162,0 cm and max. 183,0 cm), considerably shorter than Hare's (1999) values at 186,0 cm. Lastly, the mean body fat percentage was 17,22%, (with min. 11,90 and max. 32,9) high when compared with Hare's (1999) group at 11,1% measured in June 1999. It is noted that an exceptionally high fat percentage was recorded for the 15-year-old elite school rugby players used in this study. A further interesting fact is that these results were recorded during midseason.

Table 4.1: Descriptive statistics of anthropometric, physical and motor variables for 15-year-old elite school rugby players (N=27)

Variables	$\bar{x}$	s	Median	Min.	Max.
Anthropometric					
Body mass (kg)	71,31	15,93	70,00	51,00	99,00
Body length (cm)	173,69	15,25	175,0	162,00	183,00
Fat percentage (%)	17,22	6,43	14,30	11,90	32,90
Physical and motor					
the 30 m dash (sec)	4,42	0,18	4,50	4,10	4,80
Agility (sec)	18,98	1,11	18,60	17,70	21,00
Vertical jump (cm)	46,46	7,50	45,00	23,00	57,00
Horizontal jump (cm)	233,00	19,00	240,00	200,00	290,00
Abdominal curls (level)	4,72	1,79	5,00	1,00	7,00
Pull-up (n)	10,48	5,07	11,00	1,00	20,00
Bleep (level)	9,23	2,08	8,90	5,90	13,20
Speed endurance (%)	12,46	0,79	12,50	11,00	14,00

$\bar{x}$ = mean; s = standard deviation; Min. = minimum values; Max. = maximum values

For speed quantification the 30 m dash test recorded a mean value of 4,42 seconds. This is 0,4 seconds faster than values recorded by Badenhorst (1998) in a similar elite soccer playing age group. The agility component was assessed by using a prescribed *agility test* and a mean value of 18,98 seconds was achieved. To deterrnine subjects' explosive power two *jump tests* were implemented, namely the *vertical* and *horizontal.* The vertical jump test recorded mean values of 46,46 cm outperforming the Hare (1999) and Badenhorst (1998) study groups with respective means of 43,84 cm and 38,37 cm. The same tendency occurred with the horizontal jump with a mean value of 233 cm versus 201 cm recorded by Badenhorst (1998)

Abdominal curls ($\bar{x}$ = 4,72) and pull-up tests ($\bar{x}$ = 10,48) were the two power endurance protocols implemented. To measure aerobic capacity the bleep test recorded a mean value of 9,23, with Badenhorst's (1998) elite soccer group outperforming the elite rugby-playing subjects with a value of 9,79. Finally, for anaerobic capacity the speed endurance test presented a mean value of 12,46.

4.2.1.2 Biomechanical and postural variables

Table 4.2 displays biomechanical and postural data collected under five main categories, namely lower limb, pelvic girdle, spinal region, upper limb and neurodynamics. The first aspect of the lower limb region, namely lower limb dynamic mobility, was analysed by using the TA, modified Thomas with its three components (ITB, quadriceps and iliopsoas), gluteus maximus, adductor and hip internal and external rotational tests. When compared to the rest of the lower limb, the modified Thomas (ITB $\bar{x}$ = 1,78 left and 1,65 right; Quadriceps $\bar{x}$ = 1,54 left and 1,57 right; Iliopsoas mobility $\bar{x}$ = 1,51 left and 1,57 right), gluteus maximus ($\bar{x}$ = 1,68 left and 1,57 right) and hip external rotation ($\bar{x}$ = 1,57 left and 1,76 right) range tests recorded higher mean values, rendering these areas less mobile and dynamically loaded.

Table 4.2: Descriptive statistics of biomechanical and postural variables for 15-year-old elite school rugby players (N=39)

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Lower limb				
Lower limb dynamics				
TA	1,50	0,70	1,44	0,70
Modified Thomas testings: ITB Quadriceps mobility Iliopsoas mobility	 1,78 1,54 1,51	 0,48 0,61 0,51	 1,65 1,57 1,57	 0,48 0,56 0,50
Gluteus maximus mobility	1,68	0,63	1,57	0,56
Adductor	1,43	0,56	1,43	0,56
Hip internal rotation mobility	1,35	0,48	1,30	0,46
Hip external rotation mobility	1,57	0,56	1,76	0,50
Knee region				
Q-angle	1,16	0,37	1,19	0,40
Patella squint	1,14	0,35	1,14	0,35
Patella tilt	1,57	0,50	1,54	0,51
VMO-L comparison	1,35	0,49	1,38	0,49
Ankle and foot region				
Longitudinal arch status	1,65	0,54	1,65	0,54
Forefoot positional	1,62	0,49	1,62	0,49
Rear foot standing	1,65	0,68	1,57	0,56

Table 4.2 continues

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Rear foot lying	1,54	0,51	1,54	0,51
Transverse arch area comparison	1,16	0,37	1,16	0,37
Foot mobility	1,31	0,58	1,31	0,58
Toe position	1,60	0,50	1,60	0,50
Pelvic girdle region				
Leg length discrepancy	1,65	0,54	-	
ASIS	1,65	0,48	-	
PSIS	1,65	0,48	-	
Pelvic rami position	1,82	0,39	-	
Sacroiliac cleft	1,14	0,35	-	
Bilateral pelvic position	1,68	0,67	-	
Spinal region				
Spinal dynamic mobility				
TLF mobility	1,68	0,63	1,76	0,68
Sacral rhythm	1,08	0,28	1,08	0,28
Functional extension mobility	1,62	0,64	-	
Functional flexion mobility	1,73	0,65	-	
Rotational mobility	1,35	0,54	1,35	0,54
Side flexion mobility	1,43	0,56	1,43	0,56
Spinal positional alignment				
Coronal axis Head position Cervical Thoracic Lumbar	 1,35 1,38 1,43 1,30	 0,48 0,49 0,50 0,46	-	
Sagittal axis Head position Cervical Thoracic Lumbar	 1,14 1,08 1,62 1,11	 0,35 0,28 0,49 0,32	-	
Upper limb				
Hand behind back ROM	1,32	0,58	1,84	0,83
Hand behind neck ROM	1,11	0,32	1,11	0,40
Shoulder positional test	1,70	0,46	1,72	0,45
Winging positional test	1,81	0,40	1,83	0,38
Shoulder outline composition	1,43	0,50	1,42	0,50
Throwing position	1,24	0,44	1,22	0,42
Neurodynamics				
Straight leg raise	2,00	0,72	2,00	0,76
Upper limb tension	1,11	0,32	1,14	0,42
L3,4 prone knee bend	1,70	0,70	1,68	0,71
Slump	1,60	0,60	1,60	0,60

$\bar{x}$ = mean; s = standard deviation

The second lower limb aspect assessed the postural alignment of the knee complex. Among the four tests, the patella tilt ($\bar{x}$ = 1,57 left and 1,54 right) and VMO-L comparison ($\bar{x}$ = 1,35 left and 1,38 right) tests recorded the highest mean values.

The final assessed lower limb aspect was the ankle and foot region, with seven regional status tests. Two of these, namely transverse arch area comparison ($\bar{x}$ = 1,16 left and right) and foot mobility ($\bar{x}$ = 1,31 left and right) tests recorded values closer to the ideal as suggested by Hoppenfeld (1976); Hunt (1990); McPoil & Brocato (1990), rendering these areas in a preferred positional status.

In the second category (*pelvic girdle region*) six positional tests in total were performed with only the sacroiliac cleft test recording a low mean value of 1,14 (close to ideal), as with the findings of Hoppenfeld (1976), Porterfeld & DeRosa (1990) and Rocabado (2000). Thus, rendering this positional area category asymmetric and reasonably unstable.

In the third category (*spinal region*) six *dynamic mobility* tests were performed with three of the tests showing high mean values (closer to non-ideal) (Kapandji, 1974), namely TLF ($\bar{x}$ = 1,68 left and 1,76 right), extension ($\bar{x}$ = 1,62) and flexion ($\bar{x}$ = 1,73) mobility tests. A further eight *postural positional* assessments were done, four in the coronal and four in the sagittal axis, the coronal axis having very similar mean values varying between 1,30 and 1,43. Low mean values were measured in the sagittal axis, except for the thoracic area, with a mean value of 1,62 (closer to non-ideal), correlating with findings of Kapandji (1974) and Warwick & Williams (1973); this is mainly due to quadrant dominance.

In the *upper limb region* a total of six evaluation tests were performed with the shoulder ($\bar{x}$ = 1,70 left and 1,72 right) and winging positional ($\bar{x}$ = 1,81 left and 1,83 right) tests, as well as shoulder outline composition test ($\bar{x}$ = 1,43 left and 1,42 right), showing higher mean values meaning poor regional positional stability and musculature as suggested by Halbach & Tank, (1990) and Kapandji, (1970). This correlates with the developmental phase of the 15-year-old player.

Lastly, four *neurodynamic* evaluation tests showed a low mean value for the *upper limb test* ($\bar{x}$ = 1,11 left and 1,14 right) (closer to ideal), and a high mean value for *the straight* *leg raise* ($\bar{x}$ = 2,00 left and right) (non-ideal), correlating with the rapid growth phase of this age group (Butler, 1991).

4.2.2 18-year-old elite school rugby players

4.2.2.1 Anthropometric, physical and motor variables

Table 4.3 displays anthropometric, physical and motor results for the elite 18-year-old school rugby players. The mean body mass among this age group was measured at 87,13 kg, correlating well with the Spamer and Winsley (2003) findings by similar elite age-groupers (Northern Bulls $\bar{x}$ = 87,40 kg; English College team $\bar{x}$ = 87,8 kg). But this differs from the findings of Malan and Hanekom (2001), where the average body mass for the talented 16- and 18-year-old school rugby players were 77,36 kg. The mean length recorded was

180,68 cm, meaning that this study's elite school rugby players were slightly shorter than the Northern Bulls and English College teams ($\bar{x}$ = 185,6 cm and 181,9 cm respectively), but taller than the players in the Malan and Hanekom (2001) study ($\bar{x}$ = 175,61 cm). The 18-year-old elite school rugby players recorded body fat percentage values of 12,98%, which is substantially lower than the 15,8% and 22,1% recorded by the Northern Bulls and English College teams respectively, but higher than values of 9,86% as recorded by Malan and Hanekom (2001).

As with the 15-year-old , physical and motor tests were performed, with the exception that in this age group two power tests were included, namely the one repetition maximum (1RM) bench press ($\bar{x}$ = 90,79 kg) and squat ($\bar{x}$ = 133,7 kg). In the 30 m dash (speed test) ($\bar{x}$ = 4,32 sec) and agility ($\bar{x}$ = 17,74 sec) tests the 18-year-old elite school rugby players were outperformed by the Malan and Hanekom (2001) group (the 30 m dash $\bar{x}$ = 4,02 sec; agility test = 16,47 sec). The explosive power tests, namely vertical and horizontal jump presented respective means of 50,6 cm and 240 cm. With the vertical jump the findings correlated well with those of Spamer and Winsley (2003) (Northern Bulls $\bar{x}$ = 52,40 cm; English College team $\bar{x}$ = 44,00 cm), but were substantially better than values recorded by Malan and Hanekom (2001) ($\bar{x}$ = 40,96 cm). Aerobic capacity results favoured the 18-year-old elite rugby players ($\bar{x}$ = 9,61) who recorded values superior to the Malan and Hanekom (2001) group ($\bar{x}$ = 8,0).

In conclusion, the 18-year-old elite school rugby players correlated anthropometrically well with the Winsley and Spamer (2003) group, but outperformed the Malan and Hanekom (2001) subjects.

Table 4.3: Descriptive statistics of anthropometric, physical and motor variables for 18-year-old elite school rugby players (N=84)

Variables	$\bar{x}$	s	Median	Min.	Max.
Anthropometrical					
Body mass (kg)	87,13	13,88	87,55	61,85	117,85
Body length (cm)	180,68	6,47	180,05	165,50	198,40
Fat percentage (%)	12,98	4,78	11,75	5,20	26,00
Physical and motor					
the 30 m dash (sec)	4,32	0,23	4,27	3,94	5,22
Agility (sec)	17,74	0,70	17,72	16,31	20,03
Vertical jump (cm)	50,60	6,91	50,00	33,00	65,00
Horizontal jump (cm)	240,00	17,00	244,00	196,00	279,00
Abdominal curls (level)	5,76	1,32	6,00	2,00	7,00
Pull-up (n)	10,29	5,23	10,00	1,00	22,00
1RM Bench press (kg)	90,79	14,52	90,00	60,00	125,00
1RM Squat (kg)	133,70	24,25	130,00	80,00	200,00
Bleep (level)	9,61	1,68	9,60	5,10	13,20
Speed endurance (%)	12,82	0,73	13,00	11,00	14,00

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values

4.2.2.2 Biomechanical and postural variables

In table 4.4 biomechanical and postural data on the 18-year-old elite school rugby players are presented. In the *lower limb region* under dynamic mobility reasonable mean values were tested for TA ($\bar{x}$ = 1,60 left and 1,65 right), adductor ($\bar{x}$ = 1,55) and hip internal rotation mobility ($\bar{x}$ = 1,35 left and right) (close to the ideal) as with the findings of Kapandji, (1970). However, the modified Thomas with its three components (testing functional mobility) rendered subjects less mobile and thus dynamically loaded. Same tendency was seen bilaterally for the gluteus maximus mobility test ($\bar{x}$ = 1,88 left and 1,95 right).

In the second lower limb aspect (knee complex) the patella tilt test had high mean values at 1,7 and 1,8 correlating well with modified Thomas and gluteus maximus tendencies in this region (close to non-ideal) correlating with recordings by Kapandji, (1970) and Wallace *et al.*, (1990). The rest of the testing means were reasonably low and satisfactory.

In the final lower limb aspect (ankle and foot region) the toe ($\bar{x}$ = 1,83 left and right) and forefoot positional ($\bar{x}$ = 1,58 left and right) tests presented with higher mean values (close to non-ideal) corresponding with recordings by Hoppenfeld (1976); Hunt (1990) and McPoil & Brocato (1990). This also correlates with the tendency seen higher up in the mechanical chain (modified Thomas, gluteus maximus and patella tilt tests).

In the *pelvic girdle region* the highest mean value recorded was for the bilateral pelvic positional test ($\bar{x}$ = 2,03). This correlating again with the high modified Thomas values. The leg length discrepancy, ASIS, PSIS and pelvic rami positional tests, indicate asymmetry and instability in this area, thus a lack in core stability (Hoppenfeld, 1976, Porterfeld & DeRosa, 1990; Rocabado, 2000).

In the six *spinal dynamic mobility* tests, the highest mean value was recorded for the TLF test ($\bar{x}$ = 1,80 left and 1,78 right). This correlated well with earlier findings in the lower limb dynamic tendencies. The rest of the values were satisfactory, except for the functional flexion mobility test ($\bar{x}$ = 1,58). In the coronal axis the lumbar area presented a high mean value of 1,73 again correlating with the lower limb dynamic tendencies. In the sagittal axis only the thoracic area presented with a high mean value of 1,65 due to quadrant dominance.

In the *upper limb* dynamic tests the shoulder positional ($\bar{x}$ = 1,74 left and right) and winging ($\bar{x}$ = 1,73 left and 1,75 right) tests presented the highest mean values, showing poor core stability in this area (Kapandji, 1970).

In the final category (*neurodymanic* testing) the most ideal mean value recorded was seen in the results of the upper limb tension test ($\bar{x}$ = 1,38 left and 1,28 right), with the rest of the testing protocols showing high values (closer to non-ideal) (Butler, 1991).

Table 4.4: **Descriptive statistics of biomechanical and postural variables for 18-year-old elite school rugby players (N=39)**

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Lower limb region				
TA	1,60	0,71	1,65	0,70
Modified Thomas testings:				
ITB	1,75	0,49	1,80	0,46
Quadriceps mobility	1,75	0,54	1,83	0,50
Iliopsoas mobility	2,08	0,69	2,03	0,73
Gluteus maximus mobility	1,88	0,52	1,95	0,50
Adductor	1,55	0,60	-	
Hip internal rotation mobility	1,35	0,53	1,35	0,48
Hip external rotation mobility	1,88	0,46	1,93	0,53
Knee complex				
Q-angle	1,40	0,50	1,33	0,47
Patella squint	1,33	0,47	1,23	0,42
Patella tilt	1,73	0,45	1,78	0,42
VMO-L comparison	1,25	0,44	1,30	0,46
Ankle and foot region				
Longitudinal arch status	1,58	0,50	1,50	0,51
Forefoot positional	1,58	0,50	1,58	0,50
Rear foot standing	1,45	0,55	1,48	0,60
Rear foot lying	1,38	0,49	1,45	0,55
Transverse arch area comparison	1,30	0,46	1,33	0,47
Foot mobility	1,33	0,62	1,30	0,56
Toe position	1,83	0,39	1,83	0,39
Pelvic girdle region				
Leg length discrepancy	1,65	0,53	-	
ASIS	1,63	0,49	-	
PSIS	1,63	0,49	-	
Pelvic rami position	1,62	0,49	-	
Sacroiliac cleft	1,32	0,47	-	
Bilateral pelvic position	2,03	0,62	-	
Spinal region				
Spinal dynamic mobility				
TLF mobility	1,80	0,56	1,78	0,58
Sacral rhythm	1,13	0,34	1,13	0,34
Functional extension mobility	1,38	0,49	-	
Functional flexion mobility	1,58	0,59	-	
Rotational mobility	1,15	0,36	1,20	0,41
Side flexion mobility	1,33	0,47	1,35	0,48

Table 4.4 continues

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Spinal positional alignment				
Coronal axis				
Head position	1,20	0,41	-	
Cervical	1,15	0,36		
Thoracic	1,53	0,51		
Lumbar	1,73	0,45		
Sagittal axis				
Head position	1,03	0,16		
Cervical	1,03	0,16		
Thoracic	1,65	0,48		
Lumbar	1,15	0,36		
Upper limb				
Hand behind back ROM	1,35	0,58	1,55	0,75
Hand behind neck ROM	1,23	0,42	1,20	0,46
Shoulder positional test	1,74	0,44	1,74	0,44
Winging positional test	1,73	0,45	1,75	0,44
Shoulder outline composition	1,40	0,50	1,40	0,50
Throwing position	1,48	0,51	1,48	0,51
Neurodynamics				
Straight leg raise	2,08	0,62	2,05	0,60
Upper limb tension	1,38	0,59	1,28	0,55
L3,4 prone knee bend	1,90	0,81	1,85	0,77
Slump	1,70	0,69	1,70	0,69

$\bar{x}$ = mean values; s = standard deviation values

4.2.3 19-year-old (freshmen) junior elite club rugby players

4.2.3.1 Anthropometric, physical and motor variables

Table 4.5 displays anthropometric, physical and motor data on three different testing episodes done on the 19-year-old, junior elite club rugby players. Also included are the d-values comparing episodes 1 and 2, 2 and 3 and lastly 1 and 3. The mean body mass of all freshman players showed a gradually increasing tendency ($\bar{x}$ = 83,38 kg; 85,65 kg; 87,29 kg) throughout the season. However the high standard deviation between the different testing episodes proved the big difference in the individual performances. When comparing testing episode 1 and 3, a d-value of 0,28 indicated a small practical significant difference. Body length, which was only measured on the first and third episode, showed an increase from 179,35 cm to 181,45 cm, which correlates with the growth phase of this age group (small practical significant difference, d = 0,28). Finally under anthropometric testing, body fat percentage showed a only slight decrease between testing episodes 1 and 2 (d = 0,10), and also a small practical significant decrease when comparing episode 1 and 3 (d = 0,35). Body fat percentage of British elite rugby players according to Mayes & Nuttall (1995), recorded a mean value of 15,60%, higher than testing episode 3 values at 11,79%. When considering the increase in body mass and the decrease in body fat percentage, an increase in lean body mass was depicted on average.

Physical and motor abilities for the freshman players showed no practical significant difference in recorded values throughout the three testing episodes for *the 30 m dash*, *pull-up* and *speed endurance* testing protocols. Agility testing for testing episode 1 and 2 (d = 0,68), as well as 1 and 3 (d = 0,59) recorded moderately practical significant differences. In maximum power testing the squat test recorded moderately practical significant differences between testing episodes 2 and 3 (d = 0,75), and 1 and 3 (d = 0,73).

Table 4.5: Descriptive statistics of anthropometric, physical and motor variables for 19-year-old (freshmen) elite club rugby players (N=108)

Variables	**TEST EPISODE 1** (January 2002)				**TEST EPISODE 2** (May 2002)				**d-value** (Comparing test 1 & 2)	**TEST EPISODE 3** (August 2002)				**d-value** (Comparing test 2 & 3)	**d-value** (Comparing test 1 & 3)
	$\bar{x}$	s	Min.	Max.	$\bar{x}$	s	Min.	Max.		$\bar{x}$	s	Min.	Max.		
Anthropometrical															
Body mass (kg)	83,38	13,70	52,50	123,10	85,65	13,63	58,65	118,10	0,17	87,29	14,12	61,65	121,85	0,12	0,28
Body length (cm)	179,35	7,42	162,40	200,00	-	-	-	-	-	181,45	6,61	167,20	197,00	-	0,28
Fat percentage (%)	13,74	5,65	6,60	32,90	13,15	5,36	6,90	29,00	0,10	11,79	4,63	6,50	23,40	0,25	0,35
Physical and motor															
the 30 m dash (sec)	4,33	0,22	3,92	4,96	4,35	0,24	3,89	4,90	0,08	4,30	0,26	3,88	4,86	0,19	0,12
Agility (sec)	18,26	0,91	16,19	21,29	17,64	0,76	15,97	19,97	0,68	17,72	0,87	16,63	20,07	0,09	0,59
Vertical jump (cm)	52,25	7,61	32,00	72,00	52,70	6,99	35,00	70,00	0,06	55,40	8,34	32,00	71,00	0,32	0,38
Horizontal jump (cm)	250,00	22,00	180,00	293,00	247,00	24,00	171,00	310,00	0,13	252,00	23,00	195,00	295,00	0,21	0,09
Abdominal curls (level)	5,31	1,45	1,00	7,00	4,67	1,98	1,00	7,00	0,32	4,67	1,98	1,00	7,00	0,00	0,32
Pull-up (n)	10,14	4,54	1,00	19,00	10,23	4,37	1,00	22,00	0,02	9,42	5,18	1,00	20,00	0,16	0,14
1RM Bench press (kg)	91,96	17,89	50,00	130,00	92,93	18,46	60,00	135,00	0,05	95,66	18,02	60,00	160,00	0,15	0,21
1RM Squat (kg)	116,35	25,30	60,00	160,00	116,52	24,15	70,00	160,00	0,01	134,72	21,74	90,00	175,00	0,75	0,73
Speed endurance (%)	13,18	0,87	11,00	15,00	13,14	0,73	11,50	14,50	0,05	13,01	1,02	11,00	15,00	0,13	0,17

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values

0,2 = d-value with little practical significance; 0,5 = d-value with moderate practical significance; 0,8 = d-value with high practical significance

4.2.3.2 Biomechanical and postural variables

Table 4.6 displays the one-off biomechanical and postural assessment done on the freshman subjects. In the *lower limb region*, dynamic mobility testing showed reasonable high values for the *modified Thomas* (with its three components), gluteus maximus and the external rotation mobility tests in this age group correlating with range of movements as recorded by Kapandji (1970). The knee complex, on the other hand, showed low values for positional testing, except for the patella tilt test ($\bar{x}$ = 1,65 left and 1,63 right), which in turn correlates with dynamic test findings in this region by Kapandji (1970) and with Wallace *et al (*1990). In the ankle and foot region values close to the ideal were seen with the *transverse arch area comparison test* ($\bar{x}$ = 1,17 left and $\bar{x}$ = 1,13 right) and high values (closer to non-ideal) for the *toe positional test* ($\bar{x}$ = 1,59 left and 1,57 right. This correlated with tendencies seen in the lower limb dynamic testing, and with recordings by Hoppenfeld (1976), Hunt (1990) and McPoil & Brocato (1990).

In the *pelvic girdle region* the highest mean value recorded was seen in the bilateral pelvic positional test ($\bar{x}$ = 1,83). The rest of the testing components in this region showed values which indicate a margin of asymmetry and core instability, again correlating with recordings by Hoppenfeld (1976), Porterfeld & DeRosa (1990) and Rocabado (2000).

In the *spinal region*, the TLF mobility test recorded a high value ($\bar{x}$ = 2,13 left and right), which correlates with tendencies seen in the lower limb dynamic testing. With spinal region positional testing in the coronal axis, the lumbar region ($\bar{x}$ = 1,61) presented with a high value, which correlates with lower limb dynamic findings. In the sagittal axis low values (closer to ideal) were seen in all positional testing, except in the thoracic area where dominance affected the mean, as with recordings by Kapandji (1970) and Warwick & Williams (1973).

In the *upper limb* dynamic tests the hand behind back ROM showed higher mean values of 1,65 and 1,67 left and right respectively, presenting asymmetry as with recordings by Halbach & Tank (1990) and Kapandji (1970).

Neurodynamically the L3,4 prone knee bend test recorded a mean value of 2,17 left and 2,22 right, falling between the non-ideal and highly unsatisfactory categories, correlating with findings of Butler (1991).

Table 4.6: Descriptive statistics of biomechanical and postural variables for 19-year-old (freshmen) elite club rugby players (N=46)

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Lower limb region				
Lower limb dynamic mobility				
TA	2,02	0,80	2,02	0,80
Modified Thomas testings:				
ITB	2,28	0,69	2,20	0,69
Quadriceps mobility	1,74	0,58	1,78	0,66
Iliopsoas mobility	2,28	0,81	2,26	0,83
Gluteus maximus mobility	2,17	0,53	2,15	0,60
Adductor	1,72	0,72	-	
Hip internal rotation mobility	1,59	0,75	1,59	0,78
Hip external rotation mobility	2,20	0,54	2,22	0,51
Knee complex				
Q-angle	1,17	0,38	1,17	0,38
Patella squint	1,13	0,34	1,17	0,38
Patella tilt	1,65	0,53	1,63	0,53
VMO-L comparison	1,15	0,42	1,13	0,40
Ankle and foot region				
Longitudinal arch status	1,62	0,54	1,71	0,51
Forefoot positional	1,39	0,49	1,33	0,47
Rear foot standing	1,63	0,68	1,54	0,59
Rear foot lying	1,63	0,66	1,61	0,61
Transverse arch area comparison	1,17	0,38	1,13	0,34
Foot mobility	1,33	0,56	1,37	0,61
Toe position	1,59	0,50	1,57	0,50
Pelvic girdle region				
Leg length discrepancy	1,46	0,59	-	
ASIS	1,41	0,50	-	
PSIS	1,41	0,50	-	
Pelvic rami position	1,41	0,50	-	
Sacroiliac cleft	1,11	0,32	-	
Bilateral pelvic position	1,83	0,83	-	

Table 4.6 continues

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Spinal region				
Spinal dynamic mobility				
TLF mobility	2,13	0,54	2,13	0,54
Sacral rhythm	1,00	0,00	1,04	0,21
Functional extension mobility	1,72	0,81	-	
Functional flexion mobility	1,50	0,72	-	
Rotational mobility	1,33	0,60	1,35	0,60
Side flexion mobility	1,46	0,62	1,46	0,62
Spinal alignment				
Coronal axis:				
Head position	1,48	0,51	-	
Cervical	1,07	0,25		
Thoracic	1,35	0,49		
Lumbar	1,61	0,49		
Sagittal axis:				
Head position	1,07	0,25	-	
Cervical	1,07	0,25		
Thoracic	1,57	0,50		
Lumbar	1,07	0,25		
Upper limb				
Hand behind back ROM	1,65	0,74	1,67	0,73
Hand behind neck ROM	1,20	0,40	1,20	0,40
Shoulder positional test	1,54	0,50	1,52	0,51
Winging positional test	1,46	0,50	1,44	0,50
Shoulder outline composition	1,15	0,36	1,15	0,36
Throwing position	1,24	0,43	1,24	0,43
Neurodynamics				
Straight leg raise	1,61	0,58	1,63	0,61
Upper limb tension	1,48	0,75	1,54	0,81
L3,4 prone knee bend	2,17	0,90	2,22	0,84
Slump	2,09	0,78	2,13	0,78

$\bar{x}$ = mean values; s = standard deviation values

4.2.4 20-year-old (seasonal) junior elite club rugby players

4.2.4.1 Anthropometric, physical and motor variables

The results for anthropometric, physical and motor ability tests are given in Table 4.7. As with the freshmen (19-year-old group) the seasonal subjects (20-year-old group) were submitted to three evaluation episodes during January, May and August 2002. Anthropometrically, the most practical significant difference seen, however small, was between episodes 1 and 3 for body mass from 87,37 kg up to 90,93 kg (d = 0,27). Body mass and fat percentage correlated well with findings recorded by Mayes and Nuttall (1995), however, the studied 20-year-old elite club rugby players recorded slightly lower body fat values ($\bar{x}$ = 13,02% vs. $\bar{x}$ = 15,60%).

Under physical and motor variables, moderately practical significant differences were noted for the 30 m dash (between testing episodes 1 and 2, d = 0,5), abdominal curls (between testing episodes 1 and 3, d = 0,51), squat (between testing episodes 2 and 3, d = 0,51) and speed endurance (between testing episodes 1 and 2, d = 0,62) test results. However, strongly practical significant differences were recorded for the bleep test (which is typical for the increase in fitness for rugby players) between testing episode 1 and 2 (d = 1,16). Similarly, the 30 m dash (d = 0,95), squat (d = 0,81), bleep (d = 1,38) and speed endurance (d = 0,98) tests recorded strongly practical significant differences between testing episodes 1 and 3. (Attributed to fitness and power program) Lastly, vertical jump values recorded

($\bar{x}$ = 54,30 cm), correlated well with the findings of Maud and Schultz (1984), recorded on a 20-year-old United States elite rugby team ($\bar{x}$ = 56,90 cm).

Table 4.7: Descriptive statistics of anthropometric, physical and motor variables for 20-year-old (seasonal) elite club rugby players (N=112)

Variables	TEST EPISODE 1 (January 2002)				TEST EPISODE 2 (May 2002)				d-value (Comparing test 1 & 2)	TEST EPISODE 3 (August 2002)				d-value (Comparing test 2 & 3)	d-value (Comparing test 1 & 3)
	$\bar{x}$	s	Min.	Max.	$\bar{x}$	s	Min.	Max.		$\bar{x}$	s	Min.	Max.		
Anthropometrical															
Body mass (kg)	87,37	13,13	58,20	118,50	87,07	13,28	60,10	117,90	0,02	90,93	12,75	67,60	117,90	0,29	0,27
Body length (cm)	180,06	6,94	163,00	194,00	-	-	-	-	-	181,30	6,92	165,80	193,40	-	0,18
Fat percentage (%)	13,55	5,79	6,50	31,60	12,6	4,57	6,20	29,40	0,15	13,02	4,69	7,30	26,50	0,09	0,09
Physical and motor															
the 30 m dash (sec)	4,45	0,22	4,14	5,06	4,34	0,21	3,90	4,92	0,50	4,24	0,22	3,89	4,84	0,45	0,95
Agility (sec)	17,62	0,77	16,38	20,50	17,66	0,70	16,39	20,00	0,05	17,58	0,71	16,53	19,52	0,11	0,05
Vertical jump (cm)	55,14	6,56	39,50	71,00	56,47	6,38	43,00	71,00	0,20	54,30	6,97	38,00	73,00	0,31	0,12
Horizontal jump (cm)	254,00	17,00	207,00	283,00	257,00	17,00	190,00	293,00	0,18	255,00	18,00	197,00	287,00	0,11	0,06
Abdominal curls (level)	4,58	1,98	1,00	7,00	4,75	2,04	1,00	7,00	0,08	5,59	1,63	2,00	7,00	0,41	0,51
Pull-up (n)	9,79	4,28	2,00	22,00	9,79	3,75	1,00	20,00	0,00	10,15	3,47	2,00	16,00	0,10	0,08
1RM Bench press (kg)	106,89	15,88	70,00	160,00	107,64	16,77	70,00	170,00	0,04	103,59	17,09	80,00	140,00	0,24	0,19
1RM Squat (kg)	133,93	25,44	90,00	190,00	140,71	27,26	90,00	220,00	0,25	154,64	23,96	110,00	200,00	0,51	0,81
Bleep (level)	9,53	1,45	4,50	13,10	11,40	1,61	6,60	15,40	1,16	11,55	1,46	7,10	14,20	0,09	1,38
Speed endurance (%)	12,97	1,18	10,00	16,00	13,70	0,89	10,00	15,00	0,62	14,13	1,00	12,00	16,00	0,43	0,98

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;
0,8 = d-values with high practical significance

4.2.4.2 Biomechanical and postural variables

Table 4.8 displays biomechanical and postural data on the seasonal players. *Lower limb* dynamics portray mean values close to and even worse than the non-ideal for the whole region correlating with Kapandji (1970). Considering the level at which players compete, a mean value closer to 1,0 would be preferred. In the knee complex the patella tilt positional test portrayed mean values of 1,68 for left and 1,65 for right, correlating with the higher modified Thomas and gluteus maximus values recorded earlier. In the ankle and foot region, the *toe positional test* achieved mean values of 1,70 and 1,73 respectively for left and right (close to the non-ideal), correlating with dynamic lower limb test findings. *Longitudinal arch status* and *foot mobility* tests correlated with a tendency from the norm towards a more flat and mobile foot. Similarly, the *rear foot standing* and *rear foot lying* tests correlated with the tendency towards slight pronation in these players as well as with recordings by Hoppenfeld (1976); Hunt (1990) and McPoil & Brocato (1990).

In the *pelvic girdle region* the ASIS, PSIS and pelvic rami positional tests displayed a tendency towards asymmetry in this region. This is supported by the results in the leg length discrepancy test, as well as with recordings by Hoppenfeld, (1976), Porterfeld & DeRosa, (1990) and Rocabado, (2000).

In *spinal dynamic mobility* tests, all six means measured can be categorised between ideal and non-ideal, with a strong tendency towards the non-ideal. In the coronal axis all mean values were satisfactory, except for the lumbar spine status, which has a tendency towards non-ideal, again correlating with the lower limb dynamic findings. In the sagittal axis all mean values recorded were close to the ideal, rendering this area symmetrical, without presence of the quadrant dominance.

In all *upper limb* dynamic tests, the mean results recorded were between ideal and non-ideal; especially the *hand behind back ROM* ($\bar{x}$ = 1,70 left and 1,75 right) and *shoulder outline composition* ($\bar{x}$ = 1,03 left and right) tests, correlating with recordings by Halbach & Tank, (1990) and Kapandji, (1970).

In the *neurodynamic* category, all mean values were satisfactory, except for the L3,4 prone knee bend test, which were categorised as non-ideal ($\bar{x}$ = 2,43 left; $\bar{x}$ = 2,25 right) correlating with findings of Butler, (1991).

Table 4.8: Descriptive statistics of biomechanical and postural variables of 20-year-old (seasonal) elite club rugby players (N=40)

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Lower limb				
Lower limb dynamic mobility				
TA	2,28	0,75	2,23	0.80
Modified Thomas testings:				
ITB	2,00	0,72	2,20	0,76
Quadriceps mobility	1,88	0,65	1,80	0,69
Iliopsoas mobility	2,33	0,69	2,28	0,72
Gluteus maximus mobility	1,88	0,61	1,80	0,61
Adductor	1,93	0,69	-	
Hip internal rotation mobility	1,68	0,66	1,58	0,64
Hip external rotation mobility	2,10	0,55	2,08	0,53
Knee complex				
Q-angle	1,35	0,48	1,38	0,49
Patella squint	1,28	0,45	1,25	0,44
Patella tilt	1,68	0,47	1,65	0,48
VMO-L comparison	1,15	0,36	1,13	0,34
Ankle and foot region				
Longitudinal arch status	1,65	0,53	1,60	0,55
Forefoot positional	1,55	0,50	1,43	0,50
Rear foot standing	1,74	0,75	1,62	0,67
Rear foot lying	1,72	0,79	1,54	0,68
Transverse arch area comparison	1,40	0,50	1,38	0,49
Foot mobility	1,78	0,80	1,68	0,80
Toe position	1,70	0,46	1,73	0,45
Pelvic girdle region				
Leg length discrepancy	1,75	0,67		
ASIS	1,58	0,50		
PSIS	1,55	0,50		
Pelvic rami position	1,51	0,61		
Sacroiliac cleft	1,33	0,48		
Bilateral pelvic position	1,64	0,67		
Spinal region				
Spinal dynamic mobility				
TLF mobility	1,93	0,86	2,05	0,82
Sacral rhythm	1,18	0,45	1,20	0,46
Functional extension mobility	1,73	0,75		
Functional flexion mobility	1,55	0,71		
Rotational mobility	1,50	0,64	1,53	0,64
Side flexion mobility	1,40	0,63	1,35	0,62

Table 4.8 continues

Variables	Left side of anatomy		Right side of anatomy	
	$\bar{x}$	s	$\bar{x}$	s
Spinal alignment				
Coronal axis				
Head position	1,35	0,48		
Cervical	1,18	0,39		
Thoracic	1,25	0,44		
Lumbar	1,50	0,51		
Sagittal axis				
Head position	1,15	0,36		
Cervical	1,15	0,36		
Thoracic	1,35	0,48		
Lumbar	1,28	0,45		
Upper limb				
Hand behind back ROM	1,70	0,61	1,75	0,67
Hand behind neck ROM	1,30	0,46	1,33	0,47
Shoulder positional test	1,48	0,51	1,50	0,51
Winging positional test	1,45	0,50	1,48	0,51
Shoulder outline composition	1,03	0,16	1,03	0,16
Throwing position	1,33	0,48	1,35	0,48
Neurodynamics				
Straight leg raise	1,75	0,54	1,83	0,50
Upper limb tension	1,43	0,64	1,55	0,60
L3,4 prone knee bend	2,43	0,71	2,25	0,74
Slump	1,83	0,68	1,80	0,69

$\bar{x}$ = mean values; s = standard deviation values

4.3 COMPARISON OF RESULTS ACCORDING TO FORWARD AND BACK-LINE RUGBY PLAYERS

4.3.1 15-year-old elite school rugby players

4.3.1.1 Anthropometric, physical and motor variables

Table 4.9 displays the anthropometric, physical and motor data for the forward and back-line 15-year-old elite school rugby players. When considering body mass, forwards presented with a mean of 83,8 kg versus their back-line counterparts at 63,5 kg, indicating a strongly practical significant difference (d = 1,55). A moderately practical significant difference was noted for body length between the groups (d = 0,55). On the other hand, body fat percentage followed the same tendency seen in body mass measurements, with forwards measuring a mean value of 21,52% versus back-line at 14,5%, again recording a strongly practical significant difference (d = 0,86).

When considering physical and motor data the back-line players outperformed their forward counterparts as far as agility, explosive power, power endurance, aerobic and anaerobic capacity are concerned. Speed endurance and agility results recorded a strongly (d = 0,83) and moderately (d = 0,70) practical significant difference respectively between these groups. The rest of the physical and motor tests reported only a small practical significant difference.

Table 4.9: **Descriptive and inferential statistics with d-values of anthropometric, physical and motor variables for 15-year-old elite school forward and back-line rugby players (N=27)**

Variables	Forwards				Back-line players				d-values
	$\bar{x}$	s	Min.	Max.	$\bar{x}$	s	Min.	Max.	
Anthropometrical									
Body mass (kg)	83,80	13,10	67,00	99,00	63,50	12,49	51,00	88,00	1,55
Body length (cm)	176,60	8,59	162,00	183,00	171,88	6,17	162,00	180,00	0,55
Fat percentage (%)	21,52	8,13	13,30	32,90	14,53	3,41	11,90	22,40	0,86
Physical and motor									
the 30 m dash (sec)	4,45	0,15	4,20	4,60	4,39	0,21	4,10	4,80	0,29
Agility (sec)	19,29	1,25	17,70	21,00	18,42	0,54	17,70	19,10	0,70
Vertical jump (cm)	45,92	5,36	37,00	56,00	47,00	9,36	23,00	57,00	0,12
Horizontal jump (cm)	236,00	22,00	210,00	290,00	231,00	16,00	200,00	250,00	0,23
Abdominal curls (level)	4,42	2,23	1,00	7,00	5,00	1,29	3,00	7,00	0,26
Pull-up (n)	9,54	5,44	1,00	17,00	11,50	4,64	4,00	20,00	0,36
Bleep (level)	8,84	2,37	5,90	12,20	9,60	1,81	7,10	13,20	0,32
Speed endurance (%)	12,13	0,71	11,00	13,00	12,75	0,75	11,50	14,00	0,83

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;
0,8 = d values with high practical significance

4.3.1.2 Biomechanical and postural variables

As seen in Table 4.10 under lower limb dynamic mobility the forwards outperformed their back-line counterparts in the TA, quadriceps, gluteus maximus, adductor mobility and hip external rotational tests, rendering a value closer to the ideal, correlating with findings by Kapandji (1970). The quadriceps mobility test recorded a strongly practical significant difference for the left (d = 0,86) and a moderately practical significant difference for the right (d = 0,70) when comparing these groups. In the knee complex the same tendency continued as was seen in lower limb dynamics, with forwards achieving better positional values than their back-line counterparts, with moderately practical significant differences recorded by the patella squint (d = 0,53 left and right side) and tilt (d = 0,55 left side) tests, as with recordings by Kapandji, (1970) and Wallace *et al.*, (1990). Lastly, in the ankle and foot region only small or no practical significant difference could be seen between the groups.

When considering the *pelvic girdle* region values closer to the ideal were seen in the leg length discrepancy, ASIS, PSIS, rami and bilateral pelvic positional tests for the forwards. However, only small or no practical significant differences were recorded as with recordings by Hoppenfeld, (1976), Porterfeld & DeRosa, (1990) and Rocabado, (2000).

In the *spinal dynamic mobility* tests the TLF, rotational and side flexion mobility tests registered lower values (closer to ideal) for the forwards, with only the TLF mobility test reporting a moderately practical significant difference on the left side (d = 0,72) (Kapandji, 1970). This correlates with tendencies seen in the lower limb dynamic and positional tests. In *spinal region positional* testing (coronal and sagittal axis) forwards positionally outperformed the backs (values closer to ideal), supporting the findings in respect of the lower limb and pelvic girdle region, correlating with findings by Kapandji, (1970) and Warwick & Williams, (1973). The only strongly practical significant difference between these groups was noted at the coronal axis in the cervical positional test (d = 1,00). Moderate practical significant differences were noted at the coronal axis in the thoracic and lumbar tests and at the sagittal axis in the head position and lumbar tests.

Upper limb dynamic testing followed the tendency seen in the previous mentioned regions, whereby values closer to the ideal were recorded by the forwards, with moderate practical significant differences recorded in shoulder outline composition (d = 0,55) and throwing position (d = 0,51) tests on the left side and for the hand behind back ROM test on the right side (d = 0,59). However, the shoulder coronal and winging positional tests for both groups recorded high values closer to the non-ideal, indicating a lack of core stability in this region correlating with recordings by Halbach & Tank, (1990) and Kapandji, (1970).

Finally, *neurodynamic* testing, as with previous tests, recorded higher values (closer to non-ideal) for the back-line players. This especially seen in the slump test, where a strongly practical significant difference was recorded (d = 1,74), and when compared with norms recorded by Butler (1991).

Table 4.10: **Descriptive and inferential statistics with d-values of biomechanical and postural variables for 15-year-old elite school forward and back-line rugby players (N=39)**

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Lower limb										
TA	1,43	0,68	1,60	0,74	0,23	1,33	0,66	1,60	0,74	0,36
Modified Thomas testings:										
ITB	1,82	0,39	1,73	0,59	0,15	1,64	0,49	1,67	0,49	0,06
Quadriceps mobility	1,32	0,48	1,87	0,64	0,86	1,41	0,50	1,80	0,56	0,70
Iliopsoas mobility	1,45	0,51	1,60	0,51	0,29	1,55	0,51	1,60	0,51	0,09
Gluteus maximus mobility	1,64	0,73	1,73	0,46	0,12	1,45	0,60	1,73	0,46	0,47
Adductor	1,32	0,48	1,60	0,63	0,44	-		-		-
Hip internal rotation mobility	1,36	0,49	1,33	0,49	0,06	1,27	0,46	1,33	0,49	0,12
Hip external rotation mobility	1,50	0,60	1,67	0,49	0,28	1,68	0,57	1,87	0,35	0,33
Knee complex										
Q-angle	1,23	0,43	1,07	0,26	0,37	1,27	0,46	1,07	0,26	0,43
Patella squint	1,23	0,43	1,00	0,00	0,53	1,23	0,43	1,00	0,00	0,53
Patella tilt	1,68	0,48	1,40	0,51	0,55	1,64	0,49	1,40	0,51	0,47
VMO-L comparison	1,41	0,50	1,27	0,46	0,28	1,41	0,50	1,33	0,49	0,16
Ankle and foot region										
Longitudinal arch status	1,59	0,50	1,73	0,59	0,24	1,59	0,50	1,73	0,59	0,24
Forefoot positional	1,64	0,49	1,60	0,51	0,08	1,64	0,49	1,60	0,51	0,08
Rear foot standing	1,55	0,67	1,80	0,68	0,37	1,50	0,51	1,67	0,62	0,27
Rear foot lying	1,55	0,51	1,53	0,52	0,04	1,59	0,50	1,47	0,52	0,23
Transverse arch area comparison	1,14	0,35	1,20	0,41	0,15	1,14	0,35	1,20	0,41	0,15
Foot mobility	1,25	0,44	1,40	0,74	0,20	1,25	0,44	1,40	0,74	0,20
Toe position	1,55	0,51	1,67	0,49	0,24	1,64	0,49	1,53	0,52	0,21

Table 4.10 continues

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Pelvic girdle region										
Leg length discrepancy	1,73	0,55	1,53	0,52	0,36	-		-		-
ASIS	1,68	0,48	1,60	0,51	0,15	-		-		-
PSIS	1,68	0,48	1,60	0,51	0,16	-		-		-
Pelvic rami position	1,85	0,38	1,80	0,42	0,12	-		-		-
Sacroiliac cleft	1,09	0,29	1,20	0,41	0,27	-		-		-
Bilateral pelvic position	1,59	0,59	1,80	0,77	0,27	-		-		-
Spinal region										
Spinal dynamic mobility										
TLF mobility	1,50	0,60	1,93	0,59	0,72	1,68	0,72	1,87	0,64	0,26
Sacral rhythm	1,09	0,29	1,07	0,26	0,08	1,09	0,29	1,07	0,26	0,07
Functional extension mobility	1,55	0,67	1,73	0,59	0,27	-		-		-
Functional flexion mobility	1,73	0,77	1,73	0,46	0,00	-		-		-
Rotational mobility	1,27	0,55	1,47	0,52	0,36	1,27	0,55	1,47	0,52	0,36
Side flexion mobility	1,32	0,57	1,60	0,51	0,49	1,32	0,57	1,60	0,51	0,49
Spinal alignment										
<u>Coronal axis</u> Head position Cervical Thoracic Lumbar	 1,27 1,18 1,27 1,18	 0,46 0,39 0,46 0,39	 1,47 1,67 1,67 1,47	 0,52 0,49 0,49 0,52	 0,38 1,00 0,77 0,56	-	-	-		-
<u>Sagittal axis</u> Head position Cervical Thoracic Lumbar	 1,00 1,00 1,68 1,00	 0,00 0,00 0,48 0,00	 1,33 1,20 1,53 1,27	 0,49 0,41 0,52 0,46	 0,67 0,49 0,29 0,59	-	-	-		-
Upper limb										
Hand behind back ROM	1,27	0,46	1,40	0,74	0,18	1,64	0,79	2,13	0,83	0,59
Hand behind neck ROM	1,05	0,21	1,20	0,41	0,38	1,05	0,21	1,20	0,56	0,27
Shoulder positional test	1,64	0,49	1,80	0,41	0,33	1,68	0,48	1,79	0,43	0,23
Winging positional test	1,73	0,46	1,93	0,26	0,43	1,77	0,43	1,93	0,27	0,37
Shoulder outline composition	1,32	0,48	1,60	0,51	0,55	1,32	0,48	1,57	0,51	0,49
Throwing position	1,14	0,35	1,40	0,51	0,51	1,18	0,39	1,27	0,46	0,20
Neurodynamics										
Straight leg raise	2,00	0,76	2,00	0,68	0,00	2,00	0,82	2,00	0,68	0,00
Upper limb tension	1,05	0,21	1,21	0,43	0,37	1,14	0,47	1,14	0,36	0,00
L3,4 prone knee bend	1,64	0,73	1,80	0,68	0,22	1,64	0,73	1,73	0,70	0,12
Slump	1,27	0,46	2,07	0,46	1,74	1,27	0,46	2,07	0,46	1,74

$\bar{x}$ = mean values; s = standard deviation values;
0,2 = d-value with little practical significance; 0,5 = d-value with moderate practical significance;
0,8 = d-value with high practical significance

4.3.2 18-year-old elite school rugby players

4.3.2.1 Anthropometric, physical and motor variables

Table 4.11 displays the anthropometric, physical and motor data for elite 18-year-old school rugby players. Forwards presented with a mean body mass of 96,2 kg versus their back-line counterparts at 76,7 kg, depicting a strongly practical significant difference (d = 1,80). Within this age group forwards presented with a mean height of 184,04 cm and the back-line at 176,79 cm, again indicating a strongly practical significant difference (d = 1,21). Similarly, body fat percentage indicated a strongly practical significant difference (d = 1,12). With forwards recording the highest value at 15,46% and back-line players at 10,12%. The above data depict heavier and taller forwards with a greater body fat percentage.

When considering physical and motor data the back-line outperformed their forward counterparts as far as speed, agility, explosive power, power endurance, aerobic and anaerobic capacity are concerned. The 30 m dash (d = 1,04), agility (d = 1,26), pull-up (d = 1,20) and speed endurance (d = 1,00) tests recorded differences of strongly practical significance, favouring the back-line players. However, forwards achieved better values in the maximum power testing, with a moderately practical significant difference in the 1RM bench press test (d = 0,69). In conclusion, forwards are slower, less agile and not as fit as their back-line counterparts, but are especially stronger when considering maximum power.

Table 4.11: Descriptive and inferential statistics with d-values of anthropometric, physical and motor variables for 18-year-old elite school forward and back-line rugby players (N=84)

Variables	Forwards				Back-line players				d-values
	$\bar{x}$	S	Min.	Max.	$\bar{x}$	s	Min.	Max.	
Anthropometrical									
Body mass (kg)	96,22	10,90	69,60	117,85	76,65	8,53	61,85	94,60	1,80
Body length (cm)	184,04	5,98	174,10	198,40	176,79	8,53	61,85	94,60	1,21
Fat percentage (%)	15,46	4,76	6,90	26,00	10,12	2,86	5,20	18,00	1,12
Physical and motor									
the 30 m dash (sec)	4,43	0,23	4,00	5,22	4,19	0,15	3,94	4,56	1,04
Agility (sec)	18,11	0,62	16,98	20,03	17,33	0,55	16,31	18,59	1,26
Vertical jump (cm)	48,63	7,27	33,00	65,00	52,78	5,79	41,00	63,00	0,57
Horizontal jump (cm)	237,00	19,00	196,00	279,00	249,00	14,00	225,00	279,00	0,63
Abdominal curls (level)	5,56	1,38	2,00	7,00	5,87	1,26	2,00	7,00	0,22
Pull-up (n)	7,75	4,39	1,00	22,00	13,24	4,56	3,00	22,00	1,20
Bench press (kg)	95,33	12,90	70,00	120,00	85,27	14,62	60,00	125,00	0,69
Squat (kg)	138,60	23,09	110,00	200,00	127,65	24,63	80,00	190,00	0,44
Bleep (level)	9,16	1,67	5,10	12,10	10,13	1,56	7,10	13,20	0,58
Speed endurance (%)	12,50	0,69	11,00	14,00	13,19	0,59	11,50	14,00	1,00

$\bar{x}$ = mean values; s = standard deviation values; min. = minimum values; max. = maximum values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;
0,8 = d-values with high practical significance

4.3.2.2 Biomechanical and postural variables

In Table 4.12 under lower limb dynamic mobility the back-line players outperformed their forward counterparts (with values nearer to ideal) in all but the illiospoas, adductor mobility and hip internal rotational dynamic tests, with only the right ITB mobility test recording a strongly practical significant difference (d = 0,86), correlating with findings by Kapandji, (1970) and McPoil & Brocato, (1990) In the *knee complex* no differences were observed, except for the VMO-L comparison test, where the back-line players outperformed their counterparts, recording a moderately practical significant difference on the left side (d = 0,71). Lastly, in the *ankle and foot* region only small or no practical significant differences were documented between the groups, except for rear foot standing and rear foot lying, where the back-line players achieved values closer to the ideal, with only the left rear foot standing test recording a moderately practical significant difference (d = 0,51), as with the findings of Hoppenfeld, (1976); Hunt, (1990) and McPoil & Brocato, (1990).

When considering the *pelvic girdle* region, values closer to the ideal were seen in leg length discrepancy, ASIS and PSIS comparison tests for the forwards (better core stability), with only small practical significant differences noted, correlating with recordings by Hoppenfeld, (1976), Porterfeld & DeRosa, (1990) and Rocabado, (2000).

In the *spinal region* the TLF, extension and side flexion mobility tests favoured the back-line with values closer to the ideal in the *spinal dynamic mobility* testing, with only the TLF mobility on the left side recording values with moderately practical significant difference (d = 0,55). In *spinal region positional* testing within the coronal axis no strongly practical significant difference was seen between forward and back-line players, with only the thoracic area recording moderate practical significant difference (d = 0,73). Small or no practical significant differences were noted in the sagittal axis.

In the *upper limb* dynamic testing, back-line players outperformed forwards with the hand behind back (moderate practical significant difference on the left side, d = 0,66) and hand behind neck tests, with values closer to ideal as with recordings by Halbach & Tank, (1990) and Kapandji, (1970). The rest of the recorded results were very similar.

In *neurodynamic* results the back-line players outperformed the forwards with the L3,4 prone knee bend (moderate practical significant difference left and right side) and the slump tests, however, the upper limb tension test showed better values among forwards.

Table 4.12: **Descriptive and inferential statistics with d-values of biomechanical and postural variables for 18-year-old elite school forward and back-line rugby players (N=39)**

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Lower limb										
Lower limb dynamics										
TA	1,77	0,69	1,39	0,70	0,54	1,82	0,66	1,44	0,70	0,54
Modified Thomas testings:										
ITB	1,86	0,35	1,61	0,61	0,41	2,00	0,31	1,56	0,51	0,86
Quadriceps mobility	1,91	0,53	1,56	0,51	0,66	2,00	0,44	1,61	0,50	0,78
Iliopsoas mobility	2,05	0,72	2,11	0,68	0,08	2,05	0,72	2,00	0,77	0,06
Gluteus maximus mobility	1,95	0,49	1,78	0,55	0,31	2,00	0,44	1,89	0,58	0,19
Adductor	1,50	0,60	1,61	0,61	0,18	-		-		
Hip internal rotation mobility	1,27	0,46	1,44	0,62	0,27	1,27	0,46	1,44	0,51	0,33
Hip external rotation mobility	2,00	0,44	1,72	0,42	0,61	2,05	0,49	1,78	0,55	0,49
Knee complex										
Q-angle	1,41	0,50	1,39	0,50	0,04	1,41	0,50	1,22	0,43	0,38
Patella squint	1,27	0,46	1,39	0,50	0,24	1,27	0,46	1,17	0,38	0,22
Patella tilt	1,68	0,48	1,78	0,43	0,21	1,73	0,46	1,83	0,38	0,22
VMO-L comparison	1,41	0,50	1,06	0,24	0,71	1,41	0,50	1,17	0,38	0,48
Ankle and foot region										
Longitudinal arch status	1,64	0,49	1,50	0,51	0,27	1,59	0,50	1,39	0,50	0,40
Forefoot positional	1,64	0,49	1,50	0,51	0,27	1,64	0,49	1,50	0,51	0,27
Rear foot standing	1,32	0,57	1,61	0,61	0,51	1,36	0,58	1,61	0,61	0,41
Rear foot lying	1,27	0,46	1,50	0,51	0,45	1,36	0,58	1,56	0,51	0,34
Transverse arch area comparison	1,32	0,48	1,28	0,46	0,08	1,36	0,49	1,28	0,46	0,16
Foot mobility	1,41	0,67	1,22	0,55	0,28	1,36	0,58	1,22	0,55	0,24
Toe position	1,77	0,43	1,89	0,32	0,28	1,73	0,46	1,94	0,24	0,46
Pelvic girdle region										
Leg length discrepancy	1,59	0,59	1,72	0,46	0,22	-		-		-
ASIS	1,55	0,51	1,72	0,46	0,33	-		-		-
PSIS	1,55	0,51	1,72	0,46	0,33	-		-		-
Pelvic rami position	1,56	0,51	1,69	0,48	0,25	-		-		-
Sacroiliac cleft	1,33	0,48	1,29	0,47	0,08	-		-		-
Bilateral pelvic position	2,00	0,53	2,06	0,73	0,08	-		-		-

Table 4.12 continues

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Spinal region										
Spinal dynamic mobility										
TLF mobility	1,95	0,49	1,61	0,61	0,55	1,86	0,47	1,67	0,69	0,28
Sacral rhythm	1,14	0,36	1,11	0,32	0,05	1,14	0,36	1,11	0,32	0,08
Functional extension mobility	1,41	0,50	1,33	0,49	0,16	-		-		-
Functional flexion mobility	1,68	0,65	1,44	0,51	0,37	-		-		-
Rotational mobility	1,09	0,29	1,22	0,43	0,30	1,18	0,39	1,22	0,43	0,09
Side flexion mobility	1,41	0,50	1,22	0,43	0,38	1,45	0,51	1,22	0,43	0,45
Spinal positional alignment										
<u>Coronal axis</u>										
Head position	1,23	0,43	1,17	0,38	0,14					
Cervical	1,14	0,35	1,17	0,38	0,08	-		-		-
Thoracic	1,36	0,49	1,72	0,46	0,73					
Lumbar	1,64	0,49	1,83	0,38	0,39					
<u>Sagittal axis</u>										
Head position	1,00	0,00	1,06	0,24	0,25					
Cervical	1,05	0,21	1,00	0,00	0,24	-		-		-
Thoracic	1,64	0,49	1,67	0,49	0,06					
Lumbar	1,09	0,29	1,22	0,43	0,30					
Upper limb										
Hand behind back ROM	1,55	0,67	1,11	0,32	0,66	1,64	0,73	1,44	0,78	0,26
Hand behind neck ROM	1,27	0,46	1,17	0,38	0,22	1,23	0,43	1,17	0,51	0,12
Shoulder positional test	1,77	0,43	1,71	0,47	0,13	1,77	0,43	1,71	0,47	0,13
Winging positional test	1,68	0,48	1,78	0,43	0,21	1,73	0,46	1,78	0,43	0,11
Shoulder outline composition	1,36	0,49	1,44	0,51	0,16	1,36	0,49	1,44	0,51	0,16
Throwing position	1,45	0,51	1,50	0,51	0,10	1,45	0,51	1,50	0,51	0,10
Neurodynamics										
Straight leg raise	2,09	0,53	2,06	0,73	0,04	2,09	0,53	2,00	0,68	0,13
Upper limb tension	1,23	0,43	1,56	0,70	0,47	1,23	0,53	1,33	0,59	0,17
L3,4 prone knee bend	2,09	0,75	1,67	0,84	0,50	2,05	0,72	1,61	0,78	0,56
Slump	1,77	0,69	1,61	0,70	0,23	1,77	0,69	1,61	0,70	0,23

$\bar{x}$ = mean values; s = standard deviation values

0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;

0,8 = d-values with high practical significance

4.3.3 19-year-old (freshmen) junior elite club rugby players

4.3.3.1 Anthropometric, physical and motor variables

Table 4.13 displays the anthropometric, physical and motor data on this group. Anthropometric data on the 19-year-old junior elite club rugby players recorded the forwards as being heavier, taller and with a greater fat percentage than their back-line counterparts, all indicating strongly practical significant differences (d = 1,5 body mass – d = 1,5, body length – d = 0,79 and fat percentage – d = 0,91).

Physical and motor data revealed superior performance by the back-line on speed, agility, explosive power, pull-up endurance test, aerobic and anaerobic capacity in comparison with their counterparts, all recording strongly practical significant differences (d = 1,38 speed; d = 1,06 agility; d = 0,82 jump; d = 0,03 abdominal; d = 1,81 pull-up). On the other hand, forwards achieved better values in the power testing, with only a small practical significant difference (d = 0,25 bench press; d = 0,38 squat).

Table 4.13: Descriptive and inferential statistics with d-values of anthropometric, physical and motor variables for 19-year-old (freshmen)elite club forward and back-line rugby players (N=108)

Variables	Forwards				Back-line players				d-values
	$\bar{x}$	s	Min.	Max.	$\bar{x}$	s	Min.	Max.	
Anthropometrical									
Body mass (kg)	93,33	11,33	74,00	118,10	76,35	10,20	58,65	94,00	1,50
Body length (cm)	182,01	7,15	168,00	200,00	176,33	6,58	162,40	188,30	0,79
Fat percentage (%)	15,57	5,92	7,20	29,00	10,13	2,19	6,90	14,40	0,91
Physical and motor									
the 30 m dash (sec)	4,48	0,21	4,14	4,90	4,19	0,14	3,89	4,47	1,38
Agility (sec)	18,00	0,73	16,83	19,97	17,22	0,57	15,97	18,51	1,06
Vertical jump (cm)	50,03	6,99	35,00	63,00	55,77	5,67	46,00	70,00	0,82
Horizontal jump (cm)	238	24	171	283	258	17	230	310	0,83
Abdominal curls (level)	4,64	2,04	1,00	7,00	4,71	1,95	1,00	7,00	0,03
Pull-up (n)	9,19	5,06	1,00	22,00	11,57	2,87	5,00	18,00	1,81
1 RM Bench press (kg)	94,07	17,60	60,00	130,00	98,58	18,29	50,00	120,00	0,25
1 RM Squat (kg)	120,96	23,75	70,00	160,00	110,91	26,53	60,00	150,00	0,38
Speed endurance (%)	12,76	0,70	11,50	14,50	13,56	0,50	13,00	14,50	1,14

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;
0,8 = d-values with high practical significance

4.3.3.2 Biomechanical and postural variables

Table 4.14 displays biomechanical and postural variables for this age group. *Lower limb dynamic mobility* testing reported more favourable values (closer to the ideal) for the back-line in only the gluteus maximus right sided test, indicating a strongly practical significant difference (d = 0,89) Furthermore the adductor test recorded similar tendencies, with only a moderately practical significant difference (d = 0,63). In the *knee complex* similar tendencies were seen where the back-line again recorded lower values (closer to the ideal) in the knee Q-angle, squint and tilt positional tests, however all of these values were of small practical significant difference. Lastly, in the *ankle and foot* region no substantial differences could be seen between the groups. All correlating with findings of Kapandji (1970) and Wallace *et al.* (1990).

Data in the *pelvic girdle region* showed no practical significant differences between forward and back-line players. Data in this region showed a strong tendency towards asymmetry for both groups when compared with the tendencies as described by Hoppenfeld (1976), Porterfeld & DeRosa (1990) and Rocabado (2000).

Spinal dynamic mobility testing revealed less favourable values for back-line players as far as side flexion and extension are concerned, with only small practical significant differences. However, TLF values recorded were higher for the forwards (towards non-ideal), with again a small practical significant difference only seen on the left-side values (d = 0,35). In the *spinal region positional* tests no moderately or strongly practical significant differences noted between these groups.

The *upper limb* dynamic testing showed a small practical significant difference in the hand behind back test for both sides (d = 0,27 left; d = 0,22 right) and in the throwing position test for only the left side (d = 0,31).

Neurodynamically only the leftsided slump test revealed a moderately practical significant difference between forward and back-line players (d = 0,52), with back-line player values closer to the non-ideal as described by Butler (1991).

Table 4.14: **Descriptive and inferential statistics with d-values of biomechanical and postural variables for 19-year-old (freshmen) elite club forward and back-line rugby players (N=46)**

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Lower limb										
Lower limb dynamics										
TA	2,09	0,81	1,96	0,81	0,16	2,09	0,81	1,96	0,81	0,16
Modified Thomas testing:										
ITB	2,41	0,59	2,17	0,76	0,32	2,27	0,63	2,13	0,74	0,19
Quadriceps mobility	1,64	0,58	1,83	0,56	0,33	1,82	0,66	1,75	0,68	0,10
Iliopsoas mobility	2,50	0,67	2,08	0,88	0,48	2,41	0,80	2,13	0,85	0,33
Gluteus maximus mobility	2,14	0,56	2,21	0,51	0,13	2,14	0,64	2,71	0,56	0,89
Adductor	1,95	0,72	1,50	0,66	0,63	-		-		-
Hip internal rotation mobility	1,68	0,78	1,50	0,72	0,23	1,73	0,83	1,46	0,72	0,33
Hip external rotation mobility	2,27	0,46	2,13	0,61	0,33	2,27	0,46	2,17	0,56	0,18
Knee complex										
Q-angle	1,23	0,43	1,13	0,34	0,23	1,23	0,43	1,13	0,34	0,23
Patella squint	1,18	0,39	1,08	0,28	0,26	1,27	0,46	1,08	0,28	0,41
Patella tilt	1,73	0,55	1,58	0,50	0,27	1,68	0,57	1,58	0,50	0,18
VMO-L comparison	1,18	0,50	1,13	0,34	0,10	1,18	0,50	1,08	0,28	0,20
Ankle and foot region										
Longitudinal arch status	1,62	0,59	1,63	0,49	0,02	1,71	0,56	1,71	0,46	0,00
Forefoot positional	1,45	0,51	1,33	0,48	0,24	1,36	0,49	1,29	0,46	0,14
Rear foot standing	1,50	0,60	1,75	0,74	0,37	1,41	0,50	1,67	0,64	0,41
Rear foot lying	1,64	0,66	1,75	0,68	0,16	1,45	0,51	1,75	0,68	0,44
Transverse arch area comparison	1,27	0,46	1,08	0,28	0,41	1,23	0,43	1,04	0,20	0,44
Foot mobility	1,45	0,60	1,21	0,51	0,40	1,45	0,60	1,29	0,62	0,26
Toe position	1,50	0,51	1,67	0,48	0,33	1,50	0,51	1,63	0,49	0,25
Pelvic girdle region										
Leg length discrepancy	1,50	0,60	1,42	0,58	0,13	-		-		-
ASIS	1,45	0,51	1,38	0,49	0,14	-		-		-
PSIS	1,45	0,51	1,38	0,49	0,14	-		-		-
Bilateral pelvic position	1,77	0,87	1,88	0,80	0,13	-		-		-
Spinal region										
Spinal dynamic mobility										
TLF mobility	2,23	0,53	2,04	0,55	0,35	2,18	0,50	2,08	0,58	0,17
Sacral rhythm	1,00	0,00	1,00	0,00	0,00	1,05	0,21	1,04	0,20	0,05
Functional extension mobility	1,55	0,67	1,88	0,90	0,37	-		-		-

Table 4.14 continues

Variables	Forward left anatomical side		Back-line left anatomical side		d-values	Forward right anatomical side		Back-line right anatomical side		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Functional flexion mobility	1,45	0,67	1,54	0,78	0,12	-		-		-
Rotational mobility	1,27	0,46	1,38	0,71	0,15	1,32	0,48	1,38	0,71	0,08
Side flexion mobility	1,36	0,49	1,54	0,72	0,25	1,36	0,49	1,54	0,72	0,25
Spinal positional alignment										
<u>Coronal axis</u>										
Head position	1,55	0,51	1,42	0,50	0,25					
Cervical	1,09	0,29	1,04	0,20	0,17	-	-	-		-
Thoracic	1,36	0,49	1,33	0,48	0,06					
Lumbar	1,55	0,51	1,67	0,48	0,24					
<u>Sagittal axis</u>										
Head position	1,00	0,00	1,13	0,34	0,38					
Cervical	1,09	0,29	1,04	0,20	0,17	-	-	-		-
Thoracic	1,50	0,51	1,63	0,49	0,25					
Lumbar	1,05	0,21	1,08	0,28	0,11					
Upper limb										
Hand behind back ROM	1,55	0,74	1,59	0,73	0,27	1,75	0,74	1,75	0,74	0,22
Hand behind neck ROM	1,18	0,39	1,18	0,39	0,07	1,21	0,41	1,21	0,41	0,07
Shoulder positional test	1,59	0,50	1,55	0,51	0,18	1,50	0,51	1,50	0,51	0,10
Winging positional test	1,45	0,51	1,41	0,50	0,02	1,46	0,51	1,46	0,51	0,10
Shoulder outline composition	1,14	0,35	1,14	0,35	0,08	1,17	0,38	1,17	0,38	0,08
Throwing position	1,32	0,48	1,23	0,43	0,31	1,17	0,38	1,25	0,44	0,05
Neurodynamics										
Straight leg raise	1,55	0,51	1,64	0,58	0,19	1,67	0,64	1,63	0,65	0,02
Upper limb tension	1,45	0,80	1,45	0,80	0,06	1,50	0,72	1,63	0,82	0,22
L3,4 prone knee bend	2,23	0,87	2,18	0,85	0,11	2,13	0,95	2,25	0,85	0,08
Slump	1,86	0,83	2,00	0,82	0,52	2,29	0,69	2,25	0,74	0,30

$\bar{x}$ = mean values; s = standard deviation values

0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance; 0,8 = d=values with high practical significance

4.3.4 20-year-old (seasonal) junior elite club rugby players

4.3.4.1 Anthropometric, physical and motor variables

In Table 4.15 the anthropometric, physical and motor data on the forward and back-line players are displayed. Anthropometric data on the 20-year-old junior elite club rugby players recorded the forwards as being heavier, taller and slightly higher in body fat percentage than their back-line counterparts, with body mass recording a strongly practical significant (d = 1,48) and the other two variables only moderately practical significant differences. However, when compared with first-class 20-year-old British club rugby players, body mass and height compared well, but when considering body fat percentage, higher values were recorded by the 20-year-old elite club players (British forwards = 11,3% and back-line = 8,0%; 20-year-old elite club forwards = 14,63%; back-line = 10,58%), correlating with findings by Nicholas & Baker, (1995).

In the physical and motor tests on the 20-year-old players, forwards were once again outperformed by their back-line counterparts as far as speed, agility, pull-up endurance, aerobic and anaerobic capacity are concerned. In the results, speed (the 30 m dash) (d = 1,04) and agility (d = 1,11) had strongly practical significant differences, with the pull-up, bleep and speed endurance recording only moderately practical significant differences between these groups. However, maximum power data showed that forwards were more powerful than their back-line counterparts in the bench press test results, with a strongly practical significant difference (d = 0,82).

Table 4.15: Descriptive and inferential statistics with d-values of anthropometric, physical and motor variables for the 20-year-old (seasonal) elite club forward and back-line rugby players (N=112)

Variables	Forwards				Back-line players				d-values
	$\bar{x}$	s	Min.	Max.	$\bar{x}$	s	Min.	Max.	
Anthropometric									
Body mass (kg)	96,05	11,57	76,50	117,90	78,84	8,64	60,10	99,00	1,48
Body length (cm)	182,86	6,75	183,00	194,00	177,73	6,25	163,00	191,20	0,76
Fat percentage (%)	14,63	5,27	6,20	29,40	10,58	2,47	6,50	18,90	0,76
Physical and motor									
the 30 m dash (sec)	4,46	0,22	4,11	4,92	4,23	0,13	3,90	4,45	1,04
Agility (sec)	18,04	0,68	16,81	20,00	17,28	0,49	16,39	18,22	1,11
Vertical jump (cm)	55,81	7,04	43,00	71,00	57,14	5,66	47,00	69,00	0,18
Horizontal jump (cm)	257	20	190	293	258	15	223	288	0,05
Abdominal curls (level)	4,29	2,26	1,00	7,00	5,22	1,69	2,00	7,00	0,41
Pull-up (n)	8,46	4,07	1,00	20,00	11,12	2,92	4,00	16,00	0,55
1 RM Bench press (kg)	114,81	17,18	90,00	170,00	100,71	13,31	70,00	130,00	0,82
1 RM Squat (kg)	138,42	35,94	90,00	220,00	142,61	17,89	120,00	190,00	0,12
Bleep (level)	10,86	1,64	6,60	14,30	11,95	1,40	9,11	15,40	0,66
Speed endurance (%)	13,37	0,99	10,00	15,00	13,99	0,69	13,00	15,00	0,62

$\bar{x}$ = mean values; s = standard deviation values; Min. = minimum values; Max. = maximum values

0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;

0,8 = d-values with high practical significance

4.3.4.2 Biomechanical and postural variables

Table 4.16 reveals biomechanical and postural data on 20-year-old forward and back-line players. Under *lower limb dynamics* both forward and back-line players recorded values between non-ideal and highly unsatisfactory for the TA, ITB, illiospoas and hip external rotational tests, as with recordings by Kapandji (1970). When comparing forward with back-line rugby players, the only moderately practical significant difference recorded was for the left-sided quadriceps dynamic mobility (d = 0,51). The rest of the values recorded had a small practical significant difference, or no significance at all. This tendency is of concern when considering the level at which the players participate, and when compared with data from the more junior rugby-playing groups. In the *knee complex* no substantial difference is seen except for the Q-angle, which on the right side recorded a moderately practical significant difference (d = 0,50) and only small on the left (d = 0,39). With regard to the *ankle and foot region,* as with the lower limb dynamic testing, excessively high values were recorded for toe position for both forward and back-line players (closer to non-ideal), correlating with findings by Hoppenfeld, (1976); Hunt, (1990) and McPoil & Brocato, (1990). Back-line players recorded values closer to the non-ideal for the forefoot, rear foot standing, rear foot lying and mobility positional tests; all differences recorded were only of small practical significance.

In the *pelvic girdle region* leg length, ASIS, PSIS, rami and the pelvic bilateral positional tests showed for both forward and back-line players showed a strong tendency towards asymmetry (poor core stability). In all the above mentioned tests the back-line players recorded values closer to the non-ideal when compared to their counterparts, as confirmed by findings of Hoppenfeld, (1976), Porterfeld & DeRosa, (1990) and Rocabado, (2000). Differences recorded were between small and non-practical significance.

In *spinal dynamic mobility* testing all results recorded for both forward and back-line players were between ideal and non-ideal, with the back-line outperforming forwards on all tests. Differences recorded were only of small to no practical significance. In *spinal region positional* tests the values in the coronal axis showed little difference between forward and back-line players, except for the head position which recorded a moderately practical significant difference (d = 0,59) favouring the back-line. For sagittal axis, small to no differences were recorded. Higher values were recorded for both groups in the thoracic area (forwards $\bar{x}$ = 1,40; back-line players $\bar{x}$ = 1,30), indicating dominancy.

In the *upper limb* dynamic testing all values recorded were between ideal and non-ideal. When comparing forward and back-line players, small substantial differences were seen, except in the case of the hand behind back test, where the forwards recorded higher values than their counterparts, rendering a moderately practical significant difference on the right side (d = 0,53) (a larger tendency of asymmetry exists in this area), correlating with findings of Halbach & Tank, (1990) and Kapandji, (1970).

In *neurodynamic* testing, forwards recorded slightly higher mean values than their back-line counterparts (only small to no practical significant difference). L3,4 prone knee bend test in both groups recorded values between non-ideal and highly unsatisfactory, again not acceptable for participants at this level if compared with data on junior groups in this study, correlating with norms of Butler (1991).

Table 4.16: **Descriptive and inferential statistics with d-values of biomechanical and postural variables for the 20-year-old (seasonal) elite club forward and back-line rugby players (N=40)**

Variables	Forward left anatomical side		Back-line left anatomical side		d-value s	Forward right anatomical side		Back-line right anatomical side		d-value s
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Lower limb										
Lower limb dynamics										
TA	2,40	0,75	2,15	0,75	0,33	2,30	0,80	2,15	0,81	0,19
Modified Thomas testings:										
ITB	1,95	0,76	2,05	0,69	0,13	2,05	0,69	2,35	0,81	0,25
Quadriceps mobility	2,05	0,69	1,70	0,57	0,51	1,95	0,69	1,65	0,67	0,43
Iliopsoas mobility	2,30	0,66	2,35	0,75	0,07	2,25	0,64	2,30	0,80	0,06
Gluteus maximus mobility	2,00	0,56	1,75	0,64	0,39	1,90	0,64	1,70	0,57	0,31
Adductor	2,10	0,45	1,75	0,85	0,41	-		-		-
Hip internal rotation mobility	1,55	0,51	1,80	0,77	0,32	1,40	0,50	1,75	0,72	0,49
Hip external rotation mobility	2,20	0,52	2,00	0,56	0,36	2,10	0,55	2,05	0,51	0,10
Knee complex										
Q-angle	1,45	0,51	1,25	0,44	0,39	1,50	0,51	1,25	0,44	0,50
Patella squint	1,30	0,47	1,25	0,44	0,11	1,25	0,44	1,25	0,44	0,00
Patella tilt	1,70	0,47	1,65	0,49	0,10	1,65	0,49	1,65	0,49	0,00
VMO-L comparison	1,15	0,37	1,15	0,37	0,00	1,15	0,37	1,10	0,31	0,14
Ankle and foot region										
Longitudinal arch status	1,65	0,49	1,65	0,59	0,00	1,60	0,50	1,60	0,60	0,00
Forefoot positional	1,50	0,51	1,60	0,50	0,20	1,30	0,47	1,55	0,51	0,49
Rear foot standing	1,84	0,76	1,65	0,75	0,25	1,68	0,75	1,55	0,60	0,17
Rear foot lying	1,84	0,83	1,60	0,75	0,29	1,63	0,76	1,45	0,60	0,24
Transverse arch area comparison	1,45	0,51	1,35	0,49	0,20	1,45	0,51	1,30	0,47	0,29

Table 4.16 continues

Variables	Forward left anatomical side		Back-line left anatomical side		d-value s	Forward right anatomical side		Back-line right anatomical side		d-value s
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Foot mobility	1,85	0,81	1,70	0,80	0,19	1,75	0,79	1,60	0,82	0,18
Toe position	1,70	0,47	1,70	0,47	0,00	1,75	0,44	1,70	0,47	0,11
Pelvic girdle region										
Leg length discrepancy	1,70	0,73	1,80	0,62	0,14	-		-		-
ASIS	1,55	0,51	1,60	0,50	0,10	-		-		-
PSIS	1,50	0,51	1,60	0,50	0,20	-		-		-
Pelvic rami position	1,47	0,51	1,55	0,51	0,16	-		-		-
Sacroiliac cleft	1,30	0,47	1,35	0,49	0,10	-		-		-
Bilateral pelvic position	1,53	0,61	1,75	0,72	0,31	-		-		-
Spinal region										
Spinal dynamic mobility										
TLF mobility	1,95	0,89	1,90	0,85	0,06	2,15	0,81	1,95	0,83	0,24
Sacral rhythm	1,25	0,56	1,10	0,31	0,27	1,30	0,57	1,10	0,31	0,35
Functional extension mobility	1,85	0,75	1,60	0,75	0,33	-		-		-
Functional flexion mobility	1,65	0,67	1,45	0,76	0,26	-		-		-
Rotational mobility	1,60	0,68	1,40	0,60	0,29	1,65	0,67	1,40	0,59	0,37
Side flexion mobility	1,45	0,69	1,35	0,59	0,14	1,35	0,67	1,35	0,59	0,00
Spinal positional alignment										
<u>Coronal axis</u> Head position Cervical Thoracic Lumbar	 1,50 1,25 1,35 1,45	 0,51 0,44 0,49 0,51	 1,20 1,10 1,15 1,55	 0,41 0,31 0,37 0,51	 0,59 0,34 0,41 0,20	-	-	-		-
<u>Sagittal axis</u> Head position Cervical Thoracic Lumbar	 1,15 1,10 1,40 1,20	 0,37 0,31 0,50 0,41	 1,15 1,20 1,30 1,35	 0,37 0,41 0,47 0,49	 0,00 0,27 0,20 0,31	-	-	-		-
Upper limb										
Hand behind back ROM	1,85	0,67	1,55	0,51	0,45	1,95	0,76	1,55	0,51	0,53
Hand behind neck ROM	1,35	0,49	1,25	0,44	0,20	1,35	0,49	1,30	0,47	0,10
Shoulder positional test	1,50	0,51	1,45	0,51	0,10	1,50	0,51	1,50	0,51	0,00
Winging positional test	1,40	0,50	1,50	0,51	0,20	1,40	0,50	1,55	0,51	0,29
Shoulder outline composition	1,00	0,00	1,05	0,22	0,23	1,00	0,00	1,05	0,22	0,22
Throwing position	1,40	0,50	1,25	0,44	0,30	1,40	0,50	1,30	0,47	0,20
Neurodynamics										
Straight leg raise	1,80	0,52	1,70	0,57	0,18	1,90	0,45	1,75	0,55	0,45
Upper limb tension	1,50	0,69	1,35	0,59	0,22	1,60	0,68	1,50	0,51	0,15
L3,4 prone knee bend	2,40	0,75	2,45	0,69	0,07	2,30	0,80	2,20	0,70	0,13
Slump	1,90	0,64	1,75	0,72	0,21	1,90	0,64	1,70	0,73	0,27

$\bar{x}$ = mean values; s = standard deviation values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical signigicance;
0,8 = d-values with high practical significance

4.4 AGE-GROUPER COMPARISON INCLUDING ELITE SCHOOL VERSUS ELITE JUNIOR CLUB PLAYERS

Anthropometrical, physical and motor, biomechanical and postural means were compared between rugby player groups and practical significant d-values reported. Firstly, the 15-year-old elite rugby players were compared with their more senior 18-year-old elite school players, 19-year-old elite club rugby players and 20-year-old elite club group. Secondly, the 18-year-old senior school players were compared with the elite 19-year-old club freshmen and seasonal 20-year-old club player group. Thirdly the freshmen 19-year-old club players were compared with their seasonal 20-year-old player group. Lastly the combined elite school groups (15 and 18-year-olds) were compared with the combined elite club groups (19 and 20-year-olds)

4.4.1 Anthropometrical comparison

When considering body mass, strongly practical significant differences were recorded when comparing 15-year-old elite rugby players with 18-year-old, 19-year-old and 20-year-old elite players, as can be seen in Table 4.17. Furthermore, when comparing the rest of the age-groupers, no practical significant differences were recorded. Body length comparison recorded strongly practical significance between 15 and 18-year-old (d = 0,96), and 15 and 20 year old elite rugby players (d = 0,88), but only a moderately practical significant difference in the case of the 15 and 19-year-old elite players (d = 0,76). As with body mass, little practical significant differences were recorded when comparing the 18-year-olds with the rest of the elite players. Body fat percentage recorded moderate practical significant differences when comparing 15-year-olds with the rest of the elite player groups. No practical significant differences were seen when comparing the rest of the age-groupers with each other.

4.4.2 Physical and motor comparison

Information data from the agility, bench press and squat tests for the 15-year-old players could unfortunately not be compared due to either a different testing procedure or subjects being too young to perform the testing protocol. Lastly, bleep test information on the 19-year-old player group was not available for comparison.

The 30 m dash (speed test), agility (for 18, 19 and 20-year-old only) and pull-up (power endurance) tests recorded either small or no practical significant differences between the age-groupers, as can be seen in Table 4.17. In explosive power testing the vertical jump recorded strongly practical significant differences when comparing the 15-year-old elite players with the 19 and 20-year-old groups and 18-year-old with the 20-year-old player group. The horizontal jump recorded strongly practical significant differences when comparing the 15- with the 20-year-old players (d = 1,26) and the 18 with the 20-year-old players (d = 0,88). In power endurance testing the abdominal curls recorded only moderate practical significant values when comparing 15 with 18-year-old (d = 0,58), 18 with 19-year-old (d = 0,55) and 18 with 20-year-old (d = 0,50). Maximum power testing recorded strongly practical significant differences when comparing 18 with 20-year-old (d = 1,00) and 19 with 20-year-old (d = 0,80) players for the bench press test, and 19 with 20-year-old players (d = 0,89) for the squat test. As far as aerobic capacity (bleep test) is concerned, the 20-year-old players outperformed their 15-year-old (d = 1,04) and 18-year-old (d = 1,07) counterparts. Finally, in speed endurance testing, elite club players outperformed their elite school counterparts with strongly practical significant differences, as can be seen in Table 4.17.

Table 4.17: Comparison of descriptive and inferential statistics with d-values of anthropometric, physical and motor mean values between elite school and club rugby players

Variables	15-year-old N=27		18-year-old N=84		d-values Comparing 15 yr & 18 yr	19-year-old N=108		d-values Comparing 15 yr & 19 yr
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	
Anthropometrical								
Body mass (kg)	71,31	15,93	87,13	13,88	0,99	85,65	13,63	0,90
Body length (cm)	173,69	15,25	180,68	6,47	0,96	179,35	7,42	0,76
Fat percentage (%)	17,22	6,43	12,98	4,78	0,66	13,15	5,36	0,63
Physical and motor								
The 30 m dash (sec)	4,42	0,18	4,32	0,23	0,43	4,35	0,24	0,29
Agility (sec)	18,98	1,11	17,74	0,70	-	17,64	0,76	-
Vertical jump (cm)	46,46	7,50	50,55	6,91	0,55	52,70	6,99	0,83
Horizontal jump (cm)	233,00	19,00	242	17,00	0,47	247,00	24,00	0,58
Abdominal Curls (level)	4,72	1,79	5,76	1,32	0.58	4,67	1,98	0,03
Pull-up (n)	10,48	5,07	10,29	5,23	0,04	10,23	4.37	0,05
Bench press (kg)	-	-	90,79	14,52	-	92,93	18,46	-
Squat (kg)	-	-	133,70	24,25	-	116,52	24,15	-
Bleep (level)	9,23	2,08	9,61	1,68	0,18	-	-	-
Speed endurance (%)	12,46	0,79	12,82	0,73	0,46	13,14	0,73	0,86

Table 4.17 continues

Variables	20-year-old N=112		d-values Comparing 15 yr & 20 yr	d-values Comparing 18 yr & 19 yr	d-values Comparing 18 yr & 20 yr	d-values Comparing 19 yr & 20 yr
	$\bar{x}$	s				
Anthropometrical						
Body mass (kg)	87,07	13,28	0,99	0,11	0,003	0,10
Body length (cm)	180,06	6,94	0,88	0,18	0,09	0,10
Fat percentage (%)	12,6	4,57	0,72	0,03	0,08	0,10
Physical and motor						
the 30 m dash (sec)	4,34	0,21	0,38	0,13	0,09	0,04
Agility (sec)	17,66	0,70	-	0,13	0,11	0,03
Vertical jump (cm)	56,47	6,38	1,33	0,31	0,86	0,54
Horizontal jump (cm)	257,00	17,00	1,26	0,21	0,88	0,42
Abdominal Curls (level)	4,75	2,04	0,01	0,55	0,50	0,04
Pull-up (n)	9,79	3,75	0,23	0,01	0,10	0,10
Bench press (kg)	107,64	16,77	-	0,12	1,00	0,80
Squat (kg)	140,71	27,26	-	0,71	0,26	0,89
Bleep (level)	11,40	1,61	1,04	-	1,07	-
Speed endurance (%)	13,70	0,89	1,39	0,44	0,99	0,63

$\bar{x}$ = mean values; s = standard deviation values
0,2 = d-values with little practical significance; 0,5 = d-values with moderate practical significance;
0,8 = d=values with high practical significance

4.4.3 Biomechanical and postural comparison

As seen in Table 4.18 *Lower limb dynamic* results revealed a steady increase in value with increasing age in the TA, ITB, quadriceps, iliopsoas, adductor and hip internal rotational tests, indicating that more senior age-groupers recorded less ideal values. However, when comparing, the TA test results, strongly practical significant differences were noted between the 15-year-olds and 20-year-olds for left (d = 1,04) and right (d = 0,99) and also between the 18-year-olds and 20-year-olds left (d = 0,91) and right (d = 0,73 – close to a strongly practical significant difference), favouring the more junior groups with values closer to the ideal. The ITB test showed practical significant differences when comparing 15-year-old elite rugby players with 19-year-old (d = 0,72 left and 0,91 right).

When comparing the 18-year-olds with the 19-year-olds both the left- and right-sided values showed only moderately practical significant differences (d = 0,77 left and 0,58 right). In the iliopsoas test results only the 15-year-old age group recorded practical significant differences when compared with the more senior sides, as can be seen in Table 4.18. The gluteus maximus mobility test showed a practical significant difference left and right side only in the comparison between the 15-year-old and the 19-year-old player groups (d = 0,78 left and 1,07 right). On the other hand, the adductor mobility test showed a strongly practical significant difference between the 15-year-old and 20-year-old groups (d = 0,89), but only a moderate practical significant difference between 18-year-old and 20-year-old (d = 0,55), favouring the more junior groups. Finally in the dynamic testing, the hip external rotational test showed a strongly practical significant left- and right-sided difference, when comparing the 15-year-old with 19-year-old age group, and similarly when comparing the 15-year-old with the 20-year-old group (left strongly and right moderately practical significant differences), favouring the more junior players.

In the *knee complex* the Q-angle and squint tests revealed values for all age-groupers close to the ideal, the higher values recorded were seen among the 18-year-old and 20-year-old players. The tilt test revealed values closer to the non-ideal for all age-groupers – this phenomenon is especially dominant among the 18-year-old players, correlating with recordings by Kapandji, (1970) and Wallace *et al.,* (1990). VMO-L test showed a steady improvement in recorded values with increasing age. None of the above mentioned tendencies were of strongly practical significant difference when comparing the different age-groupers.

When comparing the *ankle and foot region* between age-groupers no specific tendencies were noted. However, when considering forefoot positional testing the 18-year-olds versus the 19-year-olds (d = 0,50) and 20-year-olds (d = 0,74) recorded moderately practical significant differences only on the right-sided tests. Finally, the foot mobility test showed moderately practical significant values for both the left and the right side when comparing the 15-year-olds and 18-year-olds with the 20-year-olds, as can be seen in Table 4.18.

In the *pelvic girdle region* the leg length, ASIS, PSIS, rami and cleft tests showed no apparent difference between age-groupers, except for the freshmen (19-year-old elite club-players) who recorded lower values (closer to ideal) than their counterparts. On the other hand, in the bilateral pelvic positional test the 18-year-old and the 19-year-old freshmen recorded the highest values with strongly tendencies towards the non-ideal. The only practical significant differences recorded were by the rami test when comparing the 15-year-old with the 18-year-old and 20-year-old player groups, and finally the bilateral pelvic positional test when comparing 15-year-old with 18-year-old, and 18-year-old with 20-year-old player groups.

In the *spinal dynamic mobility* testing the TLF showed a steadily increasing tendency with increasing age, with the highest values recorded between non-ideal and highly unsatisfactory. Moderately practical significant differences were noted when the 15-year-old (d = 0,71 left and 0,54 right) and 18-year-old groups (d = 0,59 left and 0,60 right) were compared with the 19-year-old elite group. Similarly, the rotational mobility test recorded moderately practical significant differences between 18-year-old and 20-year-old age groups (d = 0,55 left and 0,52 right). Sacral rhythm, flexion, and side flexion did not record any substantial differences between the elite groups.

In the *spinal region positional* testing the coronal axis in its four positional tests produced five practical significant measurements in total. In the head positional test the 18-year-old group when compared with the 19-year-old group, recorded a moderate practical significant difference. When comparing the 15-year-old with the 19-year-old age group, the cervical (d = 0,63) and lumbar positional tests (d = 0,63) recorded moderately practical significant differences. In the thoracic positional area the 18-year-olds compared to the 20-year-olds recorded a moderately practical significant difference (d = 0,55), and finally, in the lumbar area the 15-year-olds when compared to the 18-year-olds recorded a strongly practical significant difference (d = 0,93). In the sagittal axis the head, cervical and lumbar positional testing recorded no practical significant differences when comparing player age-groupers.

However, the thoracic positional tests recorded moderately practical significant values, when comparing 15-year-olds and 18-year-olds with the seasonal 20-year-old age-groupers, favouring the seasonal players, rendering them more symmetrical.

In *upper limb dynamic mobility* the hand behind back and hand behind neck tests revealed an increase in recorded values with increasing age (closer to non-ideal – less mobile). However, only the hand behind back test showed moderately practical significant differences on the left side when comparing both the 15-year-old (d = 0,62) and 18-year-old (d = 0,57) with the 20-year-old group. Shoulder position, winging and shoulder outline tests on the other hand revealed the opposite to the dynamic tests, with a tendency towards lower values (closer to the ideal) with increasing age. Here again, practical significant difference were recorded by comparing the 18-year-old with the 20-year-old age group for the shoulder positional test. On the other hand, the winging positional and shoulder outline composition tests recorded practical significant differences when comparing the 15-year-old and 18-year-old player groups with both the 19 year and 20-year-old groups. Lastly, the throwing ROM test showed only a moderate practical significant difference when comparing the 15 year and 18-year-old group, favouring the younger age group.

In the *neurodynamic* testing the straight leg raise revealed a strong tendency towards lower values for the semi-professional, junior elite club players when compared with their school counterparts. Practical significant differences were recorded between the 15 year and 19-year-olds, as well as the 18-year-olds when compared with the 19-year-old and 20-year-old groups. The upper limb tension, L3,4 prone knee bend and slump tests recorded tendencies whereby values increased with increasing age (closer to the non-ideal) (Butler, 1991). Practical significant differences were recorded in the upper limb tension test when comparing the 15-year-old with the 19-year-old (d = 0,49 left and right) and 20-year-old (d = 0,5 left and 0,68 right) groups. Similarly, in the L3,4 prone knee bend test practical significant differences were recorded when comparing the 15-year-olds with the 19 year and 20-year-old age groups, also when comparing the 18-

year-olds with the 20-year-old groups. Lastly, in the slump test practical significant differences were recorded when comparing the 15-year-olds(d = 0,63 left and 0,68 right) and 18-year-olds (d = 0,50 left and 0,55 right) with the 19-year-old groups.

Table 4.18: Comparison of descriptive and inferential statistics with d-values of biomechanical and postural mean values between elite school and club rugby players

Variables	15-year-old (N=39)				18-year-old (N=39)				D – values comparing 15 & 18 yr old		19-year-old (N+46)				D – values comparing 15 & 19 yr old	
	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Right anatomical side
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s			$\bar{x}$	s	$\bar{x}$	s		
Lower Limb																
Lower limb dynamic mobility																
TA	1,50	0,70	1,44	0,70	1,60	0,71	1,65	0,70	0,14	0,30	2,02	0,80	2,02	0,80	0,65	0,73
Modified Thomas testings:																
ITB	1,78	0,48	1,65	0,48	1,75	0,49	1,80	0,46	0,06	0,31	2,28	0,69	2,20	0,69	0,72	0,91
Quadriceps mobility	1,54	0,61	1,57	0,56	1,75	0,54	1,83	0,50	0,34	0,46	1,74	0,58	1,78	0,66	0,33	0,29
Iliopsoas mobility	1,51	0,51	1,57	0,50	2,08	0,69	2,03	0,73	0,83	0,63	2,28	0,81	2,26	0,83	0,95	0,88
Gluteus maximums mobility	1,68	0,63	1,57	0,56	1,88	0,52	1,95	0,50	0,32	0,68	2,17	0,53	2,15	0,60	0,78	1,07
Adductor	1,43	0,56		0,56	1,55	0,60			0,20		1,72	0,72			0,41	
Hip internal rotation mobility	1,35	0,48	1,30	0,46	1,35	0,53	1,35	0,48	0,00	0,10	1,59	0,75	1,59	0,78	0,32	0,39
Hip external rotation mobility	1,57	0,56	1,76	0,50	1,88	0,46	1,93	0,53	0,20	0,32	2,20	0,54	2,22	0,51	1,13	0,81
Knee region																
Q-angle	1,16	0,37	1,19	0,40	1,40	0,50	1,33	0,47	0,48	0,30	1,17	0,38	1,17	0,38	0,03	0,05
Patella squint	1,14	0,35	1,14	0,35	1,33	0,47	1,23	0,42	0,40	0,21	1,13	0,34	1,17	0,38	0,03	0,03
Patella tilt	1,57	0,50	1,54	0,51	1,73	0,45	1,78	0,42	0,32	0,47	1,65	0,53	1,63	0,53	0,15	0,21
VMO-L comparison	1,35	0,49	1,38	0,49	1,25	0,44	1,30	0,46	0,20	0,16	1,15	0,42	1,13	0,40	0,41	0,51
Andkle and foot region																
Longitudinal arch status	1,64	0,54	1,65	0,54	1,58	0,50	1,50	0,51	0,13	0,27	1,62	0,54	1,71	0,51	0,06	0,06
Forefoot positional	1,62	0,49	1,62	0,49	1,58	0,50	1,58	0,50	0,08	0,08	1,39	0,49	1,33	0,47	0,47	0,47
Rear foot standing	1,65	0,68	1,57	0,56	1,45	0,55	1,48	0,60	0,29	0,15	1,63	0,68	1,54	0,59	0,03	0,09
Rear foot lying	1,54	0,51	1,54	0,51	1,38	0,49	1,45	0,55	0,47	0,16	1,63	0,66	1,61	0,61	0,24	0,24
Transverse arch are comparison	1,16	0,37	1,16	0,37	1,30	0,46	1,33	0,47	0,30	0,36	1,17	0,38	1,13	0,34	0,03	0,03
Foot mobility	1,31	0,58	1,31	0,58	1,33	0,62	1,30	0,56	0,03	0,01	1,33	0,56	1,37	0,61	0,03	0,34
Toe position	1,60	0,50	1,60	0,50	1,83	0,39	1,83	0,39	0,46	0,46	1,59	0,50	1,57	0,50	0,02	0,02
Pelvic girdle region																
Leg length discrepancy	1,65	0,54			1,65	0,53			0,00		1,46	0,59			0,32	
ASIS	1,65	0,48			1,63	0,49			0,04		1,41	0,50			0,48	
PSIS	1,65	0,48			1,63	0,49			0,04		1,41	0,50			0,48	

Table 4.18 contiues

Variables	15-year-old (N=39)				18-year-old (N=39)				D – values comparing 15 & 18 yr old		19-year-old (N+46)				D – values comparing 15 & 19 yr old	
	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Right anatomical side
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s			$\bar{x}$	s	$\bar{x}$	s		
Pelvic rami position	1,82	0,39			1,62	0,49			0,13		1,41	0,50			0,80	
Sacroiliac cleft	1,14	0,35			1,32	0,47			0,38		1,11	0,32			0,09	
Bilateral pelvic position	1,68	0,67			2,03	0,62			0,52		1,83	0,83			0,18	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s			$\bar{x}$	s	$\bar{x}$	s		
Spinal region																
Spinal dynamic mobility																
TLF mobility	1,68	0,63	1,76	0,68	1,80	0,56	1,78	0,58	0,19	0,03	2,13	0,54	2,13	0,54	0,71	0,54
Sacral rhythm	1,08	0,28	1,08	0,28	1,13	0,34	1,13	0,34	0,15	0,15	1,00	0,00	1,04	0,21	0,00	0,00
Functional extension mobility	1,62	0,64			1,38	0,49			0,38		1,72	0,81			0,12	
Functional flexion mobility	1,73	0,65			1,58	0,59			0,23		1,50	0,72			0,30	
Rotational mobility	1,35	0,54	1,35	0,54	1,15	0,36	1,20	0,41	0,37	0,28	1,33	0,60	1,35	0,60	0,03	0,03
Side flexion mobility	1,43	0,56	1,43	0,56	1,33	0,47	1,35	0,48	0,18	0,14	1,46	0,62	1,46	0,62	0,05	0,05
Spinal positional alignment																
Coronal axis																
Head position	1,35	0,48			1,20	0,41			0,31		1,48	0,51			0,25	
Cervical	1,38	0,49			1,15	0,36			0,47		1,07	0,25			0,63	
Thoracic	1,43	0,50			1,53	0,51			0,20		1,35	0,49			0,16	
Lumbar	1,30	0,46			1,73	0,45			0,93		1,61	0,49			0,63	
Sagittal axis																
Head position	1,14	0,35			1,03	0,16			0,31		1,07	0,25			0,02	
Cervical	1,08	0,28			1,03	0,16			0,18		1,07	0,25			0,04	
Thoracic	1,68	0,49			1,65	0,48			0,06		1,57	0,50			0,10	
Lumbar	1,11	0,32			1,15	0,36			0,11		1,07	0,25			0,13	
Upper limb																
Hand behind back ROM	1,32	0,58	1,84	0,83	1,35	0,58	1,55	0,75	0,05	0,35	1,65	0,74	1,67	0,73	0,45	0,21
Hand behind neck ROM	1,11	0,32	1,11	0,40	1,23	0,42	1,20	0,46	0,29	0,20	1,20	0,40	1,20	0,40	0,23	0,23
Shoulder positional test	1,70	0,46	1,72	0,45	1,74	0,44	1,74	0,44	0,09	0,04	1,54	0,50	1,52	0,51	0,32	0,39
Winging positional test	1,81	0,40	1,83	0,38	1,73	0,45	1,75	0,44	0,18	0,18	1,46	0,50	1,44	0,50	0,70	0,78

Table 4.18 contiues

Variables	15-year-old (N=39)				18-year-old (N=39)				D – values comparing 15 & 18 yr old		19-year-old (N+46)				D – values comparing 15 & 19 yr old	
	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Left anatomical sida	Right anatomical side	Right anatomical side	Left anatomical sice	Right anatomi cal side	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical side	Left anatomical side	Right anatomical side
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s			$\bar{x}$	s	$\bar{x}$	s		
Shoulder outline composition	1,43	0,50	1,42	0,50	0,40	0,50	1,40	0,50	0,06	0,04	1,15	0,36	1,15	0,36	0,56	0,54
Throwing position	1,24	0,44	1,72	0,42	1,48	0,51	1,48	0,51	0,47	0,51	1,24	0,43	1,24	0,43	0,00	0,05
Neurodynamics																
Straight leg raise	2,00	0,72	2,00	0,76	2,08	0,62	2,05	0,60	0,11	0,07	1,61	0,58	1,63	0,61	0,54	0,49
Upper limb tension	1,11	0,32	1,14	0,42	1,38	0,59	1,28	0,55	0,46	0,25	1,48	0,75	1,54	0,81	0,49	0,49
L3,4 prone knee bend	1,70	0,70	1,68	0,71	1,90	0,81	1,85	0,77	0,25	0,22	2,17	0,90	2,22	0,84	0,52	0,64
Slump	1,60	0,60	1,60	0,60	1,70	0,69	1,70	0,69	0,14	0,14	2,09	0,78	2,13	0,78	0,63	0,68

Variables	20-year-old (N=40)				D – values comparing 15 & 20 yr old		D – values comparing 18 & 19 yr old		D – values comparing 18 & 20 yr old		D – values comparing 19 & 20 yr old	
	Left anatomical side	Left anatomical side	Right anatomical side	Right anatomical sides	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side
	$\bar{x}$	s	$\bar{x}$	s								
Lower limb												
Lower limb dynamic mobility												
TA	2,28	0,75	2,23	0,80	1,04	0,99	0,53	0,46	0,91	0,73	0,33	0,26
Modified Thomas testings:												
ITB	2,00	0,72	2,20	0,76	0,31	0,72	0,77	0,58	0,34	0,53	0,39	0,00
Quadriceps mobility	1,88	0,65	1,80	0,69	0,52	0,33	0,02	0,08	0,20	0,04	0,22	0,03
Iliopsoas mobility	2,33	0,69	2,28	0,72	1,19	0,99	0,25	0,28	0,36	0,34	0,06	0,02
Gluteus maximums mobility	1,88	0,61	1,80	0,61	0,32	0,38	0,55	0,33	0,00	0,25	0,48	0,57
Adductor	1,93	0,69			0,89		0,24		0,55		0,29	
Hip internal rotation mobility	1,68	0,66	1,58	0,64	0,50	0,44	0,32	0,31	0,50	0,36	0,12	0,01
Hip external rotation mobility	2,10	0,55	2,08	0,53	0,95	0,60	0,59	0,55	0,40	0,28	0,18	0,26
Knee region												
Q-angle	1,35	0,48	1,38	0,49	0,40	0,39	0,46	0,34	0,10	0,10	0,38	0,43
Patella squint	1,28	0,45	1,25	0,44	0,31	0,25	0,43	0,14	0,10	0,05	0,33	0,18

Table 4.18 contiues

Variables	20-year-old (N=40)				D – values comparing 15 & 20 yr old		D – values comparing 18 & 19 yr old		D – values comparing 18 & 20 yr old		D – values comparing 19 & 20 yr old	
	Left anatomic al side	Left anatomica l side	Right anatomic al side	Right anatomic al sides	Left anatomical side	Right anatomi cal side	Left anato mical side	Right anato mical side	Left anato mical side	Right anato mical side	Left anato mical side	Right anatomi cal side
	$\bar{x}$	s	$\bar{x}$	s								
Patella tilt	1,68	0,47	1,65	0,48	0,22	0,22	0,16	0,28	0,10	0,27	0,06	0,04
VMO-L comparison	1,15	0,36	1,13	0,34	0,41	0,51	0,23	0,37	0,23	0,37	0,00	0,00
Ankle and foot region												
Longitudinal arch status	1,65	0,53	1,60	0,55	0,00	0,09	0,07	0,41	0,13	0,18	0,06	0,20
Forefoot positional	1,55	0,50	1,43	0,50	0,14	0,38	0,38	0,50	0,06	0,74	0,32	0,20
Rear foot standing	1,74	0,75	1,62	0,67	0,12	0,07	0,26	0,10	0,39	0,21	0,15	0,12
Rear foot lying	1,72	0,79	1,54	0,68	0,23	0,00	0,49	0,26	0,43	0,13	0,03	0,10
Transverse arch are comparison	1,40	0,50	1,38	0,49	0,48	0,45	0,28	0,43	0,20	0,10	0,46	0,51
Foot mobility	1,78	0,80	1,68	0,80	0,59	0,46	0,00	0,11	0,56	0,48	0,56	0,39
Toe position	1,70	0,46	1,73	0,45	0,20	0,26	0,48	0,52	0,28	0,22	0,22	0,32
Pelvic girdle region												
Leg length discrepancy	1,75	0,67			0,15		0,32		0,15		0,43	
ASIS	1,58	0,50			0,14		0,44		0,09		0,34	
PSIS	1,55	0,50			0,20		0,44		0,16		0,28	
Pelvic rami position	1,51	0,61			0,63		0,42		0,22		0,20	
Sacroiliac cleft	1,33	0,48			0,40		0,45		0,02		0,46	
Bilateral pelvic position	1,64	0,67			0,06		0,24		0,58		0,46	
Spinal region												
Spinal dynamic mobility												
TLF mobility	1,93	0,86	2,05	0,82	0,29	0,35	0,59	0,60	0,15	0,33	0,23	0,10
Sacral rhythm	1,18	0,45	1,20	0,46	0,22	0,26	0,38	0,26	0,11	0,15	0,40	0,35
Functional extension mobility	1,73	0,75			0,15		0,42		0,47		0,00	
Functional flexion mobility	1,55	0,71			0,25		0,11		0,04		0,07	
Rotational mobility	1,50	0,64	1,53	0,64	0,23	0,28	0,30	0,25	0,55	0,52	0,27	
Side flexion mobility	1,40	0,63	1,35	0,62	0,05	0,13	0,21	0,18	0,11	0,00	0,10	
Spinal positional alignment												
Coronal axis												
Head position	1,35	0,48			0,00		0,55		0,31		0,25	
Cervical		0,39			0,41		0,22		0,08		0,28	
Thoracic		0,44			0,36		0,35		0,55		0,20	
Lumbar		0,51			0,39		0,24		0,45		0,22	

Table 4.18 contiues

Variables	20-year-old (N=40)				D – values comparing 15 & 20 yr old		D – values comparing 18 & 19 yr old		D – values comparing 18 & 20 yr old		D – values comparing 19 & 20 yr old	
	Left anatomical side $\bar{x}$	Left anatomical side s	Right anatomical side $\bar{x}$	Right anatomical sides s	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side	Left anatomical side	Right anatomical side
Sagittal axis												
Head position	1,15	0,36			0,03		0,16		0,33		0,22	
Cervical	1,15	0,36			0,19		0,16		0,33		0,22	
Thoracic	1,35	0,48			0,55		0,16		0,63		0,42	
Lumbar	1,28	0,45			0,38		0,22		0,29		0,47	
Upper limb												
Hand behind back ROM	1,70	0,61	1,75	0,67	0,62	0,11	0,41	0,16	0,57	0,27	0,07	0,11
Hand behind neck ROM	1,30	0,46	1,33	0,47	0,41	0,47	0,07	0,00	0,15	0,27	0,22	0,28
Shoulder positional test	1,48	0,51	1,50	0,51	0,43	0,43	0,40	0,43	0,51	0,47	0,12	0,04
Winging positional test	1,45	0,50	1,48	0,51	0,72	0,69	0,54	0,62	0,56	0,53	0,02	0,08
Shoulder outline composition	1,03	0,16	1,03	0,16	0,80	0,78	0,50	0,50	0,74	0,74	0,33	0,33
Throwing position	1,33	0,48	1,35	0,48	0,19	0,27	0,47	0,47	0,29	0,25	0,19	0,23
Neurodynamics												
Straight leg raise	1,75	0,54	1,83	0,50	0,35	0,22	0,76	0,66	0,53	0,37	0,24	0,33
Upper limb tension	1,43	0,64	1,55	0,60	0,50	0,68	0,13	0,32	0,08	0,45	0,07	0,01
L3,4 prone knee bend	2,43	0,71	2,25	0,74	1,03	0,77	0,30	0,44	0,65	0,52	0,29	0,04
Slump	1,83	0,68	1,80	0,69	0,34	0,29	0,50	0,55	0,19	0,14	0,33	0,42

4.4.4 Comparison of results between elite school and club rugby players

4.4.4.1 Anthropometric, physical and motor variables

Table 4.19 displays the anthropometric, physical- and motor variables of the elite school (15 and 18-year-old) and club (19 and 20-year-old) rugby players. When comparing the elite school group with the elite club group, no practical significant differences were reported as far as body mass, body length and body fat percentage are concerned. However, when comparing physical and motor variables, strongly practical significant differences were reported for the speed endurance test (d = 0,84) and the bleep test (d = 1,09) (aerobic capacity), in respect of which the elite school players were outperformed by their elite club counterparts. Thus can be assumed that the elite club rugby players were fitter and better conditioned (aerobically), than their school counterparts. Moderately practical significant differences were reported for the abdominal level 7 test (d = 0,45), horizontal jump test (d = 0,59) and vertical jump test (d = 0,71), where again the elite club players outperformed their elite school player counterparts. Lastly it would appear that there exists no substantial differences between the elite school and club counterparts.

Table 4.19: Comparison of descriptive and inferential statistics with d-values of anthropometric, physical and motor variables between elite school and club rugby players

Variables	Elite School Rugby Players (N=111)	Elite School Rugby Players (N=111)	Elite Club Rugby Players (N=220)	Elite Club Rugby Players (N=220)	d-values Comparing School & Club
	$\bar{x}$	s	$\bar{x}$	s	
Anthropometric					
Body mass (kg)	86,34	13,43	85,01	15,08	0,09
Body length (cm)	179,67	7,19	179,74	6,96	0,009
Fat percentage (%)	12,87	4,97	13,54	5,20	0,13
Physical and motor					
the 30 m dash (sec)	4,34	0,22	4,34	0,22	0,007
Agility (sec)	17,64	0,73	17,92	0,88	0,34
Vertical jump (cm)	54,59	6,92	49,54	7,24	0,71
Horizontal jump (cm)	2,52	0,21	2,40	0,18	0,59
Abdominal curls(level)	4,71	2,00	5,51	1,50	0,45
Pull-up (n)	9,90	4,14	10,33	5,16	0,09
Bench press (kg)	100,94	18,95	90,79	14,51	0,59
Squat (kg)	128,06	28,27	133,69	24,25	0,21
Bleep (level)	11,40	1,61	9,52	1,77	1,09
Speed endurance (%)	13,41	0,85	12,73	0,75	0,84

4.4.4.2 Biomechanical and postural variables

Table 4.20 displays the biomechanical and postural variables of the elite school and club rugby players. When comparing the elite school group with the elite club group, few practical significant differences were reported. Moderately practical significant differences were reported on the following : ITB left (d = 0,54) and right (d = 0,65), Iliopsoas left (d = 0,66) and right (d = 0,59), hip external rotation right (d = 0,58) only, rami (d = 0,50), Winging left (0,62) and right (0,67), outline left (d = 0,65) and right (d = 0,63), SLR left (d = 0,55) and right (d = 0,45) and lastly L4 left (d = 0,58) and right (d = 0,58). However strongly practical significant differences were reported for TA left (d = 0,74) and right (0,70), as well as for hip external rotation left (d = 0,78) only. In summary the elite school players outperformed their club counterparts in most of the dynamic mobility testing, rendering them more mobile. Elite club players recorded values closer to the ideal in the majority of the regional positional testing, rendering them more symmetrical with a higher core stability.

Table 4.20: **Comparison of descriptive and inferential statistics with d-values of biomechanical and postural variables between elite school and club rugby players**

Variables	Elite School Player left anatomical side (N=78)	Elite School Player left anatomical side (N=78)	Elite Club Player left anatomical side (N=86)	Elite Club Player left anatomical side (N=86)	d-values	Elite School Player right anatomical side (N=78)	Elite School Player right anatomical side (N=78)	Elite Club Player right anatomical side (N=86)	Elite Club Player right anatomical side (N=86)	d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Lower limb										
Lower limb dynamics										
TA	1,55	0,70	2,13	0,78	0,74	1,55	0,70	2,11	0,80	0,70
Modified Thomas testings:										
ITB	1,76	0,48	2,15	0,71	0,54	1,72	0,47	2,19	0,71	0,65
Quadriceps mobility	1,64	0,57	1,80	0,61	0,25	1,70	0,53	1,79	0,67	0.13
Iliopsoas mobility	1,80	0,66	2,30	0,75	0,66	1,80	0,66	2,26	0,77	0,59
Gluteus maximus mobility	1,77	0,57	2,03	0,58	0,43	1,76	0,55	1,98	0,62	0,35
Adductor	1,32	0,57	1,49	0,71	0,45	-		-		-
Hip internal rotation mobility	1,35	0,50	1,62	0,70	0,39	1,32	0,47	1,58	0,71	0,36
Hip external rotation mobility	1,72	0,52	2,15	0,54	0,78	1,84	0,51	2,15	0,52	0,58
Knee complex										
Q-angle	1,28	0,45	1,25	0,43	0,06	1,25	0,44	1,26	0,44	0,01
Patella squint	1,23	0,42	1,19	0,40	0,08	1,18	0,38	1,20	0,40	0,06
Patella tilt	1,64	0,48	1,66	0,49	0,02	1,66	0,47	1,63	0,50	0,04
VMO-L comparison	1,29	0,46	1,15	0,39	0,32	1,33	0,47	1,12	0,36	0,44

Table 4.20 continues

Variables	Elite School Player left anatomical side (N=78)		Elite Club Player left anatomical side (N=86)		d-values	Elite School Player right anatomical side (N=78)		Elite Club Player right anatomical side (N=86)		d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Ankle and foot region										
Longitudinal arch status	1,61	0,51	1,63	0,53	0,04	1,57	0,52	1,65	0,52	0,16
Forefoot positional	1,59	0,49	1,46	0,50	0,26	1,59	0,49	1,37	0,48	0,45
Rear foot standing	1,54	0,61	1,68	0,71	0,19	1,51	0,57	1,57	0,62	0,09
Rear foot lying	1,45	0,50	1,56	0,72	0,34	1,49	0,52	1,57	0,64	0,12
Transverse arch area comparison	1,23	0,42	1,27	0,45	0,10	1,24	0,43	1,24	0,43	0,00
Foot mobility	1,32	0,59	1,53	0,71	0,30	1,30	0,56	1,51	0,71	0,28
Toe position	1,71	0,45	1,63	0,48	0,15	1,71	0,45	1,63	0,48	0,15
Pelvic girdle region										
Leg length discrepancy	1,64	0,53	1,59	0,63	0,08					
ASIS	1,63	0,48	1,48	0,50	0,29					
PSIS	1,63	0,48	1,47	0,50	0,38					
Pelvic rami position	1,71	0,45	1,45	0,50	0,50					
Sacroiliac cleft	1,22	0,42	1,20	0,40	0,04					
Bilateral pelvic position	1,85	0,66	1,74	0,75	0,15					

Table 4.20 continues

Variables	Elite School Player left anatomical side (N=78)	Elite School Player left anatomical side (N=78)	Elite Club Player left anatomical side (N=86)	Elite Club Player left anatomical side (N=86)	d-values	Elite School Player right anatomical side (N=78)	Elite School Player right anatomical side (N=78)	Elite Club Player right anatomical side (N=86)	Elite Club Player right anatomical side (N=86)	d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Spinal region										
Spinal dynamic mobility										
TLF mobility	1,74	0,59	2,03	0,71	0,41	1,76	0,62	2,09	0,67	0,48
Sacral rhythm	1,10	0,30	1,08	0,31	0,07	1,10	0,30	1,11	0,35	0,03
Functional extension mobility	1,49	0,57	1,72	0,77	0,29					
Functional flexion mobility	1,64	0,62	1,52	0,71	0,17					
Rotational mobility	1,24	0,46	1,40	0,62	0,25	1,27	0,47	1,43	0,62	0,25
Side flexion mobility	1,37	0,51	1,43	0,62	0,08	1,38	0,51	1,40	0,62	0,02
Spinal positional alignment										
<u>Coronal axis:</u>										
Head position	1,27	0,44	1,41	0,49	0,29					
Cervical	1,25	0,32	1,11	0,32	0,32					
Thoracic	1,48	0,50	1,30	0,46	0,35					
Lumbar	1,51	0,50	1,55	0,49	0,07					
<u>Sagittal axis:</u>										
Head position	1,07	0,26	1,10	0,30	0,08					
Cervical	1,05	0,22	1,10	0,30	0,17					
Thoracic	1,63	0,48	1,46	0,50	0,34					
Lumbar	1,12	0,33	1,16	0,37	0,08					

Table 4.20 continues

Variables	Elite School Player left anatomical side (N=78)	Elite School Player left anatomical side (N=78)	Elite Club Player left anatomical side (N=86)	Elite Club Player left anatomical side (N=86)	d-values	Elite School Player right anatomical side (N=78)	Elite School Player right anatomical side (N=78)	Elite Club Player right anatomical side (N=86)	Elite Club Player right anatomical side (N=86)	d-values
	$\bar{x}$	s	$\bar{x}$	s		$\bar{x}$	s	$\bar{x}$	s	
Upper limb										
Hand behind back ROM	1,33	0,57	1,67	0,67	0,49	1,68	0,79	1,70	0,70	0,02
Hand behind neck ROM	1,68	0,37	1,24	0,43	0,17	1,15	0,43	1,25	0,43	0,22
Shoulder positional test	1,72	0,45	1,51	0,50	0,42	1,73	0,44	1,51	0,50	0,44
Winging positional test	1,76	0,42	1,45	0,50	0,62	1,78	0,41	1,45	0,50	0,67
Shoulder outline composition	1,41	0,49	1,09	0,29	0,65	1,40	0,49	1,09	0,29	0,63
Throwing position	1,36	0,48	1,27	0,45	0,17	1,35	0,48	1,29	0,45	0,12
Neurodynamics										
Straight leg raise	2,03	0,66	1,67	0,56	0,55	2,02	0,67	1,72	0,56	0,45
Upper limb tension test	1,25	0,49	1,45	0,69	0,29	1,21	0,49	1,54	0,71	0,47
L3,4 prone knee bend	1,80	0,76	2,29	0,82	0,58	1,76	0,74	2,23	0,79	0,58
Slump	1,64	0,64	1,96	0,87	0,42	1,64	0,64	1,97	0,75	0,43

4.5 INJURY EPIDEMIOLOGY ACCORDING TO HISTORY QUESTIONNAIRE ON ALL AGE-GROUPERS

As can be seen in Annexure 3.1 an injury history questionnaire had to be thoroughly completed by all participating age-groupers. Details on the player position injured, anatomical site affected and the type of injury had to be reported. Results for elite school players and junior elite club rugby players will be discussed and compared with modern literature.

4.5.1 Elite school rugby players

In Table 4.21 all recorded injury incidences of various player positions are given as reported in this study. Information from the injury history questionnaire allocated the largest proportion of previously recorded injuries towards the forwards, 15-year-olds 59,46% and 18-year-olds 54,55%. More distant research showed no relevant differences between forward and back-line players at school level as recorded by Davidson (1987) and Lee & Garraway (1996). If further subdivided into tight and loose forwards, the latter seems to be the highest at risk for the 15-year-old with 45,94% and 18-year-old with 36,38%. According to data the player positions most at risk, were flankers (forwards) for the 15-year-olds at 21,62%, and locks, eighth men (forwards) and wings (back-line players) for the 18-year-olds (all at 13,64%).

Table 4.21: Injury incidence as occurred in various player positions of the 15- and 18-year-old elite school rugby players

<table>
<tr><th rowspan="2">Combination of positions</th><th colspan="2">Age</th><th rowspan="2">Combination of positions</th><th colspan="2">Age</th><th rowspan="2">Specific Player position</th><th colspan="2">Age</th></tr>
<tr><th>15 yr (N=37)</th><th>18 yr (N=22)</th><th>15 yr (N=37)</th><th>18 yr (N=22)</th><th>15 yr (N=37)</th><th>18 yr (N=22)</th></tr>
<tr><td rowspan="5">Forwards</td><td rowspan="5">59,46%</td><td rowspan="5">54,55%</td><td rowspan="2">Tight forwards</td><td rowspan="2">13,52%</td><td rowspan="2">18,18%</td><td>Props</td><td>5,41%</td><td>9,09%</td></tr>
<tr><td>Hookers</td><td>8,11%</td><td>9,09%</td></tr>
<tr><td rowspan="3">Loose forwards</td><td rowspan="3">45,94%</td><td rowspan="3">36,38%</td><td>Locks</td><td>18,92%</td><td>13,64%</td></tr>
<tr><td>Flankers</td><td>21,62%</td><td>9,10%</td></tr>
<tr><td>Eighth men</td><td>5,41%</td><td>13,64%</td></tr>
<tr><td rowspan="5">Back-line players</td><td rowspan="5">40,54%</td><td rowspan="5">45,45%</td><td rowspan="2">Half-backs</td><td rowspan="2">13,52%</td><td rowspan="2">13,63%</td><td>Scrum-halves</td><td>8,11%</td><td>9,09%</td></tr>
<tr><td>Fly-halves</td><td>5,41%</td><td>4,54%</td></tr>
<tr><td rowspan="3">Rest of the back-line</td><td rowspan="3">27,02%</td><td rowspan="3">31,81%</td><td>Wings</td><td>13,51%</td><td>13,64%</td></tr>
<tr><td>Centres</td><td>8,11%</td><td>9,08%</td></tr>
<tr><td>Full-backs</td><td>5,41%</td><td>9,09%</td></tr>
</table>

When considering anatomical region as seen in Table 4.22 the lower limb at 55,42% for the 15-year-olds and 56,67% for the 18-year-olds, was the most commonly injured. This differed from the works of Davidson (1987) and Nathan *et al.* (1983) who recorded that the head and neck at 36,6% (Davidson, 1987) and the upper limb at 29,1% (Nathan *et al.*, 1983) were the most commonly injured. On the contrary Roux *et al.* (1987) and Upton *et al.* (1996) similarly found the lower limb to be the most commonly injured at 37% and 28% respectively.

Table 4.22: Anatomical regions and injury incidence of the 15- and 18-year-old elite school rugby players

Anatomical region	Age		Body part injured	Age	
	15 yr (N=37)	18 yr (N=22)		15 yr (N=37)	18 yr (N=22)
Head and face area	10,85%	13,33%	Head and face region	10,85%	13,33%
Upper limbs	14,45%	16,67%	Shoulder	8,43%	6,67%
			Arm	4,82%	6,67%
			Hand	1,20%	3,33%
Spinal region	19,27%	13,33%	Spine	13,25%	6,67%
			Neck	4,82%	3,33%
			Ribs	1,20%	3,33%
			Abdominal	-	-
Lower limbs	55,42%	56,67%	Pelvic girdle	3,61%	10,00%
			Thigh area	7,23%	6,67%
			Knee	16,87%	16,67%
			Lower leg	6,03%	6,67%
			Ankle	14,46%	13,33%
			Foot	7,23%	3,33%

Table 4.23 reflects the most common recorded type of injury as sprains for both the 15-year- old (39,33%) and the 18-year-old (35,02%) school rugby-playing groups, which differs from the findings of Roux *et al.* (1987), who recorded fractures as the most common type of injury (both at 27%) and Nathan *et al.* (1983), who recorded concussions to be the most commonly type of injury (21,5%). This phenomena can be attributed to the changes and evolutions of the game seen in the last decade.

Table 4.23: Type of injuries as occurred for the 15- and 18-year-old elite school rugby players

Type of injury	Age	
	15 yr (N=37)	18 yr (N=22)
Strains	24,67%	27,02%
Sprains	39,33%	35,02%
Dislocations	-	-
Joint injuries	8,00%	7,62%
Fracture	8,01%	3,85%
Contusions	-	-
Concussions	10,67%	14,90%
Peri-ostium & stress fractures	5,33%	7,51%
Bursa	-	-
Compartments	-	-
Dental trauma	1,33%	-
Cartilage	2,66%	3,90%

4.5.2 Junior elite club rugby players

The elite club rugby players reported 54,54% (19-year-old group) and a staggering 74,06% (20-year-old group) of previous injuries among the forwards as seen in Table 4.24. These findings were supported by Gerrard *et al.* (1994) in the RIPP II study on club rugby players (where the tendencies are similar to the mentioned findings). When further subdivided 32,46% and 48,14% of injuries had occurred among the loose forward for the 19 and 20-year-old groups respectively, rendering them definetely more at risk. The player position most at risk in the 19-year-old group was the flanker at 16,88%, and for the 20-year-old group the prop forward and flanker position neck-and-neck at 18,51%, correlating partly with the findings of Roy (1974). The back-line player position most at risk in the 19-year-old group was the centre at 11,59%, and for the 20-year-old group, also the centre with 11,13%.

Table 4.24: **Injury incidence as occurred in various player positions for the 19-year-old (freshmen) and 20-year-old (seasonal) junior elite club rugby players**

Combination of position	Age		Combination of position	Age		Specific Player position	Age	
	19 yr (N=41)	19 yr (N=41)		19 yr (N=41)	19 yr (N=41)		19 yr (N=41)	19 yr (N=41)
Forwards	54,54%	74,06%	Tight forwards	22,08%	25,92%	Props	7,79%	18,51%
						Hookers	14,29%	7,41%
			Loose forwards	32,46%	48,14%	Locks	7,79%	16,67%
						Flankers	16,88%	18,51%
						Eighth men	7,79%	12,96%
Back-line players	45,46%	25,94%	Half-backs	14,29%	5,55%	Scrum-halves	2,60%	3,70%
						Fly-halves	11,69%	1,85%
			Rest of the back-line	31,17%	20,39%	Wings	9,19%	3,70%
						Centres	11,59%	11,13%
						Full-backs	10,39%	5,56%

The anatomical region depicted in Table 4.25 where most commonly injured was the lower limb at 58,44% for the 19-year-old group and 42,58% for the 20-year-old. This was succeeded by the upper limb and head-and-face area in both groups. These findings correlated with the results reported by Bird *et al.* (1998) and O'Brien (1992) in their rugby injury epidemiology studies.

Table 4.25: **Anatomical regions and injury incidence for the 19-year-old (freshmen) and 20-year-old (seasonal) junior elite club rugby players**

Anatomical region	Age		Body part injured	Age	
	19 yr (N=41)	20 yr (N=33)		19 yr (N=41)	20 yr (N=33)
Head and face area	14,30%	16,69%	Head and face region	14,30%	16,69%
Upper limbs	15,58%	27,77%	Shoulder	12,98%	18,51%
			Arm	2,60%	5,56%
			Hand	-%	3,70%
Spinal region	11,68%	12,96%	Spine	5,1%9	9,26%
			Neck	5,19%	1,85%
			Ribs	-	1,85%
			Abdominal	1,3%0	-
Lower limbs	58,44%	42,58%	Pelvic girdle	1,30%	1,85%
			Thigh area	11,69%	5,56%
			Knee	12,98%	11,11%
			Lower leg	3,90%	3,70%
			Ankle	25,97%	18,51%
			Foot	2,60%	1,85%

Table 4.26 depicts the most common type of injury reported among the elite club rugby players as sprains at 46,67% and 39,21% for the 19-year-old and 20-year-old groups respectively, followed by strains and concussions in both groups. Similar tendencies were reported by Gerrard *et al.* (1994), Bird *et al.* (1998) and more recently Holtzhausen *et al.* (2001) in their rugby Super 12 studies.

Table 4.26: Types of injuries as occurred for the 19-year-old (freshmen) and 20-year-old (seasonal) junior elite club rugby players

Type of injury	Age	
	19 yr (N=41)	20 yr (N=33)
Strains	21,34%	17,64%
Sprains	46,67%	39,21%
Dislocations	6,67%	-
Joint injuries	8,00%	15,69%
Fracture	-	5,88%
Contusions	-	-
Concussions	11,98%	15,69%
Peri-ostium & stress fractures	2,67%	3,93%
Bursa	-	-
Compartment	-	-
Dental trauma	2,67%	-
Cartilage	-	1,96%

4.5.3 Comparison of age-groupers

In all age groups the majority of injuries occurred among the forwards, more particularly among the loose forwards. In the case of the 20-year-old elite club players 74,06% of injuries occurred among the forwards, substantially higher when compared to the other age groups. Of these injuries, 48,14% presented within the loose forwards. The player position most at risk was flankers, with fly-halves as the player position least at risk.

All age-groupers reported the lower limb to be the most commonly injured anatomical region, with the thigh and knee areas more particularly highest at risk. Lastly, all groups reported sprains, followed by strains, to be the most common injury that occurred.

4.6 INSTITUTE SPORTS MEDICAL CLINIC ATTENDANCE RECORD RESULTS ON ELITE 19- AND 20-YEAR-OLD RUGBY PLAYERS

Throughout the 2002 rugby season all injured institute junior elite rugby players had to report to the Institute Sports Medical Clinic which was held twice weekly on Mondays and Wednesdays. Clinics were manned by sports physicians, physiotherapists, biokineticists and sports scientists. The aim of the clinics was to diagnose, program and refer injured players. Statistics were kept on player positions injured, anatomical region affected, type of injury, grade of injury, when injury occurred, and lastly necessary referrals. Data on these findings will be discussed below, compared with previous injury questionnaire status and modern literature.

Data on clinic attendance records, as discussed in Chapter 3 (p. 59) will be presented in the following section.

Table 4.27 displays information gathered from 19-year-old freshmen and 20-year-old seasonal elite club rugby players' clinical records. Among the 19-year-old rugby players, 258 reported cases were documented for the 2002 season (from 1 February to the end of October) and among the 20-year-old 293 reported cases. When player position is considered the 19-year-old players reported 55,81% of injuries among the forwards and 44,19% among the back-line. The 20-year-old, on the other hand, reported 56,31% of their injuries among forwards. These results correlate with the injury history questionnaire findings and with those of Gerrard *et al.* (1994) and of Targett (1998). When further subdivided, the 19-year-old age group recorded tight forwards at 21,71%, loose forwards 34,11%, half-backs 13,18% and the rest of the back-line 31,00%. Similarly, the 20-year-old age group recorded tight forwards at 27,64%, loose forwards 28,67%, halfbacks 10,93% and the rest of the back-line at 32,76%. Finally, the player position most at risk for the 19-year-old freshmen group were the centres, and for the 20-year-old seasonal group the prop forward and wing. Findings recorded by O'Brien (1992) and Holtzhausen *et al.* (2001) in the rugby Super 12 study correlate with the 19-year-old group results, however Targett (1998) reported eighth men to be the most at risk.

The anatomical region most often reported injured for both the 19 year and 20-year-old groups, were the lower limb region at 72,72% and 66,65% respectively, correlating with the findings of Bird *et al.* (1998) and O'Brien (1992), and differing from Targett (1998), who found head and face region to be the most often injured. This can be attributed to injury definition differences.

When considering types of injury the most common and often reported were strains at 32,61%, followed by sprains at 24,72%, which correlates well with the findings of Clark *et al.* (1990), with strains at 33% and sprains at 32%. However, this differs from information reported by Bird *et al.* (1998) and more recently Holtzhausen (2001), where sprains were the most commonly reported type of injury. This can be attributed to more senior club players, as well as a more competitive level of competition.

Period prevalence statistics showed the majority of reported injuries occurred during the period April to June for both the 19-year-old (45,91%) and 20-year-old (41,08%) groups, correlating with the findings of Clark *et al.* (1990) and Targett (1998). The most common grade of injury reported was mild at 54,84%, followed by moderate at 27,10%. Fortunately, the high category reported only 18,06%. The Holtzhausen (2001) study reported a much larger percentage of high injuries at 34%. This can again be contributed to a more competitive level of competition.

Referrals from clinics were in total 129 for the 19-year-old group, where 47,69% were for specialist opinion, and secondly 52,31% for further specialised assessment procedures. Similarly, the 20-year-old side had a total of 103 referrals, where 40,18% of these were for specialist opinion, and 59,82% for specific assessments.

For the 19-year-old group the majority of reported injuries occurred during match play at 58,76%, and the rest during training. On the other hand, the more senior seasonal 20-year-old players reported 62,64% of injuries during match play, and the rest during training. This correlated well with the findings of Holtzhausen (2001), who reported 66% of injuries during match play and the rest during training. As can be expected, the majority of injuries occurred during open and general play for both freshmen at 72,66%, and seasonal players at 74,22%. This correlated well with the findings of Roux *et al.* (1897) (pre-1988 law changes), and Holtzhausen (2001).

Lastly, in both the freshmen (54,76%) and seasonal players (61,79%) the majority of injuries reported were acute, with the rest being chronic or overused type of injuries. This correlated with the work of Holtzhausen. (2001) (acute at 68% and chronic at 32%).

Table 4.27: Results of the institute sports medical clinic attendance records of the 19-year-old (freshmen) and 20-year-old (seasonal) junior elite club rugby players

INJURY INCIDENCE AND PLAYER POSITION								
Combination of position	Age		Combination of position	Age		Specific Player position	Age	
	19 YR (N of Injuries=264)	20 YR (N of Injuries=306)		19 YR (N of Injuries= 264)	20 YR (N of Injuries= 306)		19 YR (N of Injuries= 264)	20 YR (N of Injuries= 306)
Forwards	55,81 %	56,31 %	Tight forwards	21,71%	27,64%	Props	11,63%	14,68%
						Hookers	10,08%	12,96%
			Loose forwards	34,11%	28,67%	Locks	11,63%	9,90%
						Flankers	16,28%	6,14%
						Eighth men	6,20%	12,63%
Back-line players	44,19 %	43,69 %	Half-backs	13,18%	10,93%	Scrum-halves	6,69%	6,15%
						Fly-halves	3,49%	4,78%
			Rest of the back-line	31,00%	32,76%	Wings	8,91%	14,68%
						Centres	17,05%	14,33%
						Full-backs	5,04%	3,75%

ANATOMICAL REGION					
Anatomical region	Age		Body part injured	Age	
	19 YR (N of Injuries= 264)	20 YR (N of Injuries= 306)		19 YR (N of Injuries=264)	20 YR (N of Injuries=306)
Head and face area	3,04%	0,95%	Head and face region	3,04%	0,95%
Upper limbs	12,89%	21,24%	Shoulder	10,61%	15,69%
			Arm	1,14%	1,96%
			Hand	1,14%	3,59%
Spinal region	11,35%	11,16%	Spine	6,82%	7,19%
			Neck	2,27%	2,94%
			Ribs	1,89%	0,68%
			Abdominal	0,37%	0,35%
Lower limbs	72,72%	66,65%	Pelvic girdle	-	0,98%
			Thigh area	25,38%	21,57%
			Knee	23,48%	19,93%
			Lower leg	12,12%	9,80%
			Ankle	8,33%	12,41%
			Foot	3,41%	1,96%

Table 4.27 continues

TYPE OF INJURY		
Type of injury	**Age**	
	19 YR (N of Injuries=264)	**20 YR (N of Injuries=306)**
Strains	32,61%	29,94%
Sprains	24,72%	28,03%
Dislocation	2,66%	0,32%
Joint injuries	12,55%	19,11%
Fracture	2,66%	4,78%
Contusions	2,66%	5,73%
Concussions	2,66%	0,64%
Peri-ostium & stress fractures	8,36%	3,50%
Bursa	4,42%	4,14%
Compartment	2,14%	0,63%
Dental trauma	-	-
Cartilage	4,56%	3,18%

PERIOD OF PREVALENCE		
Period	**Age**	
	19 YR (N of Injuries=264)	**20 YR (N of Injuries=306)**
January to March	26,46%	25,25%
April to June	45,91%	41,08%
July to September	27,63%	33,67%

GRADE OF INJURY		
Grade	**Age**	
	19 YR (N of Injuries =264)	**20 YR (N of Injuries =306)**
Mild	54,84%	59,26%
Moderate	27,10%	31,48%
High	18,06%	9,26%

Table 4.27 continues

SPECIALIST REFERENCE					
Specialist/Assessments	**19 YR (N of Injuries=264)**	**20 YR (N of Injuries =306)**		**19 YR (N of Injuries=264)**	**20 YR (N of Injuries=306)**
Specialist opinion	47,69%	40,18%			
Specific assessments	52,31%	59,82%	X-rays	17,20%	22,32%
			Sonar	14,63%	17,27%
			Isokinetic tests	20,48%	20,23%

WHEN INJURY OCCURRED		
	Age	
	19 YR (N of Injuries=264)	**20 YR (N of Injuries=306)**
Match	58,76%	62,64%
Practise	41,24%	37,36%

PHASE OF PLAY		
	Age	
	19 YR (N of Injuries=264)	**20 YR (N of Injuries=306)**
Fix phase	27,34%	25,78%
Open play	72,66%	74,22%

ACUTE OR CHRONIC INJURY		
	Age	
	19 YR (N of Injuries=264)	**20 YR (N of Injuries=306)**
Acute	54,76%	61,79%
Chronic	45,24%	38,21%

4.7 SUMMARY

4.7.1 Age-grouper status

Differences among and performance of elite rugby age-groupers correlate with normal growth and development of players as far as *anthropometric and physical and motor variables* are concerned. This is a tendency whereby bigger, stronger and fitter players with a lower body fat percentage developed as time progressed. BMPE values recorded a regression in dynamic mobility findings with increasing age, thus rendering the more senior elite club players less mobile than their school counterparts. This applies especially to the results found in lower limb and *neurodynamic* testing. The elite club player recorded superior values for the shoulder and pelvic regional positional testing, indicating a better symmetry and core stability.

Anthropometrical results showed a practically significant increased tendency in body mass between *age* groups. Only moderately increasing tendencies in body length and body fat percentage were recorded. As can be expected, a gradual increase in physical and motor performance was seen with *increasing age.* However a practically significant increase was seen in explosive power when comparing 15-year-olds with the rest. Biomechanical and postural evaluation results depict a decrease in dynamic mobility, especially with the lower limb, spinal region and neurodynamic testing, with *increasing age.* On the other hand, an increase in postural core stability (shoulder and spinal region test) occurred with *increasing age*

4.7.2 Comparison between forward and back-line players

In a comparison between forward and back-line players a general tendency was recorded where forwards were heavier, taller and measured higher in body fat percentage than their back-line counterparts. Moderate to severe practically significant differences were recorded by all age-groupers. As could be expected, test results for *physical and motor* variables favoured back-line players when looking at speed, agility, *explosive* power, power endurance, aerobic and anaerobic capacities. Forwards recorded higher results for the maximum power tests.

Biomechanical and postural variables favoured 15-year-old forwards who outperformed their back-line counterparts in regional stability and dynamic mob*ility. On the* other hand the 18- and 19-year-old back-line players outperformed their forward counterparts, where variables recorded, especially favoured the back-line players with the lower limb dynamic, ankle and foot, upper limb and neurodynamic testing. Very few to no differences were recorded in the case of the 20-year old (seasonal) players.

4.7.3 Comparison between elite school and elite club rugby players

When comparing elite school with elite club rugby players, no practically significant difference was seen for *anthropometric* testing. The *physical and motor* test recorded practically significant outperformance by club elite players for the speed endurance, bleep, explosive power and power endurance (abdominal curls) tests.

Biomechanical and postural testing favoured elite school players as far as dynamic mobility (lower limb and neuron dynamics) was concerned. Elite club players recorded more favourable results with regard to the regional postural testing (spinal region and upper limb), which are signs of better core stability.

4.7.4 Injury History Questionnaire on all age-groupers

Results revealed that the forwards group was most commonly injured, especially the loose forwards, with the flanker being the most injured position. The anatomical site most often injured were the lower limb for both elite school and club players. This was followed by upper limb injuries for elite school and facial injuries for the elite club players. The most common type of injury reported by both groups were sprains, followed by strains and concussions.

4.7.5 Institute sports medical clinic attendance records on elite 19- and 20-year-old club rugby players

As with the previous history questionnaire results, the most commonly injured were the forwards, especially loose forwards. However, the most commonly reported player positions were centres (among 19-year-olds) and props and wings (20-year-olds).

The anatomical site most often injured was the lower limb (as in the questionnaire results). The most common type of injury was strains followed by sprains, Which differed somewhat from the history questionnaire results. The majority of injuries occurred during the first 3 months of competition. As can be expected, the majority of injuries occurred during match play, and more specifically during open or general play. Lastly, the majority of injuries reported were acquired injuries. However, a disconcertingly high percentage was still overuse or chronic injuries.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of this study was to develop a prevention programme for rugby injuries, based on analysis among adolescent players, with reference to anthropometric, physical and motor, biomechanical and postural variables. Differences and shortcomings in the current status of age-groupers were identified. A recommended prevention programme for adolescent elite school rugby players based on analyses of the above-mentioned variables was compiled. Previous injury status and clinic attendance records (last mentioned only for junior elite club players 2002 season), were also used. To achieve the aim of this study, four groups of elite male rugby-playing subjects were analysed and researched, namely elite school players (15- and 18-year-olds) and elite club players (19- and 20-year-olds).

Firstly, in this Chapter a summary of al the main findings of this study will be reported and discussed. This will be done under five main subdivisions, namely 15-, 18-, 19- and 20-year-old age-grouper status; comparison between forward and back line players; elite school versus elite junior club players; previous injury history status (elite school versus elite junior club players); and lastly clinic attendance records for only junior elite club players. Findings will be compared with modern literature.

Secondly the important findings will be highlighted, analysed and discussed in this chapter. Based on to the findings, it will be attempted to formulate a physical and motor, and a biomechanical and physical and motor prevention programme to address the identified overuse and acquired injuries, and secondly to correct identified shortcomings already at school level to manipulate current tendencies and trends.

Finally, the chapter will conclude with suggestions on norms and criteria for further *research* and follow-up studies, as well as possible shortcomings of this study.

5.2 SUMMARY

5.2.1 Individual age-grouper status

5.2.1.1 15-year-old elite school rugby players

Anthropometric testing on the elite 15-year-olds revealed that body mass compared well with the recordings of Hare (1999) in his study on elite 15-year-old rugby players. On the other hand, the average body length was slightly shorter for the elite 15-year-olds when compared with the Hare (1999) study and the body fat percentage substantially higher, rendering the elite 15-year-old group heavier, shorter and more obese than the Hare (1999) group. (See table 4.1 p. 91)

In the *physical and motor* data recorded in the 30 m dash, agility, vertical and horizontal jumps the elite school players outperformed those in the studies of the Hare (1999) and Badenhorst (1998), which means the elite school players were superior in speed, explosive power and agility. In contrast, the aerobic bleep test in the case of the 15-year-old elite rugby players recorded values lower than those documented by Badenhorst (1998) in her study on elite soccer players, classifying the elite rugby players aerobically inferior to the Badenhorst (1998) 15-year-old soccer-playing group.

Biomechanical and postural variables revealed that lower limb dynamic testing recorded high values in the Thomas and gluteus maximus test (close to the non-ideal). Furthermore, the knee complex recorded a high value for the patella tilt test, correlating with the recordings under lower limb dynamics for this age group as noted by Hoppenfeld (1976); Hunt (1990); McConnel (1999) and McPoil & Brocato (1990). (See table 4.2 p. 92)

In the *pelvic girdle region,* pelvic positional testing recorded values close to the non-ideal for most tests, rendering this area asymmetrical, with a lack of core stability as with the recordings of Hoppenfeld (1976); Porterfeld & DeRosa (1990) and Rocabado (2000). Spinal dynamic testing in the TLF and flexion test recorded high values close to *the non-ideal,* which correlated with lower limb dynamics and knee complex (positional) findings. Spinal region positional testing once again correlated with earlier lower limb dynamic findings, where high values were recorded by the lumbar spine in the coronal axis correlating with recordings of Kapandji (1974); McConnel (1999) and Warwich & Williams (1973).

As with the pelvic girdle region *upper limb* testing reveals poor core stability and symmetry, especially with the shoulder positional, winging and shoulder outline tests as correlating with the recordings of Halbach & Tank (1990) and Kapandji (1970). Lastly *neurodynamics* testing recorded reasonably good values for all tests except the Straight Leg Raise test, with values close to the non-ideal as with the norms of Butler (1991).

In summary, anthropometrically the 15-year-old group compared well with other studies except for a high recorded body fat percentage, which could be attributed to the fitness condition in the early part of the season.

In respect of the physical and motor results, findings indicated that subjects outperformed participants in other studies with regard to speed, explosive power and agility. However, the Badenhorst (1998) soccer player results recorded superior aerobic values when compared with elite club players.

The 15-year-old elite rugby player group can be positionally classified as asymmetrical and lacking in core stability, especially in the pelvic girdle and shoulder regions. Furthermore, dynamically unsatisfactory high values were recorded, especially in the lower limb and spinal regions.

5.2.1.2 18-year-old elite school rugby players

Anthropometrically in respect of body mass, a mean value of 87,1 kg was recorded, correlating well with the Spamer and Winsley (2003) recordings (Northern Bulls 87,40 kg; English College team 87,8 kg) of international 18-year old elite players. Body length recorded a mean of 180,68 cm, less than the values recorded by Spamer and Winsley (2003) in their study but higher than values recorded by Malan and Hanekom (2001). Lastly, mean body fat percentage was recorded at 12,98%, being substantially lower than values recorded by Spamer and Winsley (2003) (Northern Bulls 15,8%; English College 22.1%) but higher than those recorded by Malan and Hanekom (2001). (See table 4.3 p. 96)

Physical and motor data on the 30 m dash and agility testing reflected values lower than those recorded by Malan and Hanekom (2001) in their study. However aerobic capacity and explosive power testing (vertical and horizontal jump), correlated well with Spamer and Winsley's (2003) recordings but outperformed the Malan and Hanekom (2001) group. It is clear according to the above recordings that the Malan and Hanekom

(2001) players outperformed the 18-year-old elite players of this study as far as the 30 m dash and agility tests were concerned. However, anaerobic capacity and explosive power testing similar to the Spamer and Winsley (2003) recordings outperformed the Malan and Hanekom (2001) group. A possible reason for the superior values recorded by the Malan and Hánekom (2001) player group (in the 30 m dash and agility tests) can be attributed to the lighter, smaller and lower body fat percentage player group. It is also a possibility that this group could be talented in terms of speed.

Biomechanical and postural variables in the lower limb area recorded high values (close to the non-ideal) for the Thomas, gluteus maximus patella tilt and toe positional test as with the recordings of Hoppenfeld (1976), Hunt (1990, McConnel (1999) and McPoil & Brocato (1990). In the *pelvic girdle and shoulder region* all tests recorded reasonable high values close to the non-ideal, correlating with the recordings of Hoppenfeld (1976),

Porterfeld & DeRosa (1990) and Rocabado (2000). Which makes these areas asymmetrical and lacking in core stability. (See table 4.4 p. 98)

Lastly *neurodynamics* testing revealed reasonable high values for all tests except the upper limb tension test, indicating a lack of dynamic mobility, corresponding with the norms of Butler (1991).

In conclusion, anthropometric body mass correlated well with data from earlier studies. Body length values recorded were slightly lower than those for international player groups but higher than values recorded by Malan and Hanekom (2001) in their talented 17-year-old player group. Lastly, body fat percentage was substantially lower than values recorded by the international player group, especially those recorded by English college players.

Physical and motor-wise 18-year-old elite players were outperformed in the speed and agility tests by the Malan and Hanekom (2001) group, the latter group being probably more talented in terms of speed. Other tests correlated well with the Spamer and Winsley (2003) recordings.

Biomechanically the pelvic girdle and shoulder region can be classified as asymmetrical and lacking in core stability. Dynamically the lower limb region can be recorded as exceptionally poor in dynamic mobility.

5.2.1.3 19-year-old (freshmen) junior elite club rugby players

Anthropometric testing done on three occasions as discussed in Chapter 4 showed no practically significant differences between testing episodes as far as body mass, body length and body fat percentage were concerned. However, body fat percentage at 11,79 was substantially lower than values of 15,60% as recorded by Mayes and Nuttall (1995) in their study on elite under-21 players. (See table 4.5 p. 101)

Physical and motor data revealed no practical significant differences between testing episodes except for the agility, horizontal jump and squat tests.

In respect of *biomechanical and postural* variables high values were recorded for the Thomas gluteus maximus, hip external rotation and patella tilt test, correlating with works of Kapandji (1974) and McConnel (1999). The rest of the values recorded were more satisfactory, varying between ideal and non-ideal. In the pelvic girdle region a high value was recorded by the bilateral pelvic positional test, correlating with lower limb findings. The rest of the tests confirmed a more symmetrical pelvic girdle region. In the spinal region, dynamic testing revealed a high value for the TLF tests, while on the other hand, spinal region position recorded a high value for the lumbar area, correlating with lower limb and pelvic girdle results. In the upper limb region, a marginal asymmetry and a lack of core stability were recorded by the test results. Lastly, all neurodynamic results recorded were close to the ideal, except for the L3,4 prone knee bend test, correlating with lower limb, pelvic girdle and spinal dynamic testing. (See table 4.6 p. 103)

The 19-year-old group from an anthropometric point of view became heavier and taller (although not practically significantly so), with a lower body fat percentage. Physical and motor results revealed an increase in power, fitness, speed and agility with testing episodes, although not all results were practical significant, as can be seen in Table 4.5. This is in accordance to normal development and enhancement of skills, as confirmed by recordings by Carlson *et al.* (1994).

Biomechanically, lower limb dynamic testing (Thomas and gluteus maximus) in conjunction with the bilateral pelvic positional test identified the mechanical shortcomings in this group. The rest of the results were more satisfactory between ideal and non-ideal.

5.2.1.4 20-year-old (seasonal) junior elite club rugby players

Anthropometric testing revealed no practically significant differences between testing episodes as far as body mass, body length and body fat percentage were concerned. Body fat percentage of 13,02% correlated well with the value of 15,60% as recorded by Mayes & Nuttall (1995). Physical and motor testing revealed a strong practically significant difference between testing episodes as far as speed (the 30 m dash), bleep test (aerobic capacity), squat (maximum power) and speed endurance were concerned. This phenomenon can be attributed to a fitter, stronger, faster and better-conditioned rugby player. (See table 4.7 p. 106)

Biomechanical and postural variables in lower limb testing revealed non-ideal values as far as the Thomas, gluteus maximus, hip external rotational, patella tilt and toe positional tests were concerned, correlating with Kapandji (1974) and McConnel (1999). Further testing in the *ankle and foot* region revealed a tendency towards a flatter and more mobile foot complex. The *pelvic girdle* region recorded values that support a small margin of asymmetry, indicating reasonable core stability, as did the recordings of Hoppenfeld (1976), Porterfeld and DeRosa (1990) and Rocabado (2000). All *spinal dynamic* and positional tests recorded reasonably low values (closed to the ideal), except for the lumbar spine status test, which recorded a high value, supporting findings regarding the lower limb and pelvic girdle region. The shoulder complex recorded values which indicate symmetry and positional stability, except for the hand behind back test (larger values), indicating stiffness on the dominant side. Lastly, *neurodynamic* testing revealed values between non-ideal and highly unsatisfactory for the L3,4 prone knee bend. The rest of the values recorded in this area were more satisfactory, varying between ideal and non-ideal and correlating with the norms of Butler (1991). (See table 4.8 p. 108)

In summary, 20-year-old junior elite rugby players reported no practical significant differences between testing episodes for body mass, body length and fat percentage. However, values recorded correlated with research literature. Physical and motor *testing* recorded superior values for the last testing episode, indicating the players got faster, stronger, fitter and more agile as the season progressed.

The 20-year-old player group recorded satisfactory values for all spinal and upper limb regional tests except the bilateral pelvic position. Lower limb dynamics (Thomas, gluteus maximus and hip external rotational tests) still recorded high values closer to the non-ideal.

5.2.2 Comparison of results on forward and back-line players

5.2.2.1 15-year-old elite school rugby players

The *anthropometric* data on the elite school players revealed practical significant differences between forward and back line players as far as body mass, length and fat percentage were concerned correlating with recordings of Maud & Schultz (1984). In total the forwards were heavier and taller and carried a higher percentage of body fat. In respect of physical and motor data, the back line outperformed the fordwards, with a strongly practical significant difference recorded only in respect of agility and speed endurance testing, as with recordings of Carlson *et al.*(1994).

Biomechanical and postural variables in the lower limb region favoured forwards, who recorded values closer to the ideal than their back line counterparts, correlating with norms used by Kapandji (1974) and McConnel (1999). A practical significant difference was recorded for the quadriceps (left and right) patella squint and tilt tests. In the pelvic girdle and spinal region, dynamic and positional testing, favoured the forwards, who recorded values closer to the ideal. Only the TLF test recorded a value of practical significance when comparing these groups. *Spinal region* positional testing recorded practical significant differences in both coronal and sagittal axis, favouring forwards and supporting *lower limb* and *pelvic girdle* findings, where back line players were dynamically and positionally inferior to their forward counterparts. Finally, upper limb and *neurodynamic* testing recorded values closer to the ideal for the forwards, with a practical significant difference recorded in the slump test as stipulated by Butler (1991).

In summary, anthropometrically forwards were heavier, taller and carried a higher percentage of body fat. Physical and motor data reported superior values for the back line when compared with the forwards. However, not all values were practical significant.

The forwards outperformed their back line counterparts in dynamic mobility and core stability, although not always practical significantly so.

5.2.2.2 18-year-old elite school rugby players

Anthropometrically a strong practical significance was reported for body mass, body length and body fat percentage when comparing forward and back line players. *Physical and motor* testing revealed strongly practical significant differences for the 30 m dash, agility, pull-up (power endurance), and speed endurance tests, and front row players recorded higher values for maximum power bench press test.

Biomechanical and postural variables in the lower limb region revealed that backs outperformed their forward counterparts, with values closer to the ideal, but differing from the lower limb variables as obtained in the 15-year-old group, as was the case with the recordings of Kapandji (1974) and McPoil and Brocato (1990). The only practically significant difference was reported by the right hip external rotational test. No practically significant differences were seen in the knee complex and ankle and foot region. In the pelvic region, values closer to the ideal were recorded by the forwards, rendering this group more symmetrical with a better core stability, correlating with the descriptions of Hoppenfeld (1976), Porterfeld and DeRosa (1990) and Rocabado (2000). Spinal dynamic and positional testing revealed no practically significant differences between the groups, except for the TLF and thoracic positional test favouring the forwards. As with spinal region testing, neurodynamic mobility favoured the forwards, with a moderate practically significant difference for the L3,4 prone knee bend and slump test, which accorded with the norms as recorded by Butler (1991).

In summary, as with the 15-year-old, forwards were heavier, taller and higher in body fat percentage, correlating with recordings by Maud & Schultz (1984).

In respect of elite school players,back-line players were recorded to be physical and motor-wise superior to their front row counterparts, except for maximum power testing.

Back-line players dynamically outperformed their front row counterparts; however, the positionally front row players recorded more ideal values as far as core stability was concerned.

5.2.2.3 19-Year-old (freshmen) junior elite club rugby players

Anthropometrically (as with the earlier age-groupers) a strongly practical significant difference was seen between forward and back line players as far *as body mass*, body length and body fat percentage were concerned. Physical and motor testing revealed a strongly practical significant difference in speed, agility, vertical jump, abdominal and pull-up endurance tests. As with the earlier groups, maximum power (bench press and squat tests) favoured front row players.

Biomechanical and postural variables in the lower limb region favoured back line players with values closer to the ideal. Only the right gluteus maximus and adductor test revealed values of practical significant differences. In the pelvic girdle and spinal regions no practical significant differences were recorded between player groups. Dynamic values recorded in the spinal region showed the back line players had values closer to the ideal according to works of Hoppenfeld (1976), Porterfeld & DeRosa (1990) and Rocabado (2000). As with spinal dynamic and positional testing no practical significant difference was seen in the upper limb region; however, neurodynamic testing revealed a moderately practical significant difference on the left sided slump test, favouring front row players (values closer to the ideal) as with the norms recorded by Butler (1991).

In summary, anthropometrically front row players were recorded as being heavier, taller and with a higher body fat percentage when compared with their back line counterparts.

Back-line players outperformed their front row counterparts in all physical and motor testing, except for maximum power.

Biomechanical and postural data recorded no positional tendencies when comparing forward and back-line players; however, dynamic testing in the lower limb and spinal region favoured the back-line. On the other hand, neurodynarnic testing recorded, was more favourable (with lower values) for front row players.

5.2.2.4 20-year-old (seasonal) junior elite club rugby players

Anthropometric testing revealed a strongly practical significant difference for body mass. In total, forwards were heavier, taller and higher in body fat percentage than their back-line counterparts. These values compared well with British statistics on elite club players, except for the body fat percentage, which was substantially lower as recorded by Nicholas & Baker (1995). *Physical and motor* data revealed strongly practical significant differences for the speed, agility and bench press tests. Back-line players outperformed front row counterparts in all tests except for maximum power correlating with recordings by Carlson *et al.* (1994).

Biomechanical and postural variables under lower limb dynamics recorded no strongly practical significant difference between forward and back-line players, although values for both groups recorded were high (non-ideal). The same tendency was observed for the knee complex and *ankle and foot region* correlating with recordings by Kapandji (1970), McConnel (1999) and Wallace *et al.* (1990).

In the *pelvic girdle region* as with lower limb findings, no strongly practical significant differences were recorded between groups. Values recorded by the back line were closer to the non-ideal according to norms of Hoppenfeld (1976), Porterfeld & DeRosa (1990) and Rocabado (2000).

Spinal dynamic and positional testing recorded values closer to the ideal for the back-line players. No strongly practical significant differences were recorded in this area. *Upper limb* dynamic testing recorded only a moderately practical significant difference in the right-sided hand behind back test, with values favouring the back-line players (closer to the ideal).

Neurodynamically no practical significant differences were recorded between the forwards and backline players correlating with norms of Butler (1991).

In summary, anthropometrically in all age-groupers front row players were heavier, taller and carrying a higher percentage of body fat. Physically and motor testing-wise, back-line players outperformed their front row counterparts, except for maximum power testing.

Biomechanical and postural evaluation revealed in the 15-year-old age group that forwards were positionally and dynamically more sound than their back-line counterparts. This tendency in regard to dynamic testing, was reversed for the 18- and 19-year-old player groups. Positionally (core stability), front row players recorded values closer to ideal, indicating that they were more stable. In the 20-year-olds no substantial differences were recorded between forwards and back-line players.

5.2.3 Age-grouper comparison including elite school versus elite junior club rugby players

5.2.3.1 General comparison of results

5.2.3.1.1 Anthropometric, physical and motor comparison

Anthropometric testing revealed a strongly practical significant difference for body mass when comparing 15-year-old players with 18-, 19- and 20-year-olds as can be seen in

Table 4.17. p. 132. However, no practical significant differences were seen when comparing the rest of the age-groupers as discussed above. In respect of body length, strongly practical significant differences were recorded between 15- and 18-year-old, and 15- and 20-year-olds, indicating substantial length difference between age-groupers as can be expected. As with body mass, when comparing the rest with each other there was no practical significant difference. In respect of body fat percentage, only a moderately practical significant difference was recorded when compared with the older age-groupers, as can be expected with a normal growth trend.

In anthropometric testing the older age-groupers were recorded as being heavier and taller, with a decrease in body fat percentage with an increase in age.

Physical and motor ability comparison: As discussed in chapter 4, information on the agility, bench press and squat test could not be compared for the 15-year-olds and the bleep test for the 19-year-olds. In the vertical jump test a strong practical significant difference was recorded when comparing the 15- with the 19-year-old, the 15- with the 20-year-old and the 18- with the 20-year-olds. The horizontal jump similarly recorded strongly practical significant differences when comparing the 15- and 18-year-olds with the seasonal 20-year-olds.

The bench press test recorded strongly practical significant differences when comparing the 18- and 19-year-old players, correlating with recordings by Carlson et al. (1994) with the seasonal 20-year-olds. The squat test similarly recorded strongly practical significant differences when comparing 19-year-old with seasonal 20-year-old players. Aerobic capacity yet again recorded practical significant differences when comparing 15- and 18-year-old with seasonal 20-year-old players. Finally, with speed endurance testing, elite club players (19- and 20-year-old) outperformed their *elite school* (15- and

18-year-old) counterparts with strongly practical significant differences, as can be seen in Table 4.17.

In conclusion, with increasing age an increase in physical and motor performance were recorded; however, not all values were practical significant. This correlates with the developmental characteristics of these players as well as with the recordings by Carlson et al. (1994) and Pienaar et al. (2000).

5.2.3.1.2 Biomechanical and postural comparison

As discussed in chapter 4, *lower limb dynamics* recorded a decreaseed tendency in mobility with increasing age (older age-groupers recorded higher values closer to the non-ideal). When comparing 15-, 18-, 19- and 20-year-old elite rugby players, practical significant differences between various age groups were recorded by the TA, ITB, iliopsoas, gluteus maximus, adductor and hip external mobility tests. (See table 4.18 p. 138)

In the *knee complex and ankle and foot* region no positional practical significant differences were recorded.

In the *pelvic girdle region* values closer to the ideal were recorded by the 19-year-old freshmen group as far as ASIS, PSIS and leg length tests were concerned. This phenomena can possibly be attributed to the fact that the growth phase as seen in the 15-year-old group, had partly ended at this stage, and secondly the intense physical and motor preparation and conditioning, as with the club players, had not yet started. The only practical significant values recorded between age-groupers were for the rami and pelvic bilateral positional tests.

In the *spinal dynamic mobility* testing the TLF and rotational mobility test reported a steady increasing tendency with an increase in age, with the highest values recorded between non-ideal and highly unsatisfactory by the 20-year-old seasonal players. The only practical significant values recorded were for the TLF and rotational mobility tests between age-groupers.

In *spinal region positional* testing with regard to the coronal axis, practical significant differences were recorded for the head, cervical, thoracic and lumbar positional tests when comparing various age groups. In regard to the sagittal axis, only the thoracic spinal region showed a practical significant difference between age-groupers.

In *upper limb dynamic testing* the hand behind back and hand behind neck tests revealed an increase in recorded values with increasing age (closer to non-ideal) with only the hand behind back test recording moderately practical significant difference. The throwing ROm mobility test recorded a practical significant difference between age-groupers, favouring the younger player groups (values closer to ideal). Shoulder position, winging and shoulder outline tests on the other hand revealed the opposite to the dynamic tests, with a tendency towards lower values (closer to the ideal) with increasing age. Practical significant differences were recorded by shoulder outline positional and winging tests between age-groupers.

In *neurodynamic* testing, the straight leg raise test revealed a practical significant tendency towards lower values for the junior elite club players (closer to the ideal) when compared with their school counterparts. The upper limb tension, L3,4 prone knee bend and slump tests recorded practical significant but opposite tendencies where values increased with increasing age (closer to the non-ideal) correlating with recordings by Butler (1991).

5.2.3.2 Comparison of results between elite school and club rugby players

5.2.3.2.1 Anthropometric, physical and motor comparison

When comparing the elite school players with the junior elite club players no practical significant anthropometric differences were recorded; however, junior club players were recorded as being heavier, taller with a slightly lower body fat percentage. *Physical and motor* data revealed practical significant differences between elite school and club players as far as speed endurance (anaerobic capacity), aerobic capacity, abdominal curls, vertical and horizontal jump (explosive power) were concerned. Hereby elite junior club players outperformed their elite school player counterparts. (See table 4.19 p. 144)

5.2.3.2.2 Biomechanical and postural comparison

Lower limb dynamics revealed practical significant differences between school and club player groups as far as the TA, ITB, iliopsoas and hip external rotational tests are concerned. Values favoured the school group (closer to the ideal). In the pelvic girdle region only the rami positional test revealed a practical significant difference favouring the club players, who recorded a lower value (close to the ideal), indicating a superior core stability. In the upper limb region both the wing and shoulder outline tests recorded practical significant differences between the school and junior club player groups as seen in Table 4.20 p. 135, correlating with recordings of Halbach & Tank (1990) and Kapandji (1970) with club players presenting with a better positional and core stability status. Lastly, neurodynamic results with regard to the SLR and the L3,4 prone knee bend recorded a practical significant difference between these groups, with values favouring the school players (closer to the ideal).

In summary, elite school rugby players outperformed the junior elite club players as far as dynamic testing was concerned. In general a more balanced dynamic mobility was measured overall (closer to the ideal). However, as far as core stability and regional position was concerned, the junior elite club players outperformed the school counterparts, being more symmetrical and better regarding position, especially in the pelvic girdle and shoulder regions. With these data it can be assumed that the physical and motor conditioning of the junior elite club player throughout the seasons contributed to a better positional core stability in certain areas when compared with elite school players. With the improvement of physical and motor performance, a decrease in dynamic mobility manifested itself among the junior elite club players, values recorded especially in the lower limb, spinal and neurodynamic regions were substantially higher and closer to the non-ideal.

5.2.4 Injury epidemiology according to injury history questionnaire

5.2.4.1 Elite school rugby player injury status

As can be seen in Table 4.21 p. 149 the majority of injuries for both the 15- and 18-year-old occurred among the forwards. Older research showed no practical significant differences between forward and back line players at school level, as reported by Davidson (1987). The possible reason for this tendency reported by Davidson (1987) *could* be the change in laws brought about in 1988 to control the fixed phases of the game and a second possible reason could be the evolution of the game towards open (general) play. Garraway & MaCleod (1995) also stated that the law changes are a possible reason for this tendency, which forced the game to be mostly played in the second and third phases.

If further subdivided, the loose forwards recorded the highest percentage of injuries for both the 15- and 18-year-old. This correlated with the recordings of Roux *et al.* (1987) who found loose forwards and the back line, with the exception of the scrum-half to be the most dangerous player positions. The player positions most at risk was that of the flanker among the 15-year-olds and lock and eighth man among the 18-year-olds. The anatomical region (Table 4.22 p. 150) most often injured for both the 15- and 18-year-olds was the lower limb. This differed from the recordings of Davidson (1987) who recorded that the head and neck, and Nathan *et al.* (1983) the upper limb, were the most commonly injured. This difference in regional injury presentation can be attributed to injury definition. Davidson (1987) recorded concussions, lacerations and headaches to the head-and-neck area due to trauma as injured. On the other hand, Roux *et al.* (1987) and Upton *et al.* (1996) similarly found the lower limb to be the most commonly injured. The most common recorded type of injury (Table 4.23 p. 151) was sprains for both the 15 and 18-year-old school rugby-playing groups, a finding differing from that of Upton *et al.* (1996), who recorded fractures and Nathan *et al.* (1983) who recorded concussions to be the most common injuries, but correlated with recordings of Roux *et al.* (1987). This difference in the types of injuries reported can again be attributed to the definition of injury, and changes in the game since the early 1980s.

5.2.4.2 Junior elite club rugby player injury status

The elite club rugby players reported the majority of previous injuries among the forwards. (See table 4.24 p. 152). These findings are supported by Gerrard *et al.* (1994) in the RIPP II study on club rugby players.

When further subdivided, loose forwards were the most common injured players among the 19- and 20-year-old junior elite club player groups. Player positions most at risk were those of the flanker and prop. This correlated with the recordings of Roy (1974), but differed somewhat from the work of O'Brien (1992), Clark *et al.* (1990) and Bird *et al.* (1998).

The anatomical region (Table 4.25 p. 152) most commonly injured for both the 19- and 20-year-olds was the lower limb. These findings correlated with the results reported by Bird *et al.* (1998) and O'Brien (1992) in their rugby injury epidemiology studies. The most common type (Table 4.26 p. 153) of injury reported among the elite club rugby players was sprains. Similar tendencies were reported by Gerrard *et al.* (1994), Bird *et al.* (1998) and more recently Holtzhausen *et al.* (2001) in their rugby Super 12 study.

5.2.4.3 Comparison between elite school and junior elite club rugby players (previous injury status)

For both elite school and junior elite club players the majority of injuries reported were among the forwards, and more particularly among the loose forwards with elite club players, recording a substantially higher percentage of injuries among this group. (See table 4.26). This tendency correlates well with the later studies on junior elite and club players where the evolution of the game manipulated play into the second and third phases. School groups reported the most often injured position to be either flankers, locks or eighth men, varying slightly from the junior elite club players, who reported flankers and props to be the most commonly injured. Both groups reported the lower limb area to be the most often injured anatomical sight, and more particularly the thigh and knee area. The most common type of injury reported was sprains. With open play, and more particularly the tackle, being classified as the most dangerous phase of play in modern rugby (Chapter 2 p. 7), both the regional anatomical area and the type of injury presenting has changed. Lower limb, and more particularly the thigh and knee area, are most at risk. The most common types of injury reported in modern rugby are now sprains and strains.

5.2.5 Institute sports medical clinic attendance record results

Through the 2002 season 19-year-old players reported a total of 258 and 20-year-old 293 injuries that could be classified as mild, moderate or severe, according to Lee and Garraway (1996). Of these injuries for the two age groups respectively, 45,4% and 38,4% were classified as of being the chronic or overuse type. The positions most often reported injured were the centres for the 19-year-olds and the prop and wing positions for the 20 year old group.

These results correlate partially with the injury history questionnaire findings, with Gerrard *et al* (1994) and with Targett (1998), but differ somewhat from the Holtzhausen (2001) study. Recordings by O'Brien (1992) and Holtzhausen *et al.* (2001) in the rugby Super 12 study correlate with the 19-year-old group results; however, Targett (1998) reported eighth men to be the highest at risk.

The anatomical region most often reported injured for both groups were the lower limb, correlating with the injury history questionnaire, Bird *et al.* (1998) and O'Brien (1992), and differing from Targett (1998), who found the head and facial region to be the most often injured.

When considering types of injuries the most common and often reported were strains, followed by sprains, a finding which correlates well with that of Clark *et al.* (1990). However, this differs from information reported by the injury history questionnaires and the works of Bird *et al.* (1998), and more recently Holtzhausen (2001), where sprains were the most commonly reported type of injury.

Period prevalence statistics showed the majority of reported injuries occurred during the period April to June for both the 19- and 20-year-old groups, correlating with the recordings of Clark *et al.* (1990) and Targett (1998). The most common grade of injury reported was mild, followed by moderate.

In both groups the majority of reported injuries occurred during match play, correlating well with the recordings of Holtzhausen (2001) reporting injuries as occurring mostly during match play and the rest during training. The majority of reported injuries occurred during open and general play for both freshmen and seasonal players. This correlated well with the recordings of Roux *et al.* (1987) (pre-1988 law changes) and Holtzhausen (2001).

Lastly, in both the freshmen and seasonal players the majority of injuries reported were acute, with the rest being chronic or of the overuse type. The acute injuries of the 19-year-old consisted of 55,6% and chronic overuse injuries of 45,4%. Seasonal 20-year-old players 61,7% acute and 38,3% of chronic overuse. This correlated partly with the work of Holtzhausen (2001) but differing in the sense that junior elite club players reported more than three times the number of chronic overuse injuries.

In summary, injuries reported by both the injury history questionnaire and the clinic attendance records correlated well with more recent rugby injury epidemiological studies. As seen and reported by modern literature with increasing age and level of competition an increase in injury incidence is reported, as discussed in depth in chapter 4. Clinic attendance records revealed a disturbing high percentage of the chronic overuse type. Anthropometric and physical and motor data reported a positive correlation with increasing age, thus with heavier, taller, faster, fitter, stronger and more agile players. Biomechanical and postural statistics on the other hand reported a negative correlation with dynamic mobility with increasing age. Fortunately a positive correlation with core stability was reported (especially in the upper limb region), and to a certain extent in the pelvic girdle regions.

Despite all positive anthropometric and physical and motor tendencies reported, biomechanical and postural findings revealed dynamic and postural shortcomings from the earliest age groups through to the most senior players. Only minor regional positional improvements were reported with increasing age. Dynamic mobility results revealed less mobile and thus more at-risk freshmen and senior players when compared with their school counterparts. This is supported by the percentage of chronic overuse injuries reported by the clinic attendance records.

These findings highlight the necessity for an injury prevention programme to be introduced at school level, not only to address anthropometric and physical and motor entities, but also biomechanical and postural status especially. By correct implementation the percentage of chronic overuse reported by junior elite club players can be addressed to bring them to more acceptable and controlled levels.

5.3 CONCLUSIONS

The aim of this study was to develop a prevention programme for rugby injuries, based on an analysis among adolescent players, with reference to anthropometric, physical and motor, and biomechanical and postural variables.

The aim of the prevention programme would be to address and improve the anthropometric, physical and motor, and biomechanical and postural standards of young school players, and to be introduced at an early school level to counteract the injury epidemiology.

According to the aim of this study, the following major conclusions can be made with reference to age-grouper status:

- *Anthropometric* testing for the *15-year-old* elite school group revealed data on body mass and body length which correlated well with earlier studies. However, the body fat percentage recorded by the elite school 15-year-old group was substantially higher than in other studies. Test results indicated that mean body mass and body length recorded on elite *18-year-old* school players correlated well with similar-aged international player groups. Body fat percentage recorded was substantially lower, and more specifically so when compared with English College players. Junior elite *19- and 20-year-old players* recorded no practically significant differences between their three testing episodes. Body mass, body length and body fat percentage recorded were similar, and correlated well with tendencies reported in other studies.

- *Physical and motor* testing results revealed superior values for the *15-year-old* elite school players as far as speed, agility and explosive power were concerned when compared with results in similar studies. The *18-year-old* elite school group recorded values which correlated well with earlier research findings. Data revealed a fitter player group, talented towards explosive power but slightly slower and less agile when compared with earlier studies.

  19 and 20-year-old junior elite club players recorded practical significant improvements in agility, horizontal jump and squat tests (19-year-old) and speed, aerobic, anaerobic (capacity) and maximum power throughout the season (20-year-old).

- *Biomechanical and postural.* In the *15-year-old* group recordings on dynamic testing revealed high values for the modified Thomas, gluteus maximus, TFL and SLR tests. These indicated a lack of mobility in the lower limb and spinal regions. Positionally the patella tilt, leg length discrepancy, ASIS, PSIS, rami and bilateral pelvic positional tests recorded high values, indicating asymmetry and the lack of core stability in the pelvic girdle region. Similarly, the shoulder positional, winging and shoulder outline tests indicate the same tendency in the upper limb region. *18-year-old* elite school players recorded very similar tendencies. Dynamically a lack of mobility in the lower limb and spinal regions were recorded. Furthermore, asymmetry in the pelvic girdle and shoulder regions indicate a lack of core stability and stabilizers in these areas. *19-year-old* elite club players, as with the earlier two age-groupers, recorded a lack of dynamic mobility in the lower limb and spinal regions. However a marginal improvement in core stability in the pelvic girdle and shoulder regions were recorded. Thus positionally these two regions were closer to the ideal. *20-year-old* junior elite club players, as with earlier age-groupers, recorded dynamic shortcomings in the lower limb areas. However, higher values were recorded for the Thomas, gluteus maximus, hip external rotation, patella tilt, toe positional and L3,4 prone knee bend tests. These indicate a decrease in dynamic mobility in the lower limb region with increasing age. Positionally all regions were substantially better positioned with an improvement in core stability.

5.4 SUMMARY ON COMPARISONS OF ELITE SCHOOL WITH ELITE CLUB RUGBY PLAYERS WITH REFERENCE TO ANTHROPOMETRIC, PHYSICAL AND MOTOR AND BIOMECHANICAL AND POSTURAL VARIABLES

Anthropometric data reported no practically significant difference between the two groups. However, junior elite club players were reported to be heavier, taller and with a lower body fat percentage.

Physical and motor data revealed a practically significant positive correlation as far as aerobic, anaerobic, power endurance and explosive power were concerned, when comparing elite school with junior elite club players. Data revealed a fitter, stronger and more agile player in the junior elite club category.

Biomechanical and postural data revealed a practically significant shortcoming in both dynamic mobility and core positional stability for both player groups (recorded values close to the non-ideal). 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 the junior elite club players.

In summary anthropometric and physical and motor data revealed a positive correlation with the development of rugby players. Biomechanical and postural data identified positional dynamic and core stability shortcomings in both player groups. Dynamic mobility regressed in the junior elite club players when compared with their school counterparts. The high chronic overuse type of injuries reported in conjunction with the poor biomechanical and postural findings necessitate the introduction of an injury prevention programme at school level for the 15-, 18-, 19- and 20-year-olds, as stated according to the aim of this study.

5.5 COMPILING OF AN INJURY PREVENTION PROGRAMME

5.5.1 Introduction

The results of this study revealed the following major shortcomings in school and club rugby players: regionally lower limb, spinal and neuronal regions lacking in dynamic mobility. These phenomena affect prime mover function and positional stability, and increase the risk and presentation of the overuse type injuries. Positionally the pelvic girdle, spinal and shoulder regions presented with poor core stability. Regional asymmetry presented due to strong immobile prime movers and a lack in stabilizer capabilities. Anthropometric and physical and motor tests revealed a marginal improvement in the 30 m dash and agility performances with increasing age, constituting one of the possible reasons why more specific attention should be given to improving these two entities.

5.5.2 Implementation

The modern rugby-playing season in the southern hemisphere for school players usually commences early March with a 2–3 week prior preparation phase. Most schools in late March, early April (during the Easter holiday period) have rugby training camps, with the competitive season in full swing starting the new term. The June-July holiday period allows players a short rest period, followed by the secondary competition rounds, as well as the identification and selection of provincial players. Most competitive schools are now playing rugby over a 6–7 month period.

5.5.3 Option 1 for institutes with gym facilities as well as the services of trained medical personnel and sports scientists for elite school and junior elite club players

5.5.3.1 Pre-season testing

Tests are done in the 2–3 week period (pre-season preparation phase) before arranging the first rugby games in March.

Battery of tests for determining anthropometric, physical and motor and biomechanical and postural status:

Anthropometric variables:

- Body mass
- Body length
- Skinfold measurements (body fat percentage)

(As documented in Chapter 3 p. 59)

Physical and motor variables:

- Speed over time over a 30 m distance
- Illinois Agility test
- Vertical jump
- Horizontal jump
- Abdominal curls
- Pull-ups
- Bench press
- Squat
- Bleep test
- Speed endurance test

Biomechanical and postural variables: Dynamic mobility and positional core stability are identified in the following regions: lower limb, pelvic girdle, spinal region, upper limb and neuronal. For detailed description of battery of tests see page 62.

5.5.3.2 Pre-season programme (2-week period)

Each individual player is now issued with a personalized biomechanical and physical and motor programme, then briefed and instructed by the *medical personnel on* the various regional shortcomings and how to overcome these potential hazards. Programmes are followed intensely at home over the following 2-week period. (See Annexure 5.1 p. 210)

5.5.3.3 Start-of–season programme

A standardized maintenance biomechanical and physical and motor protocol for adolescent rugby players will be followed to the mid-season break June-July. Starting with level 1, and after 6 weeks progressing to a more advanced level 2. (See Annexure 5.2 p. 223 and 5.3 p. 234)

5.5.3.4 Mid-season programme

During the break (June-July) test batteries as implemented in the pre-season phase will be repeated and individual conditioning adapted accordingly. Biomechanical and physical and motor shortcomings once again identified and programmes adjusted for a 1-week period, whereafter level 3 (most advanced) will be implemented according to known adolescent norms, and followed till the end of the season. (See Annexure 5.4 p. 246 and 5.5 p. 261)

5.5.3.5 Off-season programme

This standard biomechanical and physical and motor low key programme will be implemented during the off-season period. Dynamic mobility as well as core stability excercises will concentrate on already identified shortcomings within these age-groupers. Programme to be followed up to the start of pre-season. (See Annexure 5.6 p. 272)

5.5.4 Option 2 for schools without the services of trained medical personnel and sport scientists

5.5.4.1 Pre-season testing

Tests are done and performed by school coaches in the 2–3 week period (pre-season preparation phase) before arranging the first rugby games in March.

Battery of tests for determining anthropometric and physical and motor variables:

A battery of tests for anthropometric and physical and motor variables will be performed. The coaching personnel are to refer to norms of this study as depicted in Tables 4.1 p. 91 and 4.3 p. 96. These norms will give the coach a good idea of the standard of his players. Players will not be submitted to biomechanical and postural evaluations, due to a lack of expertise.

Anthropometric variables

- Body mass
- Body length
- Skinfold measurements (Body fat percentage)

(As documented in Chapter 3 p. 59)

Physical and motor abilities:

- Speed over time over a 30 m distance
- Illinois Agility test
- Vertical jump
- Horizontal jump
- Abdominal curls
- Pull-ups
- Bench press
- Squat
- Bleep test
- Speed endurance test

5.5.4.2 Pre-season programme (2-week period)

According to battery tests results, coaching personnel can now plan pre- and start-of-season rugby-specific preparation. A pre-prepared biomechanical and physical and motor pre-season (norm) programme is now explained and demonstrated to all players.

This programme is followed intensely for a 2-week period in the pre-season phase (5 times per week). (See annexure 5.1 p. 210)

5.5.4.3 Start-of-season programme

With the commencement of the first rugby games, all players now start with the level 1 biomechanical and physical and motor maintenance programme. This is followed for a 6-week period, after which all participants advance to the level 2 programme, which should be followed up to the mid-season break period. (See annexure 5.2 p. 223 and 5.3 p. 234)

5.5.4.4 Mid-season programme

As with the pre-season programme, coaching personnel now repeat anthropometric and physical and motor testing as discussed in the pre-season programme. Once again, according to results, the preparation is planned for the rest of the season. In the break period all players are re-introduced to an intense 1-week (5 days) pre-prepared biomechanical and physical and motor programme, whereafter participants are advanced on to the level 3 maintenance programme, where they are kept until the end of the season. (See annexure 5.4 p. 246 and 5.5 p. 261)

5.5.4.5 Off-season programme

This standard biomechanical and physical and motor low key programme will be implemented during the off-season period. Dynamic mobility as well as core stability excercises will concentrate on already identified shortcomings within these age-groupers. Programme to be followed up to the start of pre-season. (See annexure 5.6 p. 272)

5.6 RECOMMENDATIONS

For a reduction in chronic overuse injuries, it is recommended that school coaches *implement* the prevention programme as suggested in Annexures 5.1 and 5.6. Starting in the pre-season phase, identifying certain shortcomings in player groups and progressing throughout the player season, with the main aim to address and reduce chronic overuse injuries.

5.6.1 **Prevention programme for elite school rugby players** with gym facilities, trained medical personnel and sport scientists at their disposal. Anthropometric characteristics, physical and motor abilities, and biomechanical and postural variables are tested pre-season (mid-February) and mid-season break (June–July).

5.6.2 The sports scientist designs **conditioning programmes** according to findings under anthropometric, physical and motor status. Biomechanical and postural programmes are developed according to individual player status by the medical personnel.

5.6.3 Players are submitted to their intense **individual programme** for a 2-week period (pre-season). With the commencement of the first rugby games a maintenance programme (level 1) (Annexure 5.2) is introduced for a 6 week period, followed by a more advanced (level 2) (Annexure 5.3) programme up to the mid-season break.

5.6.4 Pre-season batteries of tests are repeated and conditioning adapted and planned according to results (sport scientists). Biomechanical and postural variables are retested (medical personnel), whereby players are then exposed to their **adapted one week individual programme**. (Annexure 5.4)

5.6.5 Finally, level 3 is introduced (Annexure 5.5), an **advanced-norm programme**, to be followed until the end of the season.

5.6.6 **Off-season programme** for players to be followed till start of pre-season. (Annexure 5.6)

5.6.7 **Players with coaches only** to follow programme as described in Annexures 5.1– 5.6.

5.6.8 Shortcomings of this study

5.6.8.1 The elite school group, due to *geological* representation and a short competitive season, could only be tested on one occasion for anthropometric characteristics, physical and motor abilities and biomechanical and postural variables. The ideal would be at least 2 testing episodes for anthropometric characteristics, physical and motor abilities, and biomechanical and postural variables. Testing episodes should be done at least pre- and mid-season to allow ample time for preparation and adaptation.

5.6.8.2 For the same reasons as mentioned in the above paragraph, elite school groups could not attend Institute sports-medical *clinics* throughout the season. Valuable data and comparisons which could have been collected, were not obtained. A possible solution for this problem might be for medical and assistant personnel to run clinics and do testing on location, by travelling.

5.6.8.3 All competitive rugby-playing schools should at least attempt to have their A-teams *tested* twice per year, not once, as was the case with this study. Twice testing will enable the coaching personnel to evaluate the programmes used, and to do the necessary adaptations.

5.6.9 Recommendations for further study

5.6.9.1 Biomechanical and postural data

For the first time in the rugby-playing population this exact battery of tests was implemented to identify dynamic and positional shortcomings in player groups. Although used over a large proportion of the junior rugby-playing population, it would be to the advantage of science to have similar studies repeated in the different age groups to identify specific dynamic and positional norms and characteristics of the various player groups.

5.6.9.2 Biomechanical programmes

The implementation of these programmes as suggested in option 1 or 2 can be validated as far as dynamic mobility, positional core stability and lastly their effect especially on the chronic overuse injuries in the course of a playing season are concerned. Once these effects have been analysed adaptations to current programmes can be made, if necessary.

ADDLEY, K. & FARREN, J. 1988. Irish rugby injury survey: Dungannon football club (1986-87). *British journal of sports medicine,* 22(1):22-24, Mar. 1.

ALSOP, J.C., CHALMERS, D.J., WILLIAMS, S.M., QUARRIE, K.L., MARSHALL, S.W. & SHARPIES, K.J. 2000. Temporal patterns of injury during rugby season. *Journal of science and medicine in sport*, 3(2):97-109, Jun.

ANON. 2002. Healthy living exercises / squat. 5 p. [Web:] http://www.funtime.demon.co.uk /exercise/squat.html [Date of access: 18 Nov. 2002]

ARNHEIM, D.D. & PRETENCE, W.E. 2000. Principles of athletic training. 10th ed. Boston, Mass. : McGraw Hill. 868 p.

BABIC, Z., MISIGOJ-DURAKOVIC, M., MATASIC, H., JANCIC, J. 2001. Croatian rugby project, pt. 2: injuries. *Journal of sports medicine and physical fitness,* 41(3):392-398, Sept.

BADENHORST, E. 1998. 'n Keuringsmodel vir talentidentifisering by 16-jarige sokkerspelers. Potchefstroom : PU vir CHO. (Verhandeling - M.Sc.) 101 p.

BADLEY, B.W.D. 1990. Rugby football injuries in Canada. (*In:* Micheli, L.J. & Jenkins, M.D., (*eds.*) Preventing rugby injuries: proceedings of the International Conference on Rugby Injuries. Boston, Mass : U.S. Rugby Football Foundation. p. 1-7.)

BATHGATE, A., BEST, J.P., CRAIG, G. & JAMIESON, M. 2002. A prospective study of injuries to elite Australian rugby union players. *British journal of sports medicine*, 36(4):265-269, Aug.

BIRD, Y.N., WALLER, A.E., MARSHALL, S.W., ALSOP, J.C., CHALMERS, D.J. & GERRARD, D.F. 1998. The New Zealand rugby injury and performance, project V: epidemiology of a season of rugby injury. *British journal of sports medicine,* 32(4):319-325, Dec.

BIOFITNESS SYSTEMS INC. 2002. Bench press, chest & shoulders & arms (beginner/advanced/spotters) 1 p. [Web:] http://www.biofitness.com/demo10.html [Date of access: 18 Nov. 2002].

BLOOMFIELD, J., ACLAND, T.R. & ELLIOT, B.C. 1994. Applied anatomy and biomechanics in sport. London : Blackwell Scientific Publications. 257 p.

BOTTINI, E., POGGI, E.J.T., LUZURIAGA, F. & SECIN, F.P. 2000. Incidence and nature of the most common rugby injuries sustained in Argentina (1991-1997). *British journal of sports medicine*, 34(2):94-97, Apr.

BREWER, J., RAMSBOTTOM, R. & WILLIAMS, C. 1988. Multistage fitness test: a progressive shuttle run test for the prediction of maximum uptake. Leeds : National Coachong Foundation. 21 p.

BRUNER, P. & KHAN, K. 2000. Clinical sports medicine. 2nd ed. New York : McGraw Hill. 820 p.

BURRY, H.C. & GOWLAND, H. 1981. Cervical injury in rugby football: a New Zealand survey. *British journal of sports medicine,* 15(1):56-59, Mar.

BUTLER, D.S. 1991. Mobilisation of the nervous system. Melbourne : Churchill Livingstone. 265 p.

CARLSON, B.R., CARTER, J.E., PATTERSON, P., PETTI, K., ORFANOS, M.S. & NOFFAL, G.J. 1994. Physique and motor performance characteristics of US national rugby players. *Journal of sport sciences*, (12):403-412.

CLARK, D.R., ROUX, C. & NOAKES, T.D. 1990. A prospective study of the incidence and nature of injuries to adult rugby players. *South African medical journal,* 77:559-562, Jun. 2.

DAVIDSON, R.M. 1987. Schoolboy rugby injuries, 1969-1986. *Medical journal of Australia*, 147(3):119-120, Aug. 3.

DAVIES, J.E. & GIBSON, T. 1978. Injuries in Rugby Union football. *British medical journal,* 2(6154):1759-1761, Dec. 23.

DERMAN, W. & SCHWELLNUS, M. 2001. Current trends in sports medicine, pt. 3: practical sports medicine. (*In:* South African Sports Medicine Association. Current trends in sports medicine. Papers read at the 9th biennial congress of SASMA held in Johannesburg on 6th to 8th September 2001.)

EDGAR, M. 1995. Tackling rugby injuries. *Lancet*, 345(8963):1452-1453, Jun. 10.

GARRAWAY, M. & MACLEOD, D. 1995. Epidemiology of rugby football injuries. *Lancet*, 345(8963):1485-1487, Jun. 10

GARRAWAY, W.M., LEE, A.J., HUTTON, S.J., RUSSELL, E.B.A.W. & MACLEOD, D.A.D. 2000. Impact of professionalism on injuries in rugby union. *British journal of sports medicine*, 34(5):348-351, Oct.

GERRARD, D.F., WALLER, A.E. & BIRD, Y.N. 1994. The New Zealand rugby injury and performance project, II: previous injury experience of a rugby-playing cohort. *British journal of sports medicine,* 28(4):229-233.

GILLEARD, W., MCCONNELL, J. & PARSONS, D. 1998. The effect of patellar taping on the onset of vastus medialis obliquus and vastus lateralis muscle activity in persons with patella femoral pain. *Physical therapy*, 78:25-32.

GISSANE, C., JENNINGS, D., KERR, K. & WHITE, J.A. 2002. A pooled data analysis of injury incidence in rugby league football. *Sports medicine*, 32(3):211-216.

GOULD III, J.A. 1990. The spine. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : Mosby. p. 523-552.)

HALBACH, J.W. & TANK, R.T. 1990. The shoulder. (*In:* Gould III, J.A., (*ed).* Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : Mosby. p. 483-521.)

HARE, E. 1999. Longitudinale studie van talentvolle jeugrugbyspelers met verwysing na vaardigheid, groei en ontwikkeling. Potchefstroom : PU vir CHO. (Proefskrif - Ph.D.) 152 p.

HAZELDINE, R. & McNAB, T. 1998. The Rugby Football Union guide to fitness for rugby. London : A & C Black. 134 p.

HAZELDINE, R., & McNAB, T. 1999. Fit for rugby. London : Kingswood Press. 127 p.

HOLTZHAUSEN, L.J. 2001. The epidemiology of injuries in professional Rugby Union in South Africa. Cape Town : UCT. (Dissertation - M.Phil.) 120 p.

HOLTZHAUSEN, L.J., SCHWELLNUS, M.P., JAKOET, I. & PRETORIUS, A.L. 2001. The incidence and nature of injuries in South African rugby players during the 1999 rugby Super 12 competition. (*In:* Holtzhausen, L.J., (*ed*). The epidemiology of injuries in professional rugby union in South Africa. Cape Town : UCT. (Dissertation - M.Phil.) p. 70-106.)

HOPPENFELD, S. 1976. Physical examination of the spine and extremities. New York : Appleton-Century-Crofts. 276 p.

HOSKINS, T. 1979. Rugby injuries to the cervical spine in English schoolboys. *Practitioner*, 223(1335):365-366, Sept.

HUGHES, D.C. & FRICKER, P.A. 1994. A prospective survey of injuries to first-grade rugby union players. *Clinical journal of sports medicine*, 4(4):249-56.

HUNT, G.C. 1990. Examination of lower-extremity dysfunction. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : C.V. Mosby . p. 395-421.)

JAKOET, I. 2002. Contrast injuries in schoolboys rugby. (*In:* South African Sports Medicine Association. Papers read at the SASMA congress held in Johannesburg in 2002.)

JAKOET, I. & NOAKES, T.D. 1998. A high rate of injury during the 1995 rugby world cup. *South African medical journal*, 88(1):45-47, Jan.

KAPANDJI, I.A. 1970. Philosophy of the joints: annotated diagrams of the mechanics of the human joints, v. 1: upper limbs. Edinburgh : Churchill Livingstone.

KAPANDJI, I.A. 1970. Philosophy of the joints: annotated diagrams of the mechanics of the human joints,, v. 2: lower limb. Edinburgh : Churchill Livingstone.

KAPANDJI, I.A. 1974. Philosophy of the joints: annotated diagrams of the mechanics of the human joints,, v. 3: the trunk and vertebral column. 2nd ed. Edinburgh : Churchill Livingstone. 251 p.

KIRBY, R.F., *ed*. 1991. Kirby's guide to fitness and motor performance tests. Cape Girardeau , Mo.: Ben Oak . . 458 p.

LEE, A.J. & GARRAWAY, W.M. 1996. Epidemiological comparison of injuries in school and senior club rugby. *British journal of sports medicine*, 30(3):213-217, Sept.

LEE, A.J. & GARRAWAY, W.M. 2000. The influence of environmental factors on rugby football injuries. *Journal of sports sciences,* 18(2):91-95, Feb.

LEE, A.J., GARRAWAY, W.M. & ARNEIL, D.W. 2001. Influence of preseason training, fitness, and existing injury on subsequent rugby injury. *British journal of sports medicine*, 35(6):412-417, Dec.

LEGER, L.A. & LAMBERT, J. 1982. A multistage 20 m shuttle run test to predict VO^2max. *European journal of applied physiology*, 49:141-145.

MALAN, D.D.J. & HANEKOM, A.J. 2001. Anthropometric, physical and skill characteristics of young rugby players in the North-West province. *African journal for physical health education, recreation and dance,* 7(1):14-22, Apr.

MAUD, P.J. & SCHULTZ, B.B. 1984. The US national rugby team: a physiological and anthropometrical assessment. *Physician and sportsmedicine,* 12(1):86-94.

MAYES, R. & NUTTALL, F.E 1995. A comparison of the physiological characteristics of senior and 20-year-old elite rugby union players. *British journal of sports medicine*, 10: 209 -216.

McARDLE, W.D., KATCH, F.I. & KATCH, V.L. 1991. Exercise physiology: energy, nutrition and human performance. 3rd ed. Philadelphia : Lea & Ferbiger. 853 p.

McCONNELL, J., 1986. The management of chondromalacia patellae: a long term solution. *Australian journal of physiology,* 32:215-223.

McCONNELL, J. 1999. Invited commentary. *Journal orthophedic sports physical therapy*, 29:388-90.

McPOIL, T.G. & BROCATO, R.S. 1990. The foot and ankle: biomechanical evaluation and treatment. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo.: C.V. Mosby. p. 293-321.)

MICHELI, L.J. & RISEBOROUGH, E.M. 1974. Incidence of injuries in rugby football. *Journal of sports medicine,* 2(2)93-98, Mar./Apr.

MULLIN, M.J. 1999. Common shoulder injuries among athletes: evaluation & management. (*In:* Research techniques for orthopaedics. San Fricisco, Calif. : The Stone Clinic and The Stone Foundation. 7 p. [Web:] http://stoneclinic.com/shoulder.htm [Date of access: 12 June 1999].

MYERS, P.T. 1980. Injuries presenting from rugby union football. *Medical journal of Australia,* 2:17-20, Jul. 12.

NATHAN, M., GOEDEKE, R. & NOAKES, T.D. 1983. The incidence and nature of rugby injuries experienced at one school during the 1982 rugby season. *South African medical journal,* 64(4):132-137, Jul. 23.

NICHOLAS, C.W. & BAKER, J.S. 1995. Anthropometric and physiological characteristics of first- and second-class rugby union players. *Journal of sports science*, 13:15.

NOAKES, T.D. & DU PLESSIS, M. 1996. Rugby without risk: a practical guide to the prevention and treatment of rugby injuries. Pretoria : Van Schaik. 363 p.

NOAKES, T.D., JAKOET, I. & BAALBERGEN, E. 1999. An apparent reduction in the incidence and severity of spinal cord injuries in schoolboy rugby players in the Western Cape since 1990. *South African medical journal*, 89(5):540-545, May.

NORTON, K.I., OLD, T.S., OLIVE, S.C. & CRAIG, N.P. 1996. Anthropometry and sport performance. (*In:* Norton, K.I. & Olds, T.S., (*eds*). Anthropometrica: a textbook of body measurements for sports and health courses. Marrickville, NSW : Southwood Press. p. 287-364.)

O'BRIEN, C. 1992. Retrospective survey of rugby injuries in the Leinster province of Ireland, 1987-1989. *British journal of sport medicine*, 26(4):243-244.

O'CONNELL, T.C.J. 1954. Rugby football injuries and their prevention: a review of 600 cases. *Journal of the Irish medical association,* 34:20-26.

ORCHARD, J. & SEWARD, H. 2002. Epidemiology of injuries in the Australian Football league, seasons 1997-2000. *British journal of sports medicine*, 36(1):39-45, Feb.

PEERS, A.V. 1994. Positive or negative X-axis rotation of the innominate as a cause of a functional leg length inequality. Durban : Technikon Natal. (Dissertation - Magister's Diploma in Technology.) 84 p.

PIENAAR, A.E., SPAMER, E.J. & PRETORIUS, J.H. 2000. Veranderlikes wat onderskei tussen suksesvolle en minder suksesvolle tienjarige rugbyspelers in geselekteerde spelspesifieke posisies. *South African journal for research sport, physical aducation and recreation,* 22(2):23-35.

PORTERFIELD, J.A. & DEROSA, C. 1990. The sacroiliac joint. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : C.V. Mosby. p. 553-573.)

QUARRIE, K.L., ALSOP, J.C., WALLER, A.E., BIRD, Y.N., MARSHALL, S.W. & CHALMERS, D.J. 2001. The New Zealand rugby injury and performance project, VI: a prospective cohort study of risk factors for injury in rugby union football. *British journal of sports medicine*, 35(3):157-166, Jun.

RAMSBOTTOM, R., BREWER, J. & WILLIAMS, C. 1988. A progressive Shuttle run test to estimate maximal oxygen uptake. *British journal of sports medicine*, 22:141-145.

ROCABACO, M. 2000. Lumbar spine and pelvic girdle, v. 4: workbook. Santiago, Chile : Integramedica. 66 p.

ROSS, W.D. & MARFELL-JONES, M.J. 1991. Kinanthropometry. (*In*: McDougall, J.D., Wenger, H.A. & Green, H.J., (*eds*) . Physiological testing of the high performance athlete. Champaign, Ill. : Human Kinetics. p.223-308.)

ROUX, C.E., GOEDEKE, R., VISSER, G.R., VAN ZYL, W.A. & NOAKES, T.D. 1987. The epidemiology of schoolboy rugby injuries. *South African medical journal*, 71(5):307-313, Mar. 7.

ROY, S.P. 1974. The nature and frequency of rugby injuries: a pilot study of 300 injuries at Stellenbosch. *South African medical journal*, 48(56):2321-2327, Nov. 16.

SAS INSTITUTE. 1985. SAS's user guide: statistics. 5th ed. Raleigh, N.C. : SAS Institute Inc. 956 p.

SAUDEK, C.E. 1990. The hip. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : C.V. Mosby. p. 347-394.)

SAUNDERS, H.D. 1990. Evaluation of a musculoskeletal disorder. (*In:* Gould III, J.A., (ed). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : C.V. Mosby. p. 169-180.)

SCHER, A.T. 1977. Rugby injuries to the cervical spinal cord. *South African medical journal*, 51(14):473-475, Apr. 2.

SCHER, A.T. 1991. Catastrophic rugby injuries of the spinal cord: changing patterns of injury. *British journal of sports medicine,* 25(1):57-60.

SPAMER, E.J. & WINSLEY, R. 2003. Comparative characteristics of elite English and South African 18-year-old rugby-players with reference to game-specific skills, physical abilities and anthropometric. *Journal of human movement studies,*

SPARKS, J.P. 1985. Rugby football injuries, 1980-1983. *British journal of sports medicine,* 19(2):71-75.

STUART, M.J., MORREY, M.A., SMITH, A.M., MEIS, J.K. & ORTIGUERA, C.J. 2002. Injuries in youth football: a prospective observational cohort analysis among players aged 9 to 13 years. *Mayo clinic proceedings*, 77(4):317-322, Apr.

TARGETT, S.G.R. 1998. Injuries in professional rugby union. *Clinical journal of sport medicine; official journal of the Canadian Academy of Sport Medicine*, 8(4):280-285, Oct.

THOMAS, J.R. & NELSON, J.K. 1985. Introduction to research in health, physical education, recreation and dance. Champaign, Ill. : Human Kinetics Publishers. 414 p.

TORG, J.S., VEGSO, J.J., O'NEILL, M.J. & SENNETT, B. 1990. The epidemiologic, pathologic, and cinematographic analysis of football-induced cervical spine trauma. *American journal of sports medicine*, 18(1):50-57.

TURNBULL, R., COETZEE, D. & MCDONALD, T. 1995. Rugby fitness testing and training: a scientific approach for coaches, fitness trainers and players. [Scottsville : R. Turnbull]. 116 p.

UPTON, P.A.H., ROUX, C.E. & NOAKES, T.D. 1996. Inadequate pre-season preparation of schoolboy rugby players: a survey of players at 25 Cape Province high schools. *South African medical journal,* 86(5):531-533, May.

WALKDEN, L. 1975. The medical hazards of rugby football. *Practitioner,* 215:201-207, Aug.

WALLACE, L.A, MANGINE, R.E. & MALONE, T.R. 1990. The knee. (*In:* Gould III, J.A., (*ed*). Orthopaedic and sports physical therapy. 2nd ed. St. Louis, Mo. : C.V. Mosby. p. 323-345.)

WARWICK, R. & WILLIAMS, P.L. 1973. Gray's anatomy. 35th ed. Edinburgh : Longman. 1471 p.

WATSON, A.W.S. 2002. Sports injuries related to flexibility, posture, acceleration, clinical defects, and previous injury, in high level players of body contact sports. *International journal of sports medicine*, 22(3):222-225, Apr.

WEIGHTMAN, D. & BROWNE, R.C. 1974. Injuries in association and rugby football. *British journal of sports medicine,* 2:183-187.

WEKESA, M., ASEMBO, J.M. & NJORORAI, W.W.S. 1996. Injury surveillance in a rugby tournament. *British journal of sports medicine*, 30:61-63.

WILSON, A. 2000. Playing a dangerous game. *Guardian unlimited observer.* (No further info available.)

WILSON, B.D., QUARRIE, K.L., MILBURN, P.D. & CHALMERS, D.J. 1999. The nature and circumstances of tackle injuries in rugby union. *Journal of science and medicine in sport*, 2(2):153-162, Jun.

ANNEXURE 3.1

RUGBY EPIDIMIOLOGY QUESTIONAIRE

*DATE*_______________ *TEAM/LEVEL*____

*FULL NAMES*____ *AGE*_______________

*DATE OF BIRTH*__________________ *PLAY POSITION*______________________________

*POSTAL ADDRESS*____

*CONTACT NUMBERS*____

CURRENT AND PREVIOUS INJURIES

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

NO	***Injury***	
	Diagnose	
	Date	
	Treatment	
	Complete recovery	
	Doctor/Physio	
NO	***Injury***	
	Diagnose	
	Date	
	Treatment	
	Complete recovery	
	Doctor/Physio	
NO	***Injury***	
	Diagnosis	
	Date	
	Treatment	
	Complete recovery	
	Doctor/Physio	

DO YOU STRAP ANY OF THE FOLLOWING:

ANATOMICAL REGION	DURING GAME	DURING TRAINING	REMARKS
Ears	Yes/no	Yes/no	
Shoulder left/right	Yes/no	Yes/no	
Elbow left/right	Yes/no	Yes/no	
Wrist left/right	Yes/no	Yes/no	
Fingers	Yes/no	Yes/no	
Upper limb	Yes/no	Yes/no	
Knee	Yes/no	Yes/no	
Ankle	Yes/no	Yes/no	
Any other – please specify	Yes/no	Yes/no	

ANNEXURE 3.2

RUGBY INSTITUTE MEDICAL CLINIC QUESTIONAIRE

CLINIC DATE______________________________

NAME____

POSITION________________________________AGE GROUP_________________

ANATOMICAL REGION INJURED_______________________________________

INJURY OCCURRED DURING MATCH___________ TRAINING_____________

INJURY OCCURRED DURING PHASE: FIXED PLAY_____ OPEN PLAY_____

INJURY ACUTE _____ OR CHRONIC_____

TIME OF TRAINING______________________OF GAME___________________

DIAGNOSIS____

REFERRED TO :

DOCTOR SPECIAL TESTS AND/OR MEDICATION_________________________

____

PHYSIOTHERAPIST____

BIOKINETISIST SPECIAL TESTS___________________________________

SPORTS SCIENTIST____

REVISIT____

COMMENTS____

____

ANNEXURE 3.3

BIOMECHANICAL ASSESSMENT FORM

GROUP	*DATE*

PERSONAL INFORMATION

NAME		AGE	WEIGHT	LENGTH
SPORT TEAM LEVEL				

DOMINANT HAND	LEFT / RIGHT	**DOMINANT FOOT**	LEFT / RIGHT
POSITION			

MEDICAL HISTORY

PRESENT	**PAST**

BIOMECHANICS

LOWER LIMB

AREA	**GRADE**						**GRADE DETAIL**
	L	**R**	**L**	**R**	**L**	**R**	
TA	*1*	*1*	*2*	*2*	*3*	*3*	*1*:30° + / *2*:20° - 30° / *3*:20° -
ITB	*1*	*1*	*2*	*2*	*3*	*3*	*1*:12H00 / *2:11H55 or 12H05* / *3*:11H50 or 12H10
QUAD	*1*	*1*	*2*	*2*	*3*	*3*	*1*:50° + / *2:30° - 50°* / *3*:30° -
ILIOPSOAS	*1*	*1*	*2*	*2*	*3*	*3*	*1*:30° + / *2:15° - 30°* / *3*:15° -
GLUT MUSCLES	*1*	*1*	*2*	*2*	*3*	*3*	*1*:90° + / *2:60° - 90°* / *3*:60° -
ADDUCTOR	*1*		*2*		*3*		*1*:120° + / *2:100° - 120°* / *3*:100° -
HIP INTERN ROT	*1*	*1*	*2*	*2*	*3*	*3*	*1*:30° + / *2:15° - 30°* / *3*:15° -
HIP EXT ROT	*1*	*1*	*2*	*2*	*3*	*3*	*1*:90° + / *2:60° - 90°* / *3*:60° -
KNEE Q-ANGLE	*1*	*1*	*2*	*2*			*1*:9° - / *2:9° +*
KNEE SQUINT	*1*	*1*	*2*	*2*			*1*:9° - / *2:9° +*
KNEE TILT	*1*	*1*	*2*	*2*			*1*:0° / *2:0° +*
KNEE HEIGHT	*1*	*1*	*2*	*2*			*1*: Normal / *2:Anomalies*
VMO	*1*	*1*	*2*	*2*			*1*: Normal / *2:Anomalies*

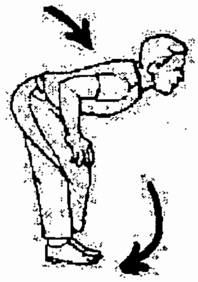
AREA	GRADE						GRADE DETAIL
	L	R	L	R	L	R	
Detail Anomalies:							
FOOT LONGITUDINAL	*1*	*1*	*2*	*2*	*3*	*3*	*1*: Flat / *2*: Normal / *3*: High
FORE FOOT	*1*	*1*	*2*	*2*			*1*: Normal / *2*: Anomalies
Detail Anomalies:							
REAR FOOT STANDING	*1*	*1*	*2*	*2*	*3*	*3*	*1*: 0° - 9 / *2*: 0° - / *3*: 9° +
REAR FOOT LYING	*1*	*1*	*2*	*2*	*3*	*3*	*1*: 0° -9° / *2*: 0° - / *3*: 9° +
TRANSVERSE	*1*	*1*	*2*	*2*			*1*: Normal / *2*: Flat
MOBILITY	*1*	*1*	*2*	*2*	*3*	*3*	*1*: Hyper / *2*: Normal / *3*: Rigid
TOES	*1*	*1*	*2*	*2*			*1*: Normal / *2*: Anomalies
Detail Anomalies:							
PELVIC GIRDLE							
LEG LENGTH	*1*	*1*	*2*	*2*	*3*	*3*	*1*: Left=Right / *2*: 1 cm discrepancy / *3*: 1 cm+ discrepancy
ASIS	*1*	*1*	*2*	*2*			*1*: Left=Right / *2*: Discrepancy
PSIS	*1*	*1*	*2*	*2*			*1*: Left=Right / *2*: Discrepancy
RAMI	*1*	*1*	*2*	*2*			*1*: Left=Right / *2*: Discrepancy
CLEFT	*1*	*1*	*2*	*2*			*1*: Left=Right / *2*: Discrepancy
PELVIS BILATERAL POSITION	*1*		*2*		*3*		*1*: 2 - 3 cm / *2*: 3 - 5 cm / *3*: 5 cm +
SPINAL							
THORACO LUMB FASCIA	*1*	*1*	*2*	*2*	*3*	*3*	*1*: 2 cm / *2*: 4 cm / *3*: 4 cm +
SACRUM RHYTHM	*1*	*1*	*2*	*2*			*1*: Left=Right / *2*: Aberrant
EXTENSION	*1*		*2*		*3*		*1*: Easy ROM / *2*: Limited ROM / *3*: Hyper
FLEXION	*1*		*2*		*3*		*1*: Easy ROM / *2*: Limited ROM / *3*: Hyper
ROTATION	*1*	*1*	*2*	*2*	*3*	*3*	*1*: Easy ROM / *2*: Limited ROM / *3*: Hyper
SIDE FLEXION	*1*	*1*	*2*	*2*	*3*	*3*	*1*: Easy ROM / *2*: Limited ROM / *3*: Hyper

AREA	GRADE						GRADE DETAIL
	L	R	L	R	L	R	
CORONAL MID							
HEAD POSITION	*1*		*2*				*1*: Normal / *2*: Anomalies
CERVICAL	*1*		*2*				*1*: Normal / *2*: Anomalies
THORASIC	*1*		*2*				*1*: Normal / *2*: Anomalies
LUMBAR	*1*		*2*				*1*: Normal / *2*: Anomalies
Detail Anomalies:							
SAGITAL MID							
HEAD POSITION	*1*		*2*				*1*: Normal / *2*: Anomalies
CERVICAL	*1*		*2*				*1*: Normal / *2*: Anomalies
THORACIC	*1*		*2*				*1*: Normal / *2*: Anomalies
LUMBAR	*1*		*2*				*1*: Normal / *2*: Anomalies
Detail Anomalies:							
UPPER LIMB – SHOULDER							
HAND BEHIND BACK	*1*	*1*	*2*	*2*	*3*	*3*	*1*:Left=Right / *2*: 4 cm - / *3*: 4 cm +
HAND BEHIND NECK	*1*	*1*	*2*	*2*	*3*	*3*	*1*:Left=Right / *2*: 4 cm - / *3*: 4 cm +
SHOULDER POSITION	*1*	*1*	*2*	*2*			*1*: Neutral / *2*: Two thirds +
WINGING	*1*	*1*	*2*	*2*			*1*:None / *2*: Winging
OUTLINE	*1*	*1*	*2*	*2*			*1*:Muscular / *2*: Bony
THROWING POSITION	*1*	*1*	*2*	*2*			*1*:Coronal mid + / *2*: Coronal mid -
NEUROLOGICAL							
STRAIGHT LEG RAISE	*1*	*1*	*2*	*2*	*3*	*3*	*1*:90° + / *2*: 70° + / *3*: 70° -
UPPER LIMB TENSION TEST	*1*	*1*	*2*	*2*	*3*	*3*	*1*:180° - 0° No tension / *2*: 180° - 0° With tension / *3*: 180° - 0° +
L4	*1*	*1*	*2*	*2*	*3*	*3*	*1*:Full ROM No tension / *2*: Full ROM with tension / *3*: Not touching
SLUMP	*1*	*1*	*2*	*2*	*3*	*3*	*1*:Full ROM;With Dorsi Flex; No tension / *2*: Full ROM;With Dorsi Flex;With tension / *3*: Limited ROM with tension
COMMENTS							

ANNEXURE 5.1

PRE-SEASON PREPARATION PROGRAMME

This intense 10-day programme should be followed over a 2-week period to address dynamic mobility and specific positional core stability shortcomings. Each exercise should be done as graphically displayed and described. If uncertain, ask your coach/trainer.

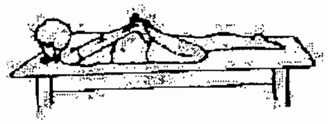


1. Stand bearing most of your weight on your L/R leg
2. Cross the other leg in front as shown
3. Lean forward, bending at the hip and keeping your back straight
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.1 : Lower limb:

1. Stand with L/R side facing wall
2. Cross the other leg behind the other leg and toward the wall
3. Twist trunk toward the wall, using hands for support as shown
4. Bend the forward knee slightly until you feel a stretch on the outside of the hip (see arrow)
5. Hold for 30 seconds
6. 3 repetitions
7. Repeat on opposite side

Figure 5.2 : Lower Limb

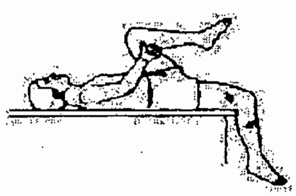


1. Lie on surface as shown
2. Hold on to your ankle and bend the knee so that you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.3: Lower limb

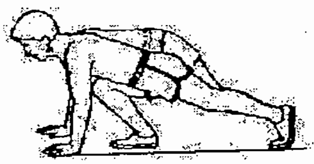
1. Stand holding the L/R ankle as shown
2. Bend the knee upward so that you feel a stretch
3. As you bend the knee, make sure the thigh stays in line with your body as shown (don't let it point forward)
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.4: Lower limb



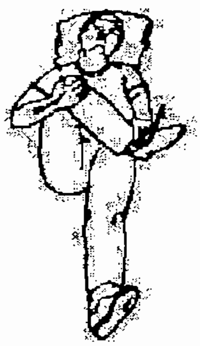
1. Lie on bench press with L/R leg hanging over edge
2. Bend the knee, keeping the thigh flat on the bench press
3. Pull your other knee up to your chest as shown
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.5 : Lower limb



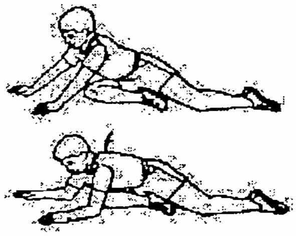
1. Assume position shown, with L/R leg straight
2. Press pelvic down toward floor as shown
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.6 : Lower limb



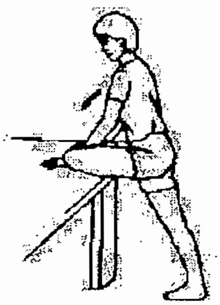
1. Lie on back holding L/R knee and ankle as shown
2. Hold knee stable as you pull ankle toward your chest so that you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.7 : Lower limb



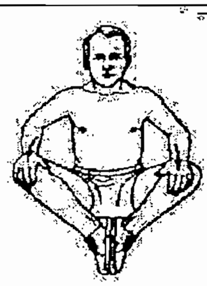
1. Assume position shown with L/R hip and knee bent, toe pointing toward opposite hip
2. Bend elbows and press trunk downward so that you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.8 : Lower limb



1. Stand propping L/R leg on solid object as shown
2. Lean your trunk forward so that you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.9 : Lower limb

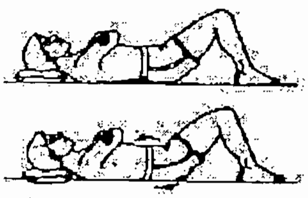


1. Sit with knees bent, feet together as shown
2. Press knees downward toward the floor, using hands as needed
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.10 : Lower limb

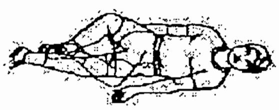
1. Lie on side, with lower ("shorter") leg behind upper leg as shown
2. Keeping hip on floor, use arms to press trunk upright
3. Hold for 30 seconds
4. 2 repetitions

Figure 5.11 : Pelvic girdle



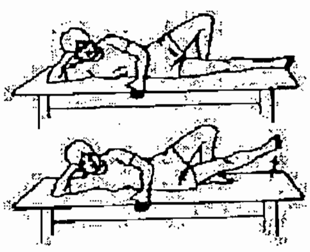
1. Lie on back with knees bent
2. Tighten abdominal muscles, squeeze buttock muscles and flatten back as shown, while pressing a ball between the knees
3. Hold for 10 seconds
4. 10 repetitions

Figure 5.12 : Pelvic girdle



1. Lie on your L/R side , with top knee bent as shown, put arms in front of body
2. Lift top leg
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat on opposite side

Figure 5.13 : Pelvic girdle



1. Lie on side as shown, with L/R leg at the bottom
2. Raise top leg up toward ceiling
3. Hold for 10 seconds, slowly relax
4. 10 repetitions
5. Repeat on opposite side

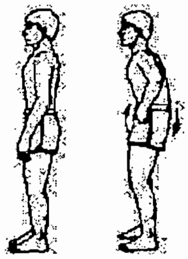
Figure 5.14 : Pelvic girdle

1. Lie on side with L/R leg on top
2. Bend lower leg slightly
3. Raise top leg straight up, without letting it come forward
4. Hold for 10 seconds, slowly relax
5. 10 repetitions
6. Repeat on opposite side

Figure 5.15 : Pelvic girdle

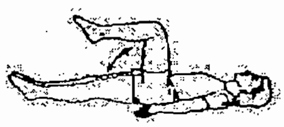
1. Lie on back
2. Bend L/R ("longer knee" only) and lift heel
3. Place hand on thigh as shown
4. Try to bend hip toward hand, but resist the motion with hand
5. Hold for 5 seconds
6. 10 repetitions

Figure 5.16 : Pelvic girdle



1. Stand with your normal posture
2. Bend knees slightly, tighten abdominal muscles, squeeze buttock muscles and flatten back as shown; learn to find pelvic neutral
3. Hold for 10 seconds
4. 10 repetitions

Figure 5.17 : Pelvic girdle

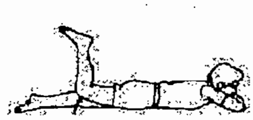


1. Lie on back with legs straight
2. Perform pelvic tilt to flatten back
3. Holding your back flat, bend L/R hip and knee as shown
4. Hold 10 seconds, slowly lower, then reverse
5. 10 repetitions
6. Repeat on opposite side

Figure 5.18 : Pelvic girdle

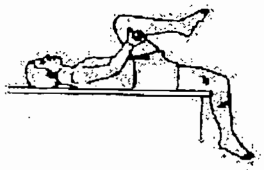
1. Begin on hands and knees and hold your spine stable in neutral throughout the rest of the exercise
2. Push your feet into the floor
3. Push your knees into the floor
4. Keep elbows bent while tightening your arms and pushing against the floor
5. Allowing no actual movement, try to pull your hands and knees toward each other
6. Reverse this and push the hands and knees apart
7. Hold for 10 seconds
8. 10 repetitions

Figure 5.19 : Pelvic girdle



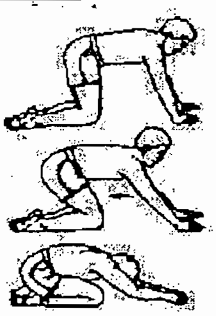
1. Lie on belly with L/R knee bent. Contract glut. max. while relaxing hamstring
2. Raise thigh off floor as you lift foot toward ceiling. Learn to use contra-lateral erector spinae/mulifidus only
3. Hold for 10 seconds, slowly relax
4. 10 repetitions
5. Repeat on opposite side

Figure 5.20 : Pelvic girdle



1. Lie on bench press with L/R leg hanging over edge
2. Bend the knee, keeping the thigh flat on the bench press
3. Pull your other knee up to your chest as shown
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.21 : Pelvic girdle

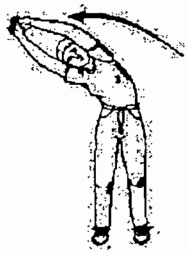


1. Assume hands and knees position
2. Bend knees to move buttocks toward heels as shown maintain posterior pelvic tilt
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.22 : Pelvic girdle

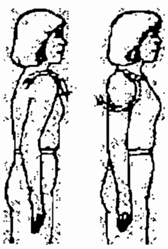
1. Assume position shown
2. Hold for 30 minutes
3. 3 repetitions

Figure 5.23 : Spinal



1. Clasp hands together and lean to the L/R until you feel a stretch
2. Hold for 30 seconds
3. 3 repetitions
4. Repeat on opposite side

Figure 5.24 : Spinal

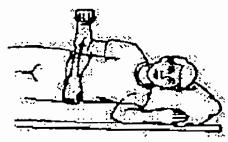


1. Begin with shoulders relaxed
2. Slowly rotate shoulders backward
3. 10 repetitions, 3 times

Figure 5.25 : Upper limb

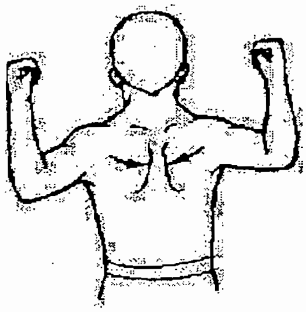
1. Stand with hands placed on door frame and 30–60 cm away from wall as shown
2. Lean into door opening so till you feel a stretch
3. Hold for 30 seconds
4. Repeat with hands in different positions as needed to vary the stretch
5. 3 repetitions

Figure 5.26 : Upper limb



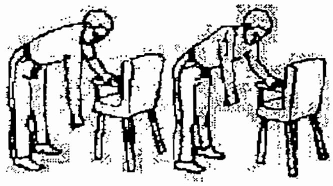
1. Lie on your side so that your L/R arm is on top
2. Rotate arm upward, keeping elbow bent as shown
3. Hold for 2 seconds and slowly lower
4. 2 x 10 repetitions
5. Repeat on opposite side

Figure 5.27 : Upper limb



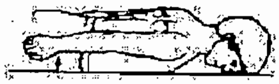
1. Stand with arms overhead as shown
2. Pinch shoulder blades together as you press your arms backward slightly
3. Hold for 5 seconds
4. 20 repetitions

Figure 5.28 : Upper limb



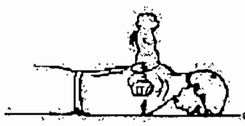
1. Lean forward over solid object, letting L/R arm hang
2. Pinch shoulder blade backward to raise shoulder upward
3. Hold for 5 seconds
4. 20 repetitions
5. Repeat on opposite side

Figure 5.29 : Upper limb



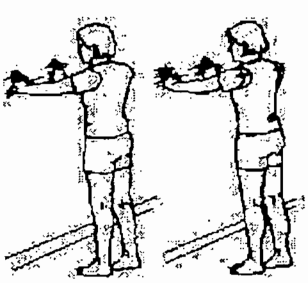
1. Lie on belly with arms resting at sides
2. Pinch shoulder blades together
3. Now, raise arms of floor as shown
4. Hold for 5 seconds and slowly lower
5. 20 repetitions

Figure 5.30 : Upper limb



1. Lie on belly with arms at 90 degrees out to side
2. Pinch shoulder blades together as shown
3. Raise arms a few inches off floor
4. Hold for 5 seconds and slowly lower
5. 20 repetitions

Figure 5.31 : Upper limb

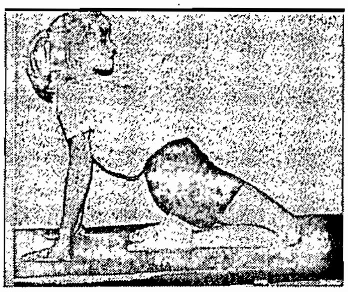


1. Stand with hands against wall as shown
2. Pinch shoulder blades together
3. Do push-ups against wall
4. Hold this position for 10 seconds
5. 20 repetitions

Figure 5.32 : Upper limb

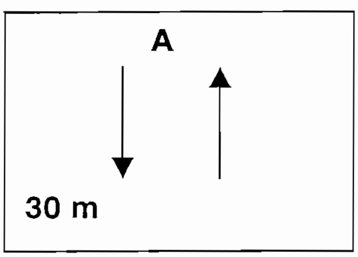
1. Lie on back holding L/R leg with towel as shown
2. Keep the opposite leg straight on the floor; put chin on chest
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat on opposite side

Figure 5.33 : Neurodynamic



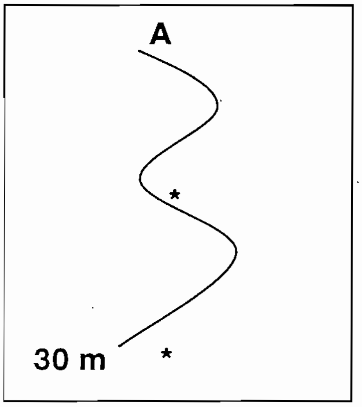
1. Lean backwards (extend) with upper body so that head moves behind (posterior to) buttocks
2. Hold for 30 seconds
3. 3 repetitions
4. Repeat on opposite side

Figure 5.34 : Neurodynamic



1. Start running straight from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.35 : Speed exercise



1. Start running "zig-zag" from marker A to marker B

2. Run as fast as possible

3. Run back to marker A, as fast as possible

4. 3 repetitions, 2 times per week

Figure 5.36 : Agility exercise

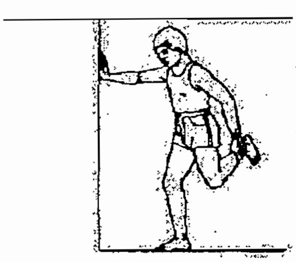
ANNEXURE 5.2

Start-of-season Level 1: 6-week maintenance programme

All exercises are done 3 times per week, included in the warm-up and warm-down phases as follow:

1. Stand with L/R side facing wall
2. Cross the L/F leg behind the other leg and toward the wall
3. Bend the forward knee slightly and lean your trunk toward the wall until you feel a stretch on the outside of the hip (see arrow)
4. Stretch both arms overhead and lean against wall with both hands
5. Hold for 30 seconds
6. 3 repetitions
7. Repeat on the opposite side

Figure 5.37 : Lower limb



1. Stand holding the L/R ankle as shown
2. Bend the knee upward until you feel a stretch
3. As you bend the knee, make sure the thigh stays in line with your body as shown (don't let it point forward); keep knees together and tilt pelvic posterior
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.38 : Lower limb

Figure 5.39: Lower limb

1. Assume position shown, with L/R knee on the floor
2. Lean your whole body forward, keeping your chest upright
3. Hold for 30 seconds
4. 4 repetitions
5. Repeat on opposite side

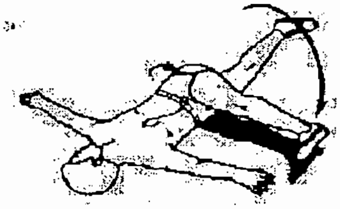


Figure 5.40 : Lower limb

1. Lie on back with knees straight, arms out to side
2. Cross L/R knee over body, turning head in opposite direction as shown, until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions

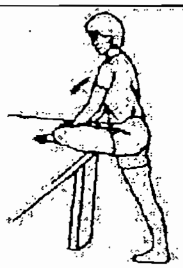


Figure 5.41 : Lower limb

1. Stand propping L/R leg on solid object as shown
2. Lean your trunk forward until you feel a stretch
3. Rotate trunk away from top leg
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.42 : **Lower limb**

1. Sit with knees bent, feet together as shown
2. Press knees downward toward the floor, by leaning forward and pressing with your elbows as shown
3. Hold for 30 seconds
4. 3 repetitions

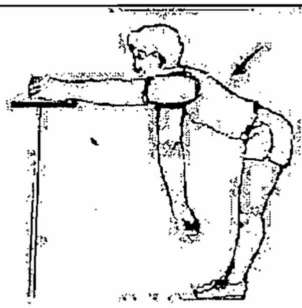


Figure 5.43 : Pelvic girdle

1. Put L arm on table (if L leg is "shorter")
2. L arm must be in line with R shoulder
3. Legs must be shoulder width apart and straight
4. Lean down in direction of arrow
5. Hold for 30 seconds
6. 3 repetitions

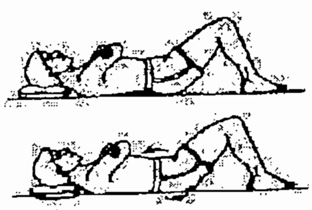
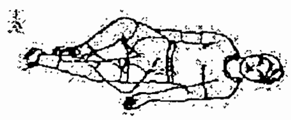


Figure 5.44 : Pelvic girdle

1. Lie on back with knees bent
2. Tighten abdominal muscles, squeeze buttock muscles and flatten back as shown, while pressing a ball between the knees
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat above with a belt around the knees
6. Repeat on opposite side

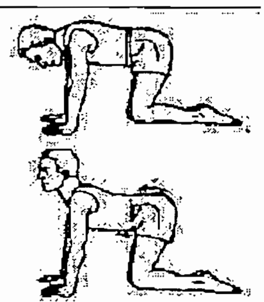


1. Lie on your L/R side, with top knee bent as shown
2. Put one arm behind your back
3. Lift top leg
4. Hold for 10 seconds
5. 10 repetitions
6. Repeat on opposite side

Figure 5.45 : Pelvic girdle

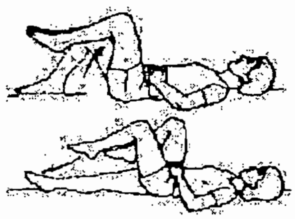
1. Sit in chair with knees bent as shown
2. Place hands on "longer" knee
3. Try to bend hip toward hand, but resist the motion with your hand
4. Hold for 10 seconds, slowly relax
5. 10 repetitions
6. Repeat on opposite side

Figure 5.46 : Pelvic girdle



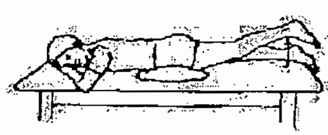
1. Assume hand and knees position
2. Let low back sag toward floor as you rotate tailbone and head upward
3. Arch back and sit down
4. Now lower your head and make a "hunch back", tucking your tailbone under as shown
5. Hold each position 10 seconds
6. 10 repetitions

Figure 5.47 : Pelvic girdle



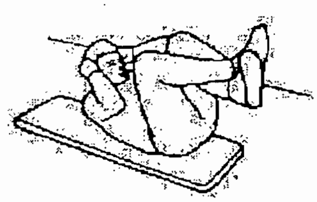
1. Lie on back with knees bent
2. Perform pelvic tilt to flatten back
3. Holding your back flat, bend hips and knees as shown
4. Then lower legs, one at a time straight to the floor
5. Hold for 10 seconds
6. 10 repetitions with each leg

Figure 5.48 : Pelvic girdle



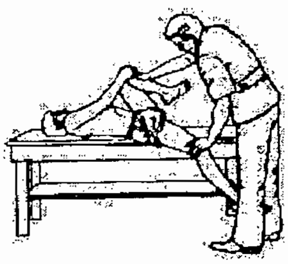
1. Lie on belly with pillow positioned as shown
2. Raise L/R leg off floor
3. Hold for 10 seconds, slowly relax
4. 10 repetitions
5. Repeat on opposite side

Figure 5.49 : Pelvic girdle



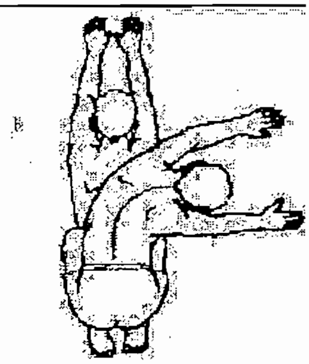
1. Position your knees and hips at 90° and tighten your abdominal muscles
2. Curl your trunk, pressing your chest towards your knees and exhaling
3. Pause in the upper position and then release
4. 20 repetitions
5. Repeat above while crossing elbow to opposite knee

Figure 5.50 : Pelvic girdle



1. Lie on bench press with L/R leg hanging over the edge
2. Pull your other knee up to your chest as shown
3. Have a partner press downward on your other thigh as shown
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.51 : Pelvic girdle



1. Kneel face down with arms outstretched as shown
2. "Walk" arms and trunk sideways to the L/R until you feel a stretch
3. Hold for 30 seconds L and R
4. 3 repetitions

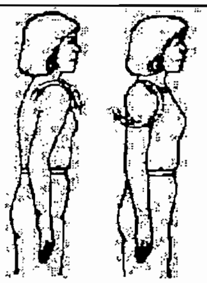
Figure 5.52 : Pelvic girdle

1. Place thumb firmly against lower back as shown (place at a specific level if instructed by exercise provider)
2. Bend backward until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.53 : Spinal

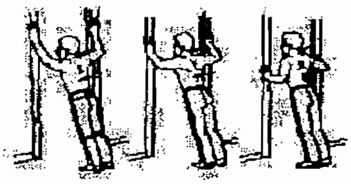
1. Lean to the L/R until you feel a stretch, with arm grasped over head as shown
2. Hold for 30 seconds
3. 3 repetitions
4. Repeat on opposite side

Figure 5.54 : Spinal



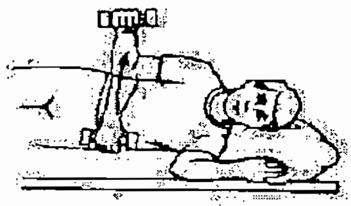
1. Begin with shoulder relaxed
2. Slowly rotate shoulders backward
3. 10 repetitions, 3 times

Figure 5.55 : Upper limb



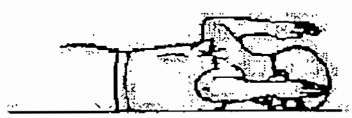
1. Stand with hands placed on door frame
2. 30–60 cm away from wall as shown
3. Lean into door opening until you feel a stretch
4. Hold for 30 seconds
5. Repeat with hands in different positions as needed to vary stretch
6. 3 repetitions

Figure 5.56 : Upper limb



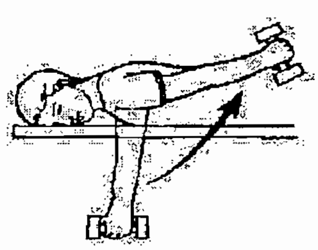
1. Hold a ______ weight in your L/R hand
2. Lie on side so that arm holding weight is on top
3. Rotate arm upward, keeping elbow bent as shown
4. Hold for 3 seconds and slowly lower
5. 2 x 15 repetitions
6. Repeat on opposite side

Figure 5.57 : Upper limb



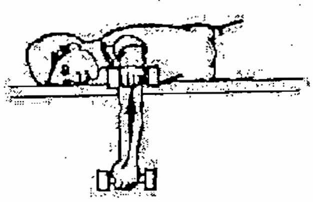
1. Lie on belly with arms at 90° out to the side
2. Pinch shoulder blades together as shown
3. Raise arms a few inches off floor
4. Hold for 10 seconds and slowly lower
5. 10 repetitions

Figure 5.58 : Upper limb



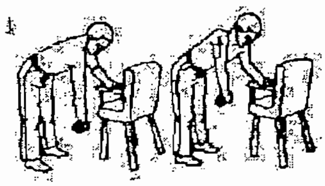
1. Hold ______ weight in L/R hand
2. Lie on belly with arms off edge of bed as shown
3. Raise arms backward
4. Hold for 10 seconds and slowly lower
5. 10 repetitions
6. Repeat on opposite side

Figure 5.59 : Upper limb



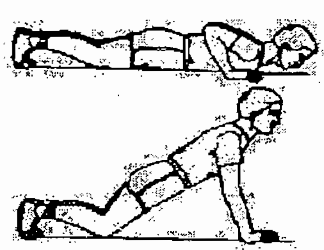
1. Hold ______ weight in both hands
2. Lie on belly with arm hanging over edge of bed as shown
3. Raise arms up until it is level with the edge of the bed
4. Hold for 10 seconds and slowly lower
5. 10 repetitions

Figure 5.60 : Upper limb



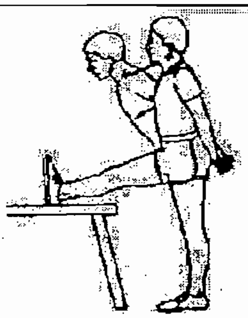
1. Hold ______ weight in L/R hand
2. Lean forward over solid object, letting arm hang
3. Pinch shoulder blade backward to raise shoulder upward
4. Hold for 10 seconds
5. 10 repetitions
6. Repeat on opposite side

Figure 5.61 : Upper limb



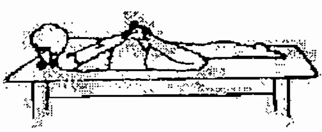
1. Lie on belly, pinch shoulder blades together
2. Do push-ups from knees
3. Keep back and neck stabilised in a neutral position
4. Hold for 10 seconds
5. 10 repetitions

Figure 5.62 : Upper limb



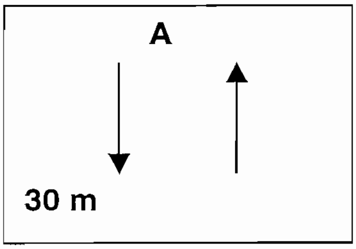
1. Prop L/R leg on bench press as shown
2. Bend forward at the hip
3. Keeping the knee and back straight, until you feel stretch
4. Pull foot upward and put chin on chest
5. Hold for 30 seconds
6. 3 repetitions
7. Repeat on opposite side

Figure 5.63 : Neurodynamic



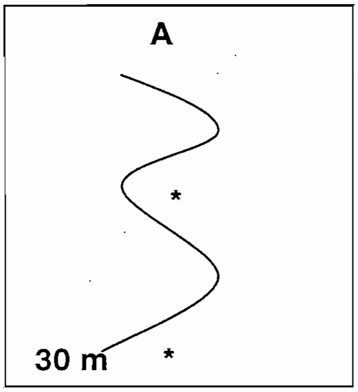
1. Lie on surface as shown
2. Hold on to your ankle and bend the knee until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.64 : Neurodynamic



1. Start running straight from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.65 : Speed exercise



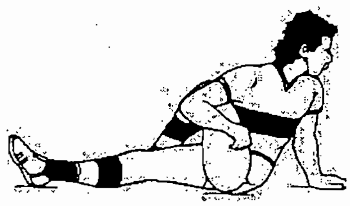
1. Start running "zig-zag" from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.66 : Agility exercise

ANNEXURE 5.3

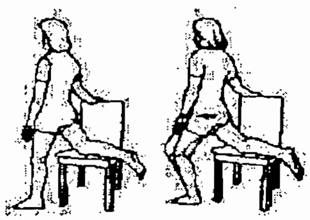
START-OF-SEASON LEVEL 2 : ADVANCED MAINTENANCE PROGRAMME

As with level 1 exercises, these are done three times per week, included in the warm-up and warm-down phases.



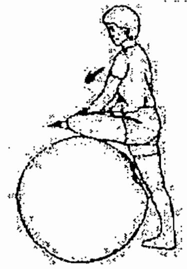
1. Sit and then bend your L leg at the knee, and cross it over the straight leg
2. Rest your R elbow against the outside of your L thigh
3. Turn your head slowly to look over your left shoulder
4. Hold for 30 seconds
5. Repeat on the opposite side
6. 3 repetitions

Figure 5.67 : Lower limb



1. Assume position shown, with L/R knee on chair
2. Bend the opposite knee until you feel a stretch
3. Do not allow your lower back to arch
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.68 : Lower limb



1. Stand propping L/R leg on physio ball as shown
2. Lean your trunk forward until you feel a stretch
3. Turn trunk in direction away from top leg
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.69 : Lower limb

1 Assume a "half squat" position as shown with L/R leg out to the side

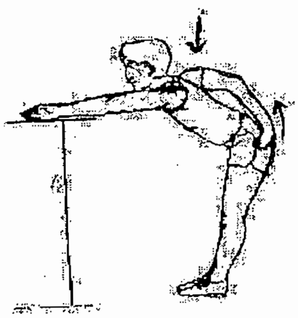
2 Press inside of thigh downward, by shifting weight towards bent leg

3 Hold for 30 seconds

4 3 repetitions

5 Repeat on opposite side

Figure 5.70 : Lower limb



1. Do only on side of "shorter" leg
2. Place feet shoulder width apart and lock knees
3. If L leg is "shorter", place L arm on table, in line with R shoulder
4. Place other hand on L hip
5. Lean down and pull with hand in direction of arrow
6. Hold for 30 seconds
7. 3 repetitions

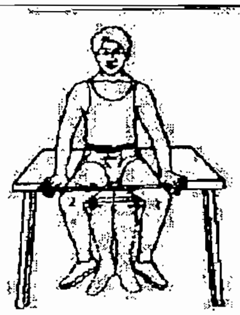
Figure 5.71 : Pelvic girdle

1. Lie on side with knees straight, arms positioned as shown
2. Stretch your head out long and push it back into your hand
3. Push your upper hand down into the floor
4. Pull your toes upward
5. Slowly raise the upper leg to the level of your hip
6. Slowly raise the lower leg toward the upper one,

leaving a space between the legs

7. Hold for 10 seconds, slowly relax in reverse order
8. 10 repetitions
9. Repeat on opposite side

Figure 5.72 : Pelvic girdle

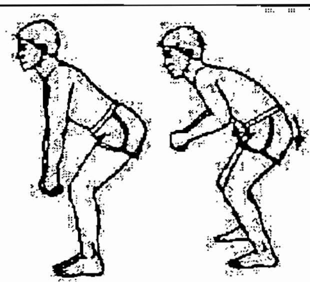


1. Sit on chair or table
2. Place rubber tubing around knees as shown
3. Spread knees apart as far as possible
4. Hold for 10 seconds, slowly relax
5. 10 repetitions

Figure 5.73 : Pelvic girdle

1. Sit with back against the wall/or lie down on back with knee ("longer" side) straight and the other knee bent as shown
2. Keep the leg completely straight, then raise it about ______ centimetres
3. Hold for 10 seconds and slowly lower
4. 10 repetitions
5. Repeat on opposite side

Figure 5.74 : Pelvic girdle



1. Stand with knees bent slightly, upper body inched forward

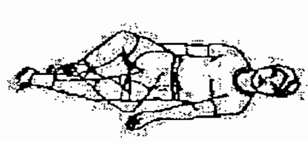
and back neutral as shown

2. Tighten abdominal muscles, squeeze buttock muscles

and flatten back as shown

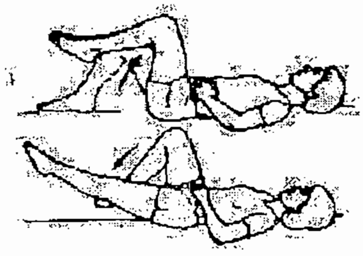
3. Hold for 10 seconds
4. 10 repetitions

Figure 5.75 : Pelvic girdle



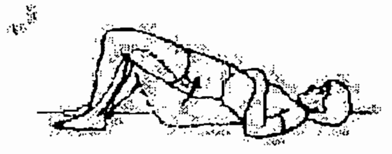
1. Lie on your side with top knee bent as shown
2. Lift bottom leg upward
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat on opposite side

Figure 5.76: Pelvic girdle



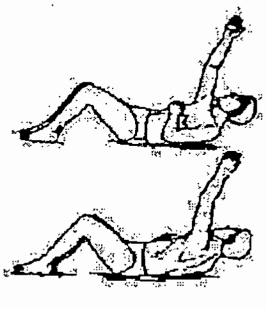
1. Lie on back with legs straight
2. Perform pelvic tilt to flatten back
3. Raise both knees toward chest as shown
4. Slowly straighten one leg, keeping the other bent and back flat, do not allow heel to touch the floor
5. 2 x 10 repetitions
6. Repeat on opposite side

Figure 5.77 : Pelvic girdle



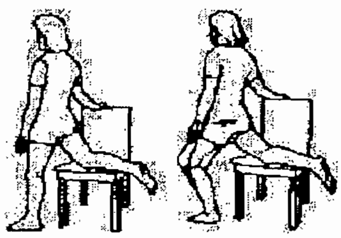
1. Lie on back with L/R leg bent as shown
2. Tighten buttocks and raise them off the floor as high as you can
3. Keep pelvic level
4. Hold for 10 seconds, slowly relax
5. 10 repetitions

Figure 5.78 : Pelvic girdle



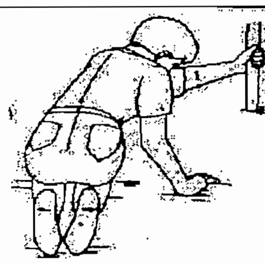
1. Lie on back with knees bent
2. Reach upward with one arm, lifting head and shoulder blade of the floor
3. Hold for 2 seconds
4. 2 x 20 repetitions
5. Repeat on opposite side

Figure 5.79 : Pelvic girdle



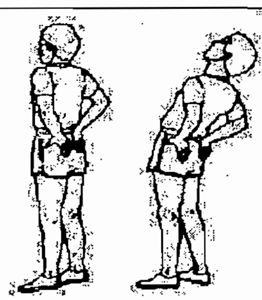
1. Assume position shown, with L/R knee on chair
2. Bend the opposite knee until you feel a stretch
3. Do not allow your lower back to arch
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.80 : Pelvic girdle



1. Hold onto object with L/R hand as shown
2. Sit back onto heels
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

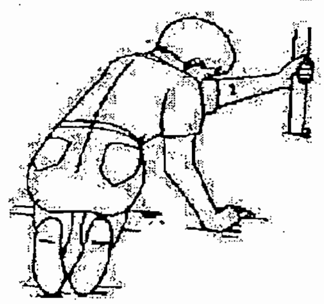
Figure 5.81 : Pelvic girdle



1. Place hands firmly against hips as shown
2. Bend backward until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions

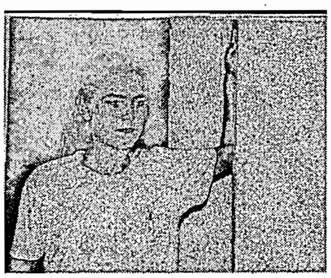
Figure 5.82 : Spinal

(Omit exercise if already done under Pelvic girdle)



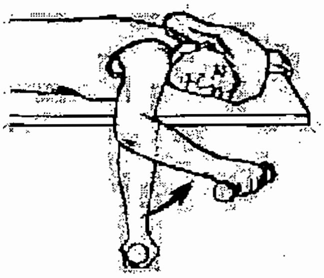
1. Hold onto object with L/R hand as shown
2. Sit back onto heels
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.83 : Spinal



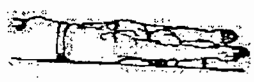
1. Stand with L/R hand placed on door frame as shown
2. Lean into door opening until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.84 : Upper limb



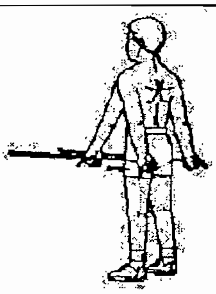
1. Hold a _____ weight in your L/R hand
2. Lie on bed as shown, with arm out to side, elbow bent, and the crease of the elbow over edge of bed
3. Keeping elbow bent, rotate arm upward (bring back of hand up toward ceiling)
4. Hold for 3 seconds and slowly lower
5. 2 x 15 repetitions
6. Repeat on opposite side

Figure 5.85 : Upper limb



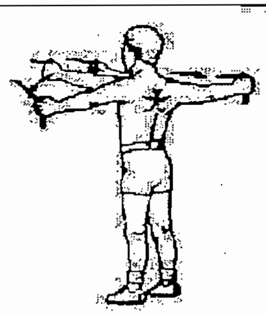
1. Lie on belly with arms over head as shown
2. Pinch shoulder blades together
3. Raise arms 1-3 inches off floor
4. Hold for 5 seconds
5. 2 x 10 repetitions

Figure 5.86 : Upper limb



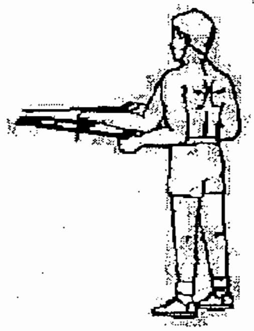
1. Anchor rubber tubing to a solid object
2. Stand holding rubber tubing in both hands with arms in front of body
3. Pinch shoulder blades backward as shown
4. Holding the shoulder blades stable, pull arms backward
5. Hold for 10 seconds and slowly relax
6. 10 repetitions

Figure 5.87 : Upper limb



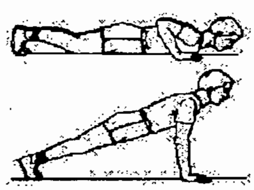
1. Anchor middle of rubber tubing to solid object
2. Hold tubing in both hands, arms straight in front of you as shown
3. Pinch shoulder blades together as you pull arms straight backward
4. Hold for 10 seconds and slowly relax
5. 10 repetitions

Figure 5.88 : Upper limb



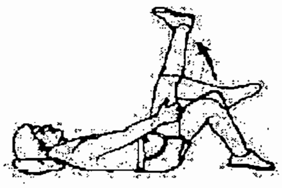
1. Anchor rubber tubing to a solid object
2. Hold rubber tubing in both hands, elbows bent
3. Squeeze shoulder blades together
4. Pull arms backward as shown
5. Hold for 10 seconds
6. 10 repetitions

Figure 5.89 : Upper limb



1. Assume position on floor as shown
2. Squeeze shoulder blades together
3. Straighten arms to raise your trunk (push-up)
4. Slowly lower and hold 10 seconds at bottom
5. 10 repetitions

Figure 5.90: Upper limb

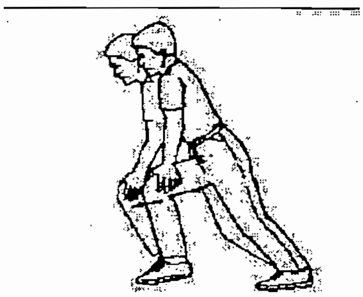


1. Lie on back holding L/R leg with hands as shown
2. Keep the opposite knee bent
3. Straighten the knee as far as you can, move foot towards head

and place chin on chest

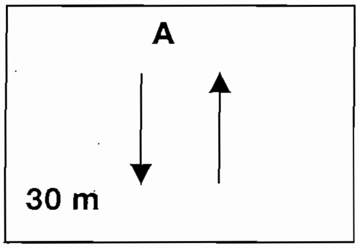
4. Hold for 10 seconds
5. 10 repetitions

Figure 5.91 : Neurodynamic



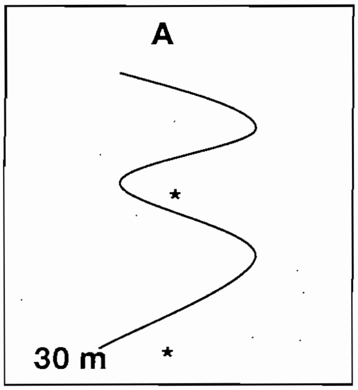
1. Assume position shown, with the L/R foot forward
2. Lean your body weight forward to bend the L/R knee until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.92 : Neurodynamic



1. Start running straight from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.93 : Speed exercise



1. Start running "zig-zag" from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.94 : Agility exercise

ANNEXURE 5.4

MID-SEASON 1 WEEK CONDITIONING PROGRAMME

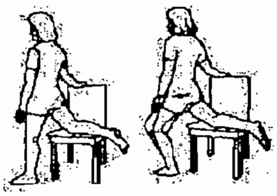
This intense 5 day programme should be followed over a week period to address dynamic mobility and specific positional core stability shortcomings. Each exercise should be done as graphically displayed and described. If uncertain do ask your coach/trainer.

1. Sit and then bend your Lt leg at the knee, and cross it over the straight leg
2. Rest your R elbow against the outside of your L thigh
3 Turn your head slowly to look over your left shoulder
5. Hold for 30 seconds
6. Repeat on the opposite side
7. 3 repetitions

Figure 5.95 : Lower limb

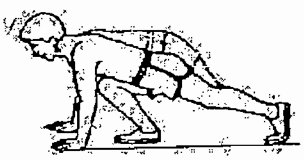
1. Stand bearing most of your weight on your L/R leg
2. Cross the other leg in front as shown
3. Lean forward, bending at the hip and keeping your back straight
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.96 : Lower limb



1. Assume position shown, with L/R knee on chair
2. Bend the opposite knee until you feel a stretch
3. Do not allow your lower back to arch
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.97 : Lower limb

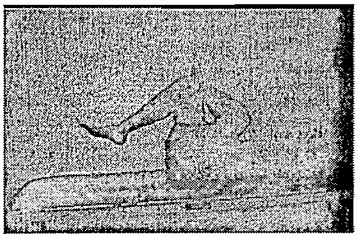


1. Place front leg on a bench
2. Assume position shown, with L/R leg straight
3. Press pelvic down toward floor as shown
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.98 : Lower limb

1. Stand, propping L/R leg on physio-ball as shown
2. Bend hip 90° and knee 45°
3. Lean your trunk forward until you feel a stretch
4. Turn trunk away from top leg
5. Hold for 30 seconds
6. 3 repetitions
7. Repeat on opposite side

Figure 5.99 : Lower limb



1. Lie on back, rest ankle on knee (use bottom knee to help)
2. Hold on to bottom leg and pull L/R leg toward your chest until you feel a stretch
3. Use elbow to press against top knee
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

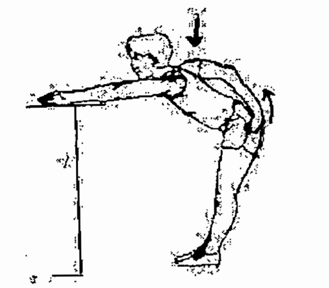
Figure 5.100 : Lower limb

1. Assume a "half squat" position as shown, with L/R leg out to the side
2. Press inside of thigh downward, by shifting weight toward the bent leg
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.101 : Lower limb

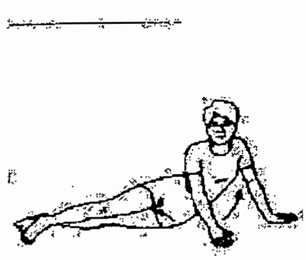
1. Sit on floor with straight legs, spread apart as shown
2. Lean forward over L/R leg, keeping back straight
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.102 : Lower limb



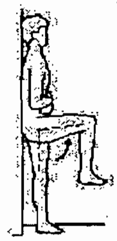
1. Do only on side of "shorter" leg
2. Place feet shoulder width apart and lock knees
3. If L leg is "shorter", place left arm on table, in line with R shoulder
4. Place other hand on L hip
5. Lean down and pull with hand in direction of arrow
6. Hold for 30 seconds
7. 3 repetitions

Figure 5.103 : Pelvic girdle



1. Lie on L/R side, with lower leg ("shorter" leg) behind upper leg as shown
2. Keeping hip on floor, use arms to press trunk upward to stretch your back
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.104 : Pelvic girdle



1 Stand tall on L/R foot and lean back against the wall

2 Hollow the abdominals to flatten the back to the wall

3 Slowly lift the non-weight bearing knee up in front

4 Keep the shoulders and pelvic level

5 Do not allow any movement of the trunk or pelvic

6 Only bend the hip as far as pelvic control allows

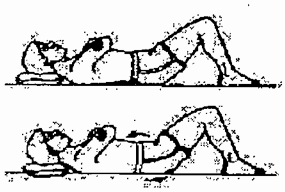
7 (maximum 90°)

8 Hold for 10 seconds

9 10 repetitions

10 Repeat on opposite side

Figure 5.105 : Pelvic girdle

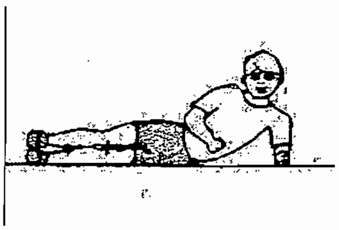


1. Lie on back with knees bent
2. Tighten abdominal muscles, squeeze buttock muscles and flatten back as shown, while pressing a ball between the knees
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat above with a belt around the knees
6. Repeat on opposite side

Figure 5.106 : Pelvic girdle

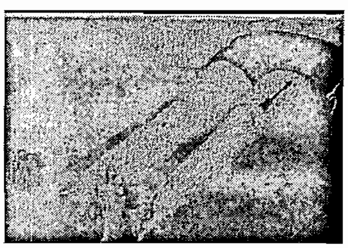
1. Sit with ball between knees as shown
2. Squeeze thighs together tightly
3. Hold for 10 seconds, slowly relax
4. 10 repetitions

Figure 5.107 : Pelvic girdle



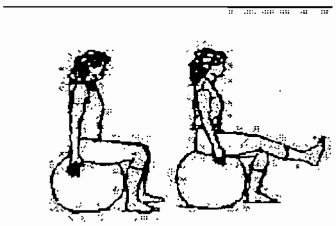
1. Lie on your side as shown
2. Lift body upwards
3. Support your weight on your elbow, forearm and feet
4. Stabilise the trunk by tightening the abdominals
5. Hold for 10 seconds
6. 10 repetitions
7. Repeat on opposite side

Figure 5.108 : Pelvic girdle



1. Sit with back against wall
2. Pull "longer" leg towards body (in direction of arrow)
3. Hold for 10 seconds
4. 10 repetitions

Figure 5.109 : Pelvic girdle



1. Sit correctly on ball in optimal posture
2. Position arms at sides or as desired
3. Using only "longer leg", kick L/R foot up until knee is as straight as is comfortable (do not compensate by bending trunk)
4. Hold for 10 seconds
5. 10 repetitions

Figure 5.110 : Pelvic girdle

(Caution – make sure exercise can be done without bouncing, tight hamstrings will not allow knee to straighten)

1. Assume hands and knees position as shown
2. Keeping knee bent, lift L/R hip out to side
3. Hold for 10 seconds, slowly relax
4. 10 repetitions
5. Repeat on opposite side

Figure 5.111 : Pelvic girdle

1. Lie on back with both feet lifted and the hips flexed to 90°
2. Initiate lower lateral abdominal hollowing with activation of

transverse abdominals to flatten back

3. Sustain this contraction
4. Slowly lower both heels until they are 5 cm above the floor
5. Keeping the heels off the floor, slowly extend both legs out
6. Only extend legs as far as trunk control allows
7. Slowly return to start position with control
8. Hold for 10 seconds
9. 10 repetitions

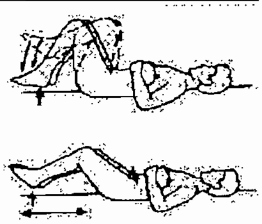
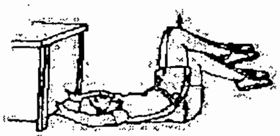


Figure 5.112 : Pelvic girdle

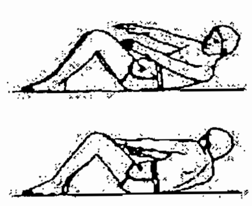
1. Lie on back with L/R leg bent as shown
2. Tighten buttocks and raise them off the floor
3. Keep pelvic level
4. Hold for 10 seconds, slowly relax
5. 10 repetitions
6. Repeat on opposite side

Figure 5.113 : Pelvic girdle



1. Lie on back with knees bent, holding onto solid object as shown
2. Tighten abdominal muscles to raise hip and knees straight upward
3. Hold for 3 seconds
4. 2 x 15 repetitions

Figure 5.114 : Pelvic girdle



1. Lie on back with knees bent
2. Reach toward knees, raise head and shoulders
3. Curl trunk upward and to the side as shown
4. Hold for 3 seconds
5. Repeat in opposite direction
6. 2 x 15 repetitions

Figure 5.115 : Pelvic girdle

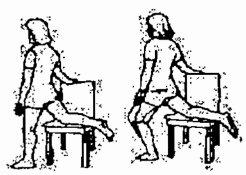


Figure 5.116 : **Pelvic girdle**

1. Assume position shown, with L/R knee on chair
2. Bend the opposite knee until you feel a stretch
3. Do not allow your lower back to arch
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

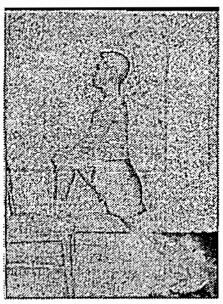


Figure 5.117 : **Pelvic girdle**

1. Assume position as shown, with L/R leg straight
2. Press pelvic down toward floor as shown
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

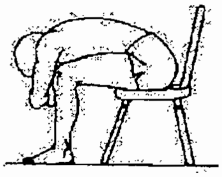
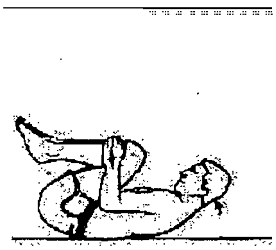


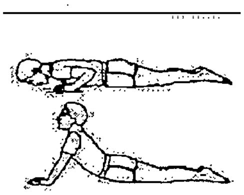
Figure 5.118 : **Pelvic girdle**

1. Sit in chair
2. Bend forward as shown
3. Hold for 30 seconds
4. 3 repetitions



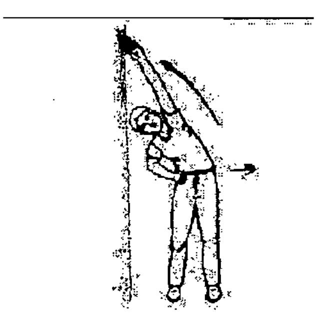
1. Lie on back
2. Pull both knees to chest
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.119 : Pelvic girdle



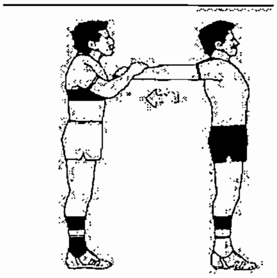
1. Assume position as shown
2. Straighten arms to press trunk upward, letting hips sag toward floor
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.120 : Spinal



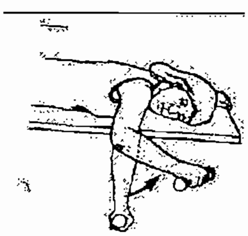
1. Lean to the L/R until you feel a stretch, with arm over head as shown
2. Hold on to pole and lean away from pole
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.121 : Spinal



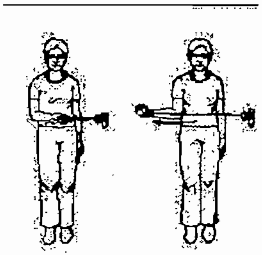
1. Stand with arms held out horizontally to the side
2. Partner takes hold of your arms, and slowly and gently pull them back
3. Hold for 30 seconds
4. 3 repetitions

Figure 5.122 : Upper limb



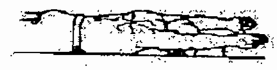
1. Hold a _____ weight in your L/R hand
2. Lie on bed as shown, with arm out to the side, elbow bent
3. Crease of elbow over edge of bed
4. Keeping elbow bent, rotate arm upward (bring back of hand up toward ceiling)
5. Hold for 10 seconds and slowly lower
6. 10 repetitions
7. Repeat on opposite side

Figure 5.123 : Upper limb



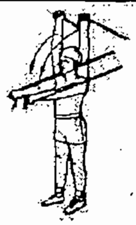
1. Anchor rubber tubing to a solid object
2. Grasp rubber tubing in L/R hand as shown
3. Rotate arm outward, keeping elbow bent
4. Hold for 5 seconds and slowly lower
5. 2 x 10 repetitions
6. Repeat on opposite side

Figure 5.124 : Upper limb



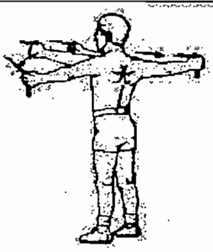
1. Lie on belly with arms over head as shown
2. Pinch shoulder blades together
3. Raise arms 1-3 inches off floor, point thumbs up
4. Hold for 5 seconds
5. 2 x 10 repetitions

Figure 5.125 : Upper limb



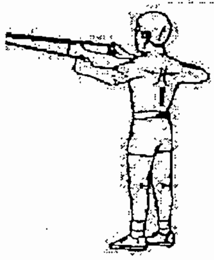
1. Anchor rubber tubing to a solid object
2. Grasp rubber tubing over head with both hands
3. Pull straight arms down and forward as shown
4. Hold for 10 seconds and slowly relax
5. 10 repetitions

Figure 5.126 : Upper limb



1. Anchor middle of rubber tubing to solid object
2. Hold tubing in both hands, arms straight in front of you as shown
3. Pinch shoulder blades together as you pull arms straight backward
4. Hold for 10 seconds and slowly relax
5. 10 repetitions

Figure 5.127 : Upper limb

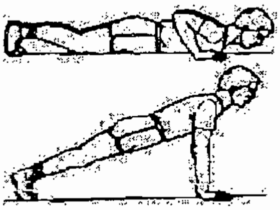


1. Anchor middle of rubber tubing to solid object
2. Hold tubing in both hands, arms straight in front of you as shown
3. Pinch shoulder blades backwards as you bend elbows and pull elbows straight backward
4. Hold for 10 seconds and slowly relax
5. 10 repetitions

Figure 5.128 : Upper limb

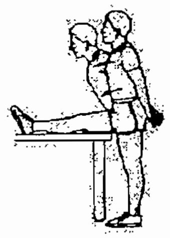
1. Sit or stand with your arms grasping the rubber band overhead
2. Pinch shoulder blades together
3. Pull your arms downward and outward
4. Hold for 10 seconds and slowly return
5. 10 repetitions

Figure 5.129 : Upper limb



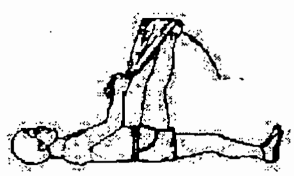
1. Lie on belly, put tight elastic band over back and under hands
2. Squeeze shoulder blades together
3. Do push-up against resistance of band
4. Keep back and neck stabilised in neutral
5. Hold for 10 seconds in bottom position
6. 10 repetitions

Figure 5.130 : Upper limb



1. Prop L/R leg on bench as shown
2. Bend forward at the hip, keeping the knee and back straight until you feel a stretch
3. Pull foot up and put chin on chest
4. Hold for 10 seconds
5. 10 repetitions
6. Repeat on opposite side

Figure 5.131 : Neurodynamic

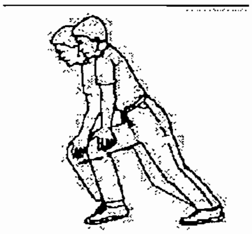


1. Lie on back holding L/R leg with towel as shown
2. Keep opposite leg straight on the floor, put chin on chest
3. Hold for 10 seconds
4. 10 repetitions
5. Repeat on opposite side

Figure 5.132 : Neurodynamic

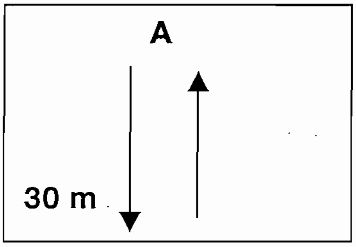
1. Stand holding L/R ankle as shown
2. Bend the knee upward until you feel a stretch
3. As you bend the knee, make sure the thigh stays in line with your body as shown (do not let it point forward)
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.133 : Neurodynamic



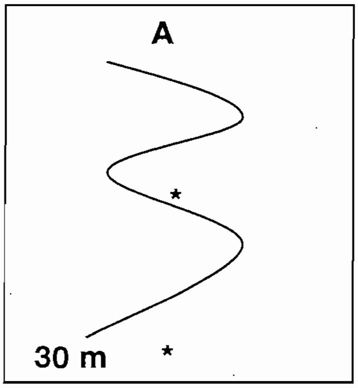
1. Assume position shown, with the L/R foot forward
2. Lean your body weight forward to bend the L/R knee until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.134 : Neurodynamic



1. Start running straight from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.135 : Speed exercise



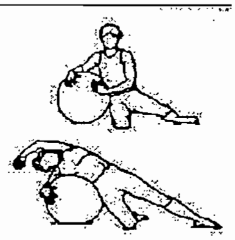
1. Start running "zig-zag" from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.136 : Agility exercise

ANNEXURE 5.5

MID-SEASON LEVEL 3 MOST ADVANCED CONDITIONING PROGRAMME

All exercises are done 3 times per week. Included in the warm-up and warm-down phases as follow:



1. Kneel next to ball
2. Place top L/R leg out to side and hands on ball
3. Press foot into floor and extend top leg allowing trunk to roll over ball sideways
4. Bring top arm up next to ear and let hand dangle towards floor increasing the stretch, gently rock at end range
5. Hold for 30 seconds and return to start
6. 3 repetitions
7. Repeat on opposite side

Figure 5.137 : Lower limb

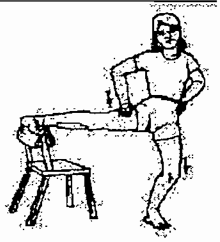
1. Grab L foot with R hand
2. Pull L foot toward the buttock
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

(Caution – do not do if injured knee)

Figure 5. 138 : Lower limb

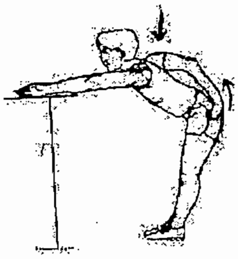
1. Stand propping L/R leg on ball as shown
2. Lean your trunk forward until you feel a stretch
3. Turn trunk away from top leg
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.139 : Lower limb



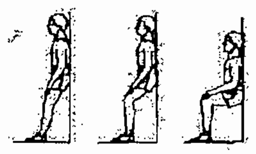
1. Stand with L/R leg out to side as shown, supported on solid object
2. Bend the opposite knee until you feel a stretch
3. Hold for 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.140 : Lower limb



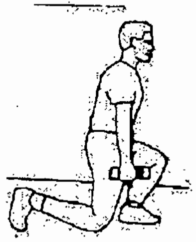
1. Do only on side of “shorter” leg
2. Place feet shoulder width apart and lock knees
3. If L leg is “shorter”, place left arm on table, in line with R shoulder
4. Place other hand on L hip
5. Lean down and pull with hand in direction of arrow
6. Hold for 30 seconds
7. 3 repetitions

Figure 5.141 : Pelvic girdle



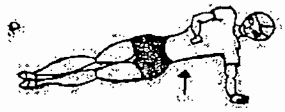
1. Stand with back against wall, feet shoulder width apart and about 45 cm from wall
2. Do posterior pelvic tilt
3. Slowly slide down wall until you are in a "chair position"
4. Hold for 10 seconds
5. 10 repetitions

Figure 5.142 : Pelvic girdle



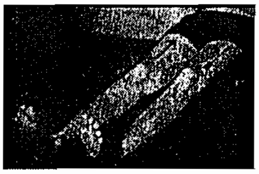
1. Do with dumbbells, stand with your feet shoulder width apart
2. Do posterior pelvic tilt
3. Step forward and down with your R leg, allowing your L knee to come towards the level of your R foot
4. Stand straight once again
5. 3 x 10 repetitions
6. Repeat on opposite side

Figure 5.143 : Pelvic girdle



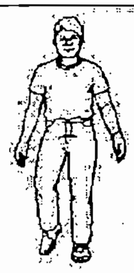
1. Lie on side as shown
2. Raise body from the floor, support body weight on the outstretched arm and feet
3. Stabilise the trunk by tightening the abdominals
4. Hold for 10 seconds
5. 10 repetitions
6. Repeat on opposite side

Figure 5.144 : Pelvic girdle



1. Sit on floor with legs straight
2. Pull L/R leg towards body, in direction of arrow
3. Pull other leg in direction of arrow
4. By switching legs in this way, slowly "walk" backwards
5. Keep knees flat on floor
6. 5 x "steps" per leg
7. 10 repetitions

Figure 5.145 : Pelvic girdle

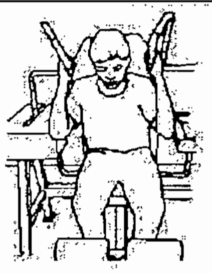


1. Stand upright, do posterior pelvic tilt with eyes closed
2. Tighten buttocks and abdominal muscles to hold spine stable in neutral throughout the rest of the exercise
3. Lift L/R leg from floor, without allowing the spine to move, or weight to shift excessively
4. Hold for 20 seconds
5. 5 repetitions
6. Repeat on opposite side

Figure 5.146 : Pelvic girdle

1. Lie on back with knees bent
2. Tighten buttock and abdominal muscles to hold spine stable in neutral throughout the rest of the exercise
3. Relax neck and shoulders as lift arms and feet off the floor
4. Slowly move arms and legs up and down as shown without allowing spine to move
5. 2 x 10 repetitions

Figure 5.147 : Pelvic girdle

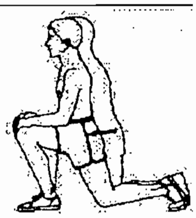


1. Sit on the machine adjusting the seat and pads for comfort
2. Flex the trunk bowing head down towards knees, leaning forward while doing so
3. Pause in this lower position and then return to start.
4. 2 x 15 repetitions

Figure 5.148 : Pelvic girdle

1. Position yourself in the leg raise machine, back against the back support
2. Ensure that body weight is balanced evenly feet placed on the low bench
3. Bend hips and knees, flexing them towards you, allowing tail bone to come forwards from the pad
4. Pause in this upper position and slowly lower legs once again to touch feet the bench
5. Do not allow feet to stand on the bench, or your legs to swing at any point in the movement
6. 2 x 15 repetitions
7. Repeat on opposite side

Figure 5.149 : Pelvic girdle

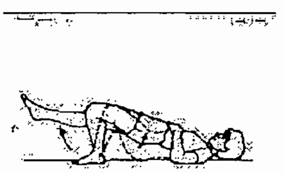


1. Assume position shown, with L/R knee on the floor
2. Lean whole body forward, keeping chest upright
3. Grab ankle of back leg and pull up
4. Hold for 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.150 : Pelvic girdle

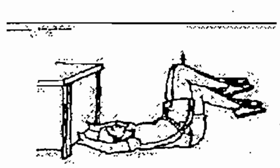
1. Lie on back
2. Bring legs over head
3. Use hands to keep balance
4. Hold for 30 seconds
5. 3 repetitions

Figure 5.151 : Pelvic girdle



1. Lie on back with L/R leg bent as shown, arms in vertical position
2. Tighten buttocks and raise them off floor
3. Keep pelvic level
4. Hold for 10 seconds, slowly relax
5. 10 repetitions
6. Repeat on opposite side

Figure 5.152 : Pelvic girdle



1. Lie on back with knees bent, holding onto solid object as shown
2. Do posterior pelvic tilt
3. Tighten abdominal muscles to raise hips and knees straight upward
4. Hold for 3 seconds
5. 2 x 10 repetitions

Figure 5.153 : Pelvic girdle

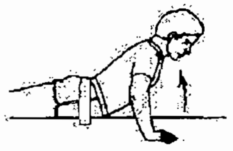


Figure 5.154 : Spinal

1. Assume position shown, with strap anchored below waist
2. Straighten arms to press trunk upward until feeling a stretch
3. Hold for 30 seconds
4. 3 repetitions

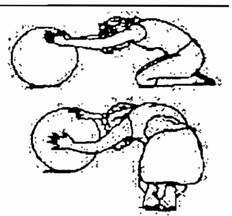
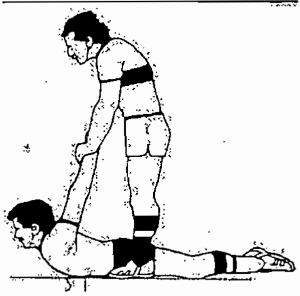


Figure 5.155 : Spinal

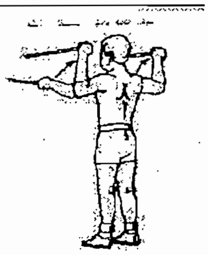
1. Sit on heels with hands on top of ball
2. Lean forward letting the ball roll and relax spine into a C curve
3. Keeping hands still on ball and head between arms, roll ball to one side, allowing trunk to turn
4. Hold and look under arm, return to centre and repeat to other side
5. Breathing – inhale on roll to side, exhale on return to centre
6. Hold for 30 seconds
7. 3 repetitions

(Caution – stay within pain free range, pad knees if necessary)



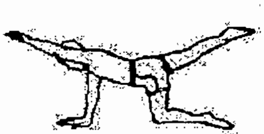
1. Lie on the floor with face down, and arms out to the side as shown
2. Partner stands astride player on floor, takes hold of his arms, and pulls them carefully upwards
3. Hold 30 seconds
4. 3 repetitions

Figure 5.156: Upper limb



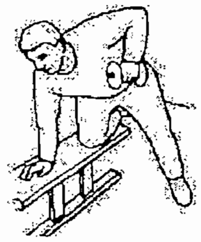
1. Anchor rubber tubing to solid object
2. Gras rubber tubing in both hands
3. Hold arms elevated with elbows bent and fists pointing forward as shown
4. Rotate arms upward from the starting position
5. Hold 10 seconds, slowly relax
6. 10 repetitions

Figure 5.157: Upper limb



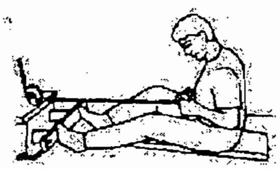
1. Assume hands and knees position, pinch shoulder blades together
2. Keeping back level, raise one arm and opposite leg as shown
3. Hold 5 seconds, repeat with opposite arm and leg
4. 2 x 10 repetitions

Figure 5.158: Upper limb



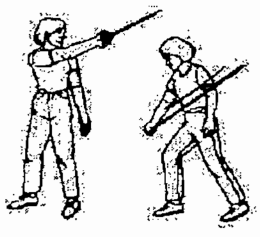
1. Half kneel on a bench with your right knee and right arm on the bench
2. Left leg straight with your foot on the floor
3. Grip a light dumbbell, pinch shoulder blades together and pull it upwards towards chest level, pause 10 seconds and then lower
4. 10 repetitions.
5. Repeat on opposite side

Figure 5.159: Upper limb



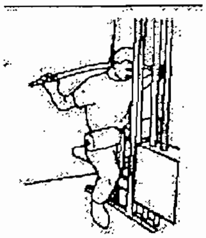
1. Sit on the seated row unit with your knees bent
2. Your back should be straight and your lower back slightly hollow
3. Pinch shoulder blades together then grip the bar and pull it towards you, attempting to scrape the sides of your body with your elbows
4. Hold 10 seconds
5. 10 repetitions

Figure 5.160: Upper limb



1. Anchor rubber tubing to solid object
2. Grasp tubing with L/R arm across body as shown
3. Pull arm outward and downward, letting your head follow the full movement
4. Notice that the hand rotates as the arm movement occurs
5. Hold 10 seconds and slowly relax
6. 10 repetitions
7. Repeat on opposite side

Figure 5.161: Upper limb



1. Take a wide grip on a lateral pull down bar
2. Sit on the unit adjusting the knee grips
3. Pinch shoulder blades
4. Pull the bar down and across your shoulders, pause and then release unitl your arms are straight
5. 2 x 10 repetitions

Figure 5.162: Upper limb

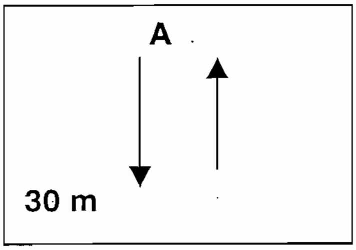
1. Lie on bed or table as shown
2. Place L/R leg on partner's shoulder as shown
3. Partner places hands and one knee on your legs as shown
4. Partner moves his/her body forward until you feel a stretch in the back of your leg, pull foot toward chest and put chin on chest
5. Hold 10 seconds
6. 10 repetitions
7. Repeat on opposite side

Figure 5.163: Neurodynamic

1. Position yourself in the leg raise machine, back against the back support
2. Ensure that body weight is balanced evenly feet placed on the low bench
3. Bend hips and knees, flexing them towards you, allowing tail bone to come forwards from the pad
4. Pause in this upper position and slowly lower legs once again to touch feet the bench
5. Do not allow feet to stand on the bench, or your legs to swing at any point in the movement
6. 2 x 15 repetitions
7. Repeat on opposite side

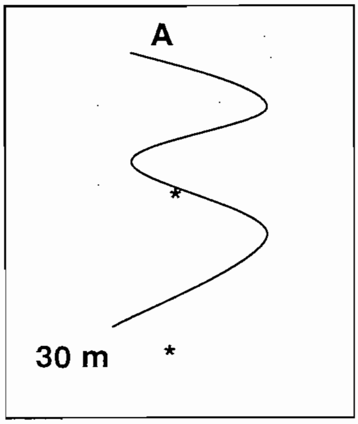
Figure 5.164 : Neurodynamic

(Do not do this exercise if already done under pelvic girdle)



1. Start running straight from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.165 : Speed exercise



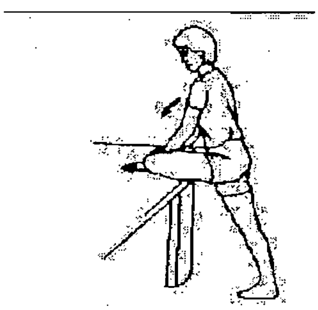
1. Start running "zig-zag" from marker A to marker B
2. Run as fast as possible
3. Run back to marker A, as fast as possible
4. 3 repetitions, 2 times per week

Figure 5.166 : Agility exercise

ANNEXURE 5.6

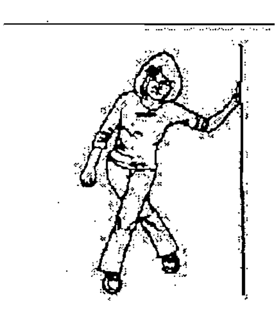
OFF-SEASON MAINTENANCE PROGRAMME

All exercises are done 3 times per week. Included in the warm-up and warm-down phases. To be done during off-season up to start of pre-season.



1. Stand propping L/R leg on solid object as shown
2. Lean your trunk forward until you feel a stretch
3. Rotate trunk away from top leg
4. Hold 30 seconds
5. 3 repetitions
6. Repeat on opposite side

Figure 5.167: Lower limb

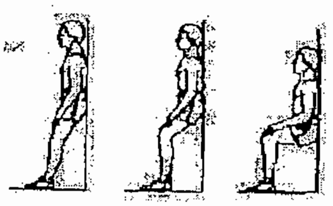


1. Stand with L/R side facing wall
2. Cross the L/R leg behind the other leg and toward the wall
3. Bend the forward knee slightly and lean your trunk toward the wall until you feel a stretch on the outside of the hip (see arrow)
4. Stretch both arms over head and lean against wall with both hands
5. Hold for 30 seconds
6. 3 repetitions
7. Repeat on the opposite side

Figure 5.168: Lower limb

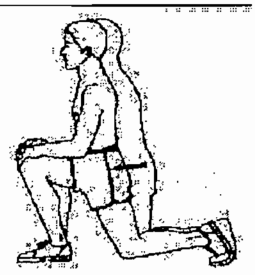
1. Sit with back against the wall/or lie down as shown, with knee ("longer" side) straight and the other knee bent as shown
2. Keep the leg completely straight, then raise it about______inches
3. Hold 10 seconds and slowly lower
4. 10 repetitions
5. Repeat on opposite side

Figure 5.169: Lower limb



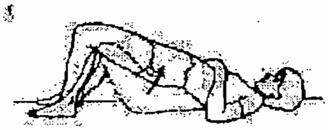
1. Stand with back against wall, feet shoulder width apart and 18 inches from wall
2. Do posterior pelvic tilt
3. Slowly slide down wall until you are in a "chair position"
4. Hold 10 seconds
5. 10 repetitions

Figure 5.170: Lower limb



1. Assume position shown, with L/R knee on the floor
2. Lean your whole body forward, keeping your chest upright
3. Hold 30 seconds
4. 4 repetitions
5. Repeat on opposite side

Figure 5.171: Pelvic girdle

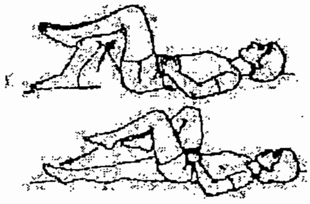


1. Lie on back with L/R leg bent as shown
2. Tighten buttocks and raise them off the floor as high as you can
3. Keep pelvic level
4. Hold 10 seconds, slowly relax
5. 10 repetitions

Figure 5.172: Pelvic girdle

1. Sit with knees bent, feet together as shown
2. Press knees downward toward the floor, by leaning forward and pressing with your elbows as shown
3. Hold 30 seconds
4. 3 repetitions

Figure 5.173: Pelvic girdle



1. Lie on back with knees bent
2. Perform peliv tilt to flatten back
3. Holding your back flat, bend hips and knees as shown
4. Then lower legs, one at a time straight to the floor
5. Hold 10 seconds
6. 10 repetitions with each leg

Figure 5.174: Pelvic girdle

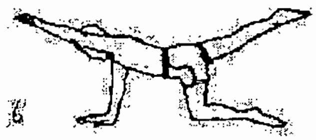


Figure 5.175: Spinal

1. Assume hands and knees position, pinch shoulder blades together
2. Keeping back level, raise one arm and opposite leg as shown
3. Hold 5 seconds, repeat with opposite arm and leg
4. 2 x 10 repetitions

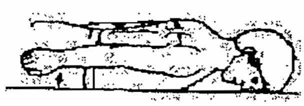


Figure 5.176: Spinal

1. Lie on belly with arms resting at sides
2. Pinch shoulder blades together
3. Now, raise arms of floor as shown
4. Hold 5 seconds and slowly lower
5. 20 repetitions

Figure 5.177: Spinal

1. Place thumb firmly against lower back as shown (place at specific level if instructed by exercise provider)
2. Bend backward until you feel a stretch
3. Hold 30 seconds
4. 3 repetitions

1. Lie on side with knees straight, arms positioned as shown
2. Stretch your head out long and push it back into your hand
3. Push your upper hand down into the floor
4. Pull your toes upward
5. Slowly raise the upper leg to the level of your hip
6. Slowly raise the lower leg toward the upper one, leaving a space between the legs
7. Hold 10 seconds, slowly relax in reverse order
8. 10 repetitions
9. Repeat on opposite side

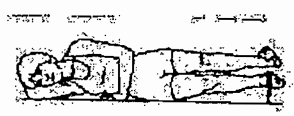


Figure 5.178: Spinal

1. Stand with hands placed on door frame
2. 1-2 feet away from wall as shown
3. Lean into door opening until you feel a stretch
4. Hold 30 seconds
5. Repeat with hands in different positions as needed to vary stretch
6. 3 repetitions

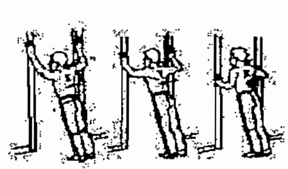


Figure 5.179: Upper limb

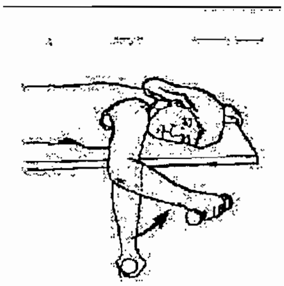


Figure 5.180: Upper limb

1. Hold a______ weight in your L/R hand
2. Lie on bed as shown, with arm out to side, elbow bent, and the crease of the elbow over edge of bed
3. Keeping elbow bent, rotate arm upward (bring back of hand toward ceiling)
4. Hold 3 seconds and slowly lower
5. 2 x 15 repetitions
6. Repeat on opposite side

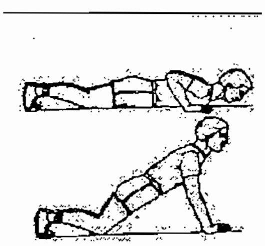


Figure 5.181: Upper limb

1. Lie on belly, pinch shoulder blades together
2. Do push-ups from knees
3. Keep back and neck stablilized in a neutral position
4. Hold 10 seconds
5. 10 repetitions

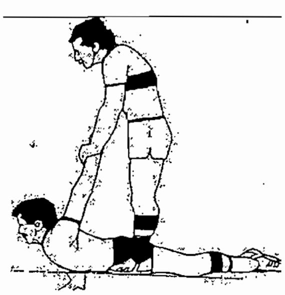
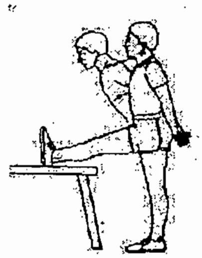


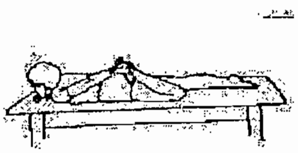
Figure 5.182: Upper limb

1. Lie on the floor with face down, and arms out to the side as shown
2. Partner stands astride player on floor, takes hold of his arms, and pulls them carefully upwards
3. Hold 30 seconds
4. 3 repetitions



1. Prop L/R leg on bench as shown
2. Bend forward at the hip
3. Keeping the knee and back straight, until you feel a stretch
4. Pull foot upward and put chin on chest
5. Hold 30 seconds
6. 3 repetitions
7. Repeat on opposite side

Figure 5.183: Neurodynamic



1. Lie on surface as shown
2. Hold on to your ankle and bend the knee until you feel a stretch
3. Hold 30 seconds
4. 3 repetitions
5. Repeat on opposite side

Figure 5.184: Neurodynamic

1. Do with dumbbells, stand with your feet shoulder width apart
2. Do posterior pelvic tilt
3. Step forward and down with your R leg, allowing your L knee to com towards the level of your R foot
4. Stand straight once again
5. 3 x 10 repetitions
6. Repeat on opposite side

Figure 5.185: Neurodynamic