Position-specific characteristics for elite adolescent male rugby players in the North West Province

Sumari Brand

21054363

Position-specific characteristics for elite adolescent male rugby players in the North West province

S Brand

orcid.org/ 0000-0003-1283-3600

Dissertation submitted in fulfilment of the requirements for the degree *Master of Health Science in Human Movement Sciences* at the North West University

Supervisor:	Prof JH de Ridder
Co-supervisor:	Mr R Broodryk
Assistant-supervisor:	Dr Y Willemse

Graduation: May 2019

Student number: 21054363

DECLARATION

The co-authors of the two articles that form part of this dissertation, Prof. Hans de Ridder (Supervisor), Mr Retief Broodryk (Co-supervisor) and Dr Yolandi Willemse (Assistant-supervisor) hereby give permission to the candidate, Miss. Sumari Brand, to include the two articles as part of a master's dissertation. The contribution (advisory and supportive) of the co-authors was kept within reasonable limits, enabling the candidate to submit the dissertation for examination purposes. This dissertation, therefore, serves as partial fulfilment of the requirements for the degree Master of Health Science in Human Movement Sciences in the School of Human Movement Sciences in the Faculty of Health Sciences at the North-West University (Potchefstroom Campus), South Africa.

Sumari Brand
Master's student

Prof. Hans de Ridder
Supervisor and co-author

Dr Yolandi Willemse
Assistant-supervisor and co-author

Mr Retief Broodryk
Co-supervisor and co-author

PREFACE

This dissertation is submitted for the degree Master of Health Science in Human Movement Sciences at the North-West University, Potchefstroom Campus. The dissertation, titled *Position-specific characteristics for elite adolescent male rugby players in the North West province*, contains five chapters. First, an introduction is provided to describe the background to this dissertation, state the research problem, and detail the aims of research. An extensive overview of literature is then included, detailing all previous work relevant to this research area. Next, two articles are presented, outlining the various parts of the study, together with analysis and discussion of the data. Finally, a summary chapter reports all major findings, conclusions, limitations and draws attention to suggested areas for future research.

ACKNOWLEDGEMENTS

- To my supervisor Prof. Hans and assistant-supervisor Dr Yolandi, thank you for your guidance and help throughout this dissertation.
- To my co-supervisor Retief, thank you for your guidance and willingness to always assist and to help improve my work. Thank you for the example you have set.
- To all my family, friends, netball players and colleagues who motivated me, supported me and cheered me up in difficult times, thank you.
- To Prof. Suria Ellis, thank you for helping me with the statistical consultation related to this dissertation.
- To all the rugby players who worked with me, thank you for the privilege of being part of your rugby lives.

SUMMARY

The purpose of this study was to identify position- and age-specific anthropometric, physical and motor characteristics of 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province. Players were compared to determine if anthropometric (body mass, stature, selected skinfolds, girth measurements, sum of skinfolds, percentage body fat and percentage muscle mass), physical (explosive power, strength, strength endurance) and motor (speed and aerobic endurance) characteristics differentiated between playing positions and age groups. The following age groups: u/15 (N=190), u/16 (N=164) and u/18 (N=192) were divided into six positional groups, namely front row (positions 1, 2 and 3) (N=109), locks (positions 4 and 5) (N=56), loose forwards (positions 6, 7 and 8) (N=142), halves (positions 9 and 10) (N=69), centres (positions 12 and 13) (N=74) and outside backs (positions 11, 14 and 15) (N=96).

Descriptive statistics (means, standard deviations) were calculated from cross-sectional data for anthropometric, physical and motor characteristics. A hierarchical linear model (mixed model) was used to determine if any positional and age group differences were practically significant by means of Cohen's effect size (ES). An effect size of 0.2 was considered as small, 0.5 as medium and 0.8 as large (Cohen, 1988). The mean ($\bar{x}$) for each playing position and age group was calculated and used to evaluate each player according to his own age group and playing position.

Positional differences occurred between the u/15, u/16 and u/18 players: forward players (front row, locks and loose forwards) showed higher values in most of the anthropometric characteristics compared to the back line players (halves, centres and outside backs) and also showed better values in most of the age groups for strength (1 RM bench press, 1 RM back squat and 1 RM RFE left and right leg). Large practically significant differences occurred when the u/15 players were compared to the u/18 players. The u/16 players performed better than the u/18 players in the following positional groups: front row players performed better in the aerobic endurance test, locks and loose forwards performed better in the 10- and 40 m speed test, centres performed better in the 40 m speed and aerobic endurance test. Halves and outside backs performed better in the 10 m speed and aerobic endurance test. All the u/18 positional groups, except for the centres, performed better in the upper and lower body strength tests when compared to the u/15 and u/16 players.

The results, therefore, indicate that practically significant differences in playing positions and age groups exist with regard to anthropometric, physical and motor characteristics. These findings can

serve as a valuable normative data scale for RU players in these age groups in the North West province. Mean scores can be used as guidelines to assist coaches, selectors and sport scientists with team selection, physical preparation and talent identification. Coaches and sport scientists should be familiarized with the effect of growth and maturation among adolescents when players are selected for specific teams and playing positions. However, to compile an accurate norm scale for all Rugby Union players for the age groups u/15, u/16 and u/18, it is strongly recommended to use players from all provinces in South Africa.

Keywords: adolescence; age group differences; anthropometric characteristics; elite rugby players; motor characteristics; physical characteristics; position-specific characteristics

OPSOMMING

Die doelwit van hierdie studie was om die posisie- en ouderdomspesifieke antropometriese, fisiese en motoriese eienskappe van 15- tot 18-jarige manlike, adolessente, elite Suid-Afrikaanse rugby-uniespelers (RU) in die Noordwesprovinsie te identifiseer. Spelers is vergelyk om te bepaal of die antropometriese (liggaamsmassa, liggaamslengte, geselekteerde velvoue, omtrekke, som van velvoue, persentasie liggaamsvet en persentasie spiermassa), fisiese (eksplosiewe krag, spierkrag en spier uithouvermoë) en motoriese (spoed en aërobiese uithouvermoë) eienskappe verskil tussen spelerposisies en ouderdomsgroepe. Die volgende ouderdomsgroepe: o/15 (N=190), o/16 (N=164) en o/18 (N=192), is verdeel in ses posisionele groepe, naamlik voorry (posisies 1, 2 en 3) (N=109), slotte (posisies 4 en 5) (N=56), losvoorspelers (posisies 6, 7 en 8) (N=142), vleuels (posisies 9 en 10) (N=69), senters (posisies 12 en 13) (N=74) en agterspelers (posisies 11, 14 en 15) (N=96).

Beskrywende statistieke (gemiddelde, standaardafwykings) om die antropometriese, fisiese en motoriese eienskappe te beskryf is bereken met behulp van deursneëdata. ’n Hiërargiese liniêre model (gemengde model) is gebruik om te bepaal of daar enige prakties betekenisvolle verskille tussen posisies of ouderdomme is deur middel van Cohen se effekgroottes (EG). ’n Effekgrootte van 0.2 is klein geag, 0.5 medium en 0.8 groot (Cohen, 1988). Die gemiddelde ($\bar{x}$) vir elke spelerposisie en ouderdomsgroep is gebruik om elke speler te evalueer binne sy eie ouderdomsgroep en posisie.

Daar was posisionele verskille tussen die o/15, o/16 en o/18 spelers: voorspelers (voorrye, slotte en losvoorspelers) het hoër waardes in meeste van die antropometriese eienskappe behaal vergeleke met agterlynspelers (vleuels, senters en agterspelers). Hulle het ook beter waardes behaal ten opsigte van krag in meeste van die ouderdomsgroepe (1 RM repitisie maksimum borsopstote met stang “*bench press*”, 1 RM hurk terug, “*back squat*” en 1 RM RFE agterste voet opstote, “*rear foot elevation*”, linker en regter been). Daar was groot prakties betekenisvolle verskille tussen die o/15 spelers en die o/18 spelers. Die o/16 spelers het beter as die o/18 spelers gevaar in die volgende posisionele groepe: voorryspelers het beter gevaar in die aërobiese uithoutoets, slotte en losvoorspelers het beter gedoen in die 10- en 40 m spoedtoets, senters het beter gevaar in die 40 m spoed- en aërobiese uithoutoetse, en vleuels en agterspelers het beter gedoen in die 10 m spoed- en aërobiese uithoutoets. Al die o/18 posisionele groepe behalwe die senters het beter gedoen met die bolyf en onderlyf kragtoetse vergeleke met die o/15 en o/16 spelers.

Die resultate toon dus dat daar wel prakties betekenisvolle verskille tussen spelerposisies en ouderdomsgroepe is met betrekking tot antropometriese, fisiese en motoriese eienskappe. Die bevindinge kan dien as ’n waardevolle normatiewe skaal vir RU-spelers in hierdie ouderdomsgroepe in die Noordwesprovinsie. Gemiddeldes kan gebruik word as riglyne om afrigters, keurders en sportwetenskaplikes te help met spanseleksie, fisiese voorbereiding en talentidentifikasie. Afrigters en sportwetenskaplikes moet bewus wees van die invloed van groei en rypwording op adolessente wanneer hulle spelers kies vir spesifieke spanne en posisies. Die studie beveel egter aan dat spelers uit al die provinsies in Suid-Afrika geëvalueer word ten einde ’n akkurate normskaal vir RU-spelers vir die ouderdomsgroepe o/15, o/16 en o/18 op te stel.

Sleutelwoorde: adolessente; ouderdomsgroepverskille; antropometriese eienskappe; elite rugbyspelers; motoriese eienskappe; fisiese eienskappe; posisie-spesifieke eienskappe

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

%	Percentage
∑ 6 skinfolds	Sum of six skinfolds
1 RM	One repetition maximum
BL	Back line
BMI	Body mass index
cm	Centimetres
d	Practical significance
ES	Effect size
FFM	Fat free mass
H	Halves
HREC	Health Research Ethics Committee
ISAK	International Society for the Advancement of Kinanthropometry
ISSD	Institute for Sport Science and Development
kg	Kilogram
LF	Loose forward
LRU	Leopards Rugby Union
m	Meter
MSE	Mean squared error
N	Population size
p	Statistical significance

PL.min $^{-1}$	PlayerLoad™ per minute
PLslow.min^{-1}	PlayerLoad™ slow per minute
RFE	Rear foot elevation
RL	Rugby League
RS	Rugby Sevens
RT	Rugby Tens
RU	Rugby Union
SD	Standard deviation
TF	Tight forward
TR	Touch Rugby
u/13	Under thirteen
u/15	Under fifteen
u/16	Under sixteen
u/18	Under eighteen
VO_2 max	Aerobic endurance capacity
$\bar{x}$	Total mean

CHAPTER 1:
INTRODUCTION

1.1 INTRODUCTION

Rugby Union is an intriguing form of rugby that involves various demands, making the physiological analysis complex (Pook, 2012:10). Rugby players should possess a variety of motor skills that constitute specific anthropometric and physical profiles (Spamer & De la Port, 2006:176). The combination of size and performance is considered essential in rugby (Krause *et al*., 2015:360). Large body size (stature and body mass) is a significant predictor of success in rugby and Olds (2001:260) predicts that the current trend of recruiting and selecting players with greater body size will continue in rugby. The body composition of rugby players might influence the position played as the different positions have different requirements (Macedonio & Dunford, 2009:32). The difference in demands between the playing positions can be attributed to the different levels of physicality demanded from forwards and backs. Physicality is influenced by the number of tackles, rucks and set pieces in which the players are involved (Pook, 2012:12). Rugby has become more competitive, with more countries competing and more international competitions, and this has brought a shift to increasing the level of fitness and conditioning of all players (Macedonio & Dunford, 2009:32).

Olds (2001:258) identifies major shifts in the physique of rugby players from 1975 to 2000 as players have become taller, heavier and more athletically built, with well-developed muscles when compared to players before 1975. The average body weight of a rugby player has increased by 20 per cent between the early 1980s and the 2010 Tri Nations (Pook, 2012:1–2). Quarrie and Hopkins (2007:895) suggest that rule changes also contribute to the different physical characteristics of players. From 1972 to 2004, there was an increase in passes, tackles, tries, ball-in-play time and body mass, while there were fewer lineouts, mauls, kicks in play and mean participation time per player than before (Quarrie & Hopkins, 2007:902). Statistics from the 2010 Tri-Nations showed 50 per cent more tackles and rucks possibly due to rule changes such as rules permitting quick line-outs and preventing a player from kicking directly into touch from his own 22, encouraging less kicking and more passing. All of these changes have had significant implications for physical preparation and conditioning of players (Pook, 2012:3).

A study done by Durandt *et al*. (2006:42–43) on the South African Rugby Union Green Squad (16 and 18-year-old elite junior South African players) found significant positional differences between props and scrum halves, fly halves and wings, wings and centres as well as locks and scrum halves. The props displayed greater upper body strength for one repetition maximum (1RM) in absolute bench press measures, were significantly slower than most other positions and ran fewer shuttles in the multistage shuttle run. Various researchers have been documenting the same game-specific tasks for each position in RU over the past 20 years, even though the anthropometric and physical characteristics have changed, as RU became more competitive. Morphological changes have occurred in the physique of rugby players and there have also been rule changes (Delahunt *et al*., 2013; Quarrie & Hopkins, 2007; Duthie *et al*., 2005; Duthie *et al*., 2003; Olds, 2001; Nicholas, 1997). Props are involved in gaining possession of the ball and are the cornerstones at set pieces (Delahant *et al*., 2013:3256; Nicholas, 1997:377). They therefore require strength and power (Nicholas, 1997:377). Hookers specialise in winning the ball and support work and should have agility and suppleness, leg power for driving in the scrum, fast reaction and leg speed. They are generally the smallest and lightest of the forwards (Delahant *et al*., 2013:3256; Nicholas, 1997:377). Locks need leg power and height, flankers and the number eight require power and mobility in open play as well as speed, acceleration and endurance for regaining and retaining possession of the ball (Nicholas, 1997:377). Halfbacks (inside backs), need endurance and speed to control and distribute possession and the centres should have speed, strength and power for running in contact and defence (Nicholas, 1997:378). Wings and full backs need a combination of speed and strength to beat the opposition by means of pace (Delahant *et al*., 2013:3256; Nicholas, 1997:378).

1.2 PROBLEM STATEMENT

Apart from the positional differences mentioned earlier, there are also differences between age groups. Van Gent and Spamer (2005:58–59) note the anthropometric differences between u/13 and u/18 elite rugby players. They also determined in the same study that the anthropometric parameters of the u/16 players seemed relatively similar, irrespective of player positions, which was true for both forward and back-line players (Van Gent & Spamer, 2005:58–59). The study done by Durandt *et al.* (2006:43) on the South African Rugby Union Green Squad found that anthropometric parameters, arm strength and aerobic fitness varied between age groups while the percentage body fat, speed (10 m and 40 m) and agility of the u/16 and u/18 players were alike.

The stature and body mass of the sixteen-year-olds were 175.6 ± 5.7 cm and 76.5 ± 8.2 kg respectively and those of the eighteen-year-olds were 179.2 ± 6.7 cm and 84.9 ± 8.3 kg (Durandt *et al.*, 2006:43). The sixteen-year-olds lifted less weight than the eighteen-year-olds, completed fewer push-ups and also fewer aerobic fitness shuttles (Durandt *et al.*, 2006:44). Durandt *et al.* (2006:43) explain that age differences can be attributed to maturation, training discrepancies or a combination of the two. The previous statement supports the findings of Noakes and Du Plessis (1996:222), who stated that schoolboys mature at different growth rates, which directly influences their anthropometric, physical and motor characteristics and affects the optimal playing potential to become a successful rugby player. Physical maturity is at its highest between the ages 13 and 15 years, especially peak growth velocity (Nutton *et al*., 2012:2). Awareness of the different characteristics of players per age category is very important for understanding a players' profile (Darrall-Jones *et al*., 2015:2086). Team selection can occur according to these profiles (Darrall-Jones *et al*., 2015:2086) and according to Nutton *et al*. (2012:1-2), the chances of catastrophic spinal injuries among youth rugby players can increase when there is a mismatch between schoolboys and their playing position. Playing under the wrong age group is one of the major causes of these injuries (Nutton *et al*., 2012:1-2).

For above mentioned reasons, it seems important that players in the different playing positions of various age groups should possess specific anthropometrical, physical and motor characteristics in accordance with their own age group and maturation status. Plotz and Spamer (2006:101-107) compared talented South African and English youth rugby players (18 years old) and found that the South African players performed the best in game-specific skills. They concluded that differences in game-specific skills could be attributed to more exposure to rugby training and physical conditioning. It is crucial to understand when these characteristic changes will occur and at which age category these changes will take place (Darrall-Jones *et al*., 2015:2086) to train players optimally.

This leads to the following research questions: Firstly, what are the position-specific anthropometrical characteristics of fifteen- to eighteen-year-old elite adolescent male South African Rugby Union players in the North West province? Secondly, what are the position-specific physical and motor ability characteristics of fifteen- to eighteen-year-old elite adolescent male South African Rugby Union players in the North West province? Answers to these questions can guide the formulation of a set of position-specific anthropometric, physical and motor characteristics for different playing positions among fifteen- to eighteen-year-old elite adolescent

male South African Rugby Union players in the North West province. Researchers such as Spamer *et al*. (2009), Durandt *et al*. (2006), Plotz and Spamer, (2006), Spamer and De la Port (2006) and van Gent and Spamer (2005) have compared positional groups (u/13, u/16, u/18, u/19) of players in the North West province. This studies, however, compare the playing positions of six different positional groups using a large number of participants (front row players (N=109), locks (N=56), loose forwards (N=142), centres (N=74), halves (N=69) and outside backs (N=96).) and they compare u/15, u/16 and u/18 players.

Such a documented set of characteristics will enable sport scientists and coaches to develop or adapt training programmes specifically to the players' positional needs and to help evaluate player positions according to their own age group. This can also be utilised as a valid tool for talent identification programmes to identify the key characteristics that should be developed and to direct players to the appropriate playing position. Catastrophic injuries among youth rugby players can also be decreased, by minimizing and eventually ruling out the mismatching of players to the wrong age group and playing position.

1.3 OBJECTIVES

The objectives of this study are:

- to identify the position- and age-specific anthropometrical characteristics of 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province; and
- to identify position- and age-specific physical and motor characteristics of 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province.

1.4 HYPOTHESES

This study is based on the following hypotheses:

- A large practically significant difference exists between the different positions and age groups among 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province with regard to their anthropometrical characteristics.

- A large practically significant difference exists between the different positions and age groups among 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province with regard to their physical and motor characteristics.

1.5 STRUCTURE OF DISSERTATION

The dissertation is submitted in article format as approved by the Senate of the North-West University and is structured as follows:

Chapter 1:

Introduction. The bibliography is provided at the end of this chapter in accordance with the guidelines of the North-West University.

Chapter 2:

Literature review: Performance characteristics of rugby players. The bibliography is provided at the end of this chapter in accordance with the guidelines of the North-West University.

Chapter 3:

Article 1: Position-specific anthropometric characteristics of elite adolescent male South African Rugby Union players. This article will be submitted to the *South African Journal for Research in Sport, Physical Education and Recreation.* The bibliography is provided at the end of the article in accordance with the guidelines of the journal.

Chapter 4:

Article 2: Position-specific physical and motor ability characteristics of elite adolescent male South African Rugby Union players. This article will be submitted to the *South African Journal of Sports Medicine.* The bibliography is provided at the end of the article in accordance with the guidelines of the journal.

Chapter 5:

Summary, conclusions, limitations and recommendations for practice and future research.

1.6 REFERENCES

Darrall-Jones, J.D., Jones, B. & Till, K. 2015. Anthropometric and physical profiles of English academy Rugby Union players. *Journal of strength and conditioning research*, 29(8):2086–2096.

Delahunt, E., Byrne, R.B., Doolin, R.K., McInerney, R.G., Ruddock, C.T.J. & Green, B.S. 2013. Anthropometric profile and body composition of Irish adolescent Rugby Union players aged 16-18. *Journal of strength and conditioning research*, 27(12):3252–3258.

Durandt, J., Du Toit, S., Borresen, J., Hew-Butler, T., Masimla, H., Jakoet, I. & Lambert, M. 2006. Fitness and body composition of elite junior South African rugby players. *South African journal of sports medicine*, 18(2):38–45.

Duthie, G.M., Pyne, D., & Hooper, S. 2005. Time motion analysis of 2001 and 2002 Super12 rugby. *Journal of sport sciences*, 23(5):523–530.

Duthie, G.M., Pyne, D., & Hooper, S. 2003. The applied physiology and game analysis of rugby union. *Sports medicine*, 33(13):973–991.

Krause, L.M., Naughton, G.A., Denny, G., Patton, D., Hartwig, T. & Gabbett, T.J. 2015. Understanding mismatches in body size, speed and power among adolescent rugby union players. *Journal of science and medicine in sport*, 18(3):358–363.

Macedonio, M.A. & Dunford, M. 2009. The athlete's guide to making weight. Champaign, IL: Human Kinetics.

Nicholas, C.W. 1997. Anthropometric and physiological characteristics of Rugby Union football players. *Sports medicine*, 23(6):275–396.

Noakes, T. & Du Plessis, M. 1996. Rugby without risk. A practical guide to the prevention and treatment of rugby injuries. Pretoria: J.L. van Schaik.

Nutton, R.W., Hamilton, D.F., Hutchison, J.D., Mitchell, M.J., Simpson, A.H.R.W. & MacLean, J.G.B. 2012. Variation in physical development in schoolboy rugby players: can maturity testing reduce mismatch? *British medical journal*, 2(4):1–6.

Olds, T. 2001. The evolution of physique in male rugby union players in the twentieth century. *Journal of sports sciences*, 19(4):253–262.

Plotz, A.F. & Spamer, M.J. 2006. A comparison of talented South African and English youth rugby players with reference to game-specific-, anthropometric-, physical and motor variables. *South African journal for research in sport, physical education and recreation*, 28(1):101–107.

Pook, P. 2012. Complete conditioning for rugby. Champaign, IL: Human Kinetics.

Quarrie, K.L. & Hopkins, W.G. 2007. Changes in player characteristics and match activities in Bledisloe Cup Rugby Union from 1972 to 2004. *Journal of sport sciences*, 25(8):895–903.

Spamer, E.J. & De la Port, Y. 2006. Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18-year-old South African schoolboy rugby players. *Kinesiology*, 38(2):176–184.

Spamer, E.J., Du Plessis, D.J. & Kruger, E.H. 2009. Comparative characteristics of elite New Zealand and South African u/16 rugby players with reference to game-specific skills, physical abilities and anthropometric data. *South African journal of sports medicine*, 21(2):53–57.

Van Gent, M.M. & Spamer, E.J. 2005. Comparisons of positional groups in terms of anthropometric, rugby-specific skills, physical and motor components among U 13, U 16, U 18 and U 19 elite rugby players. *Kinesiology*, 37(1):50–63.

CHAPTER 2:

LITERATURE REVIEW: PERFORMANCE CHARACTERISTICS OF RUGBY PLAYERS

2.1 INTRODUCTION

Rugby codes have steadily increased in popularity and are played professionally around the world at national and international levels (Hogarth *et al*., 2016:451). Professionalism in rugby (professional rugby codes such as RU, RS and RL) has increased over the years and has resulted in national unions developing high-performance profiles. Physical preparation is an important component of these high-performance profiles for elite player development to ensure success (Duthie, 2006:2). These performance profiles include exposing players to various performance (for example strength and speed) and anthropometric tests. Team selection can also occur according to these profiles (Darrall-Jones *et al*., 2015:2086). These profiles are characterised by specific functional (for example aerobic power, speed, strength, agility) and anthropometric characteristics (for example stature, body mass, body fat, fat-free mass). Awareness of the different characteristics of players per age category is very important for understanding a player's profile (Darrall-Jones *et al*., 2015:2086). Performance profiles represent the requirements of the sport (Fontana *et al*., 2017:409) and help coaches and selectors distinguish between talented and less talented rugby players (Van Gent & Spamer, 2005:50). Requirements are position- and age-specific due to the varying demands of different positions and age groups (Van Gent & Spamer, 2005:51). In an effort to train players optimally, it is crucial to understand when these characteristic changes will occur and at which age category these changes will take place (Darrall-Jones *et al*., 2015:2086). Players in the different playing positions of various age groups, should possess specific anthropometrical, physical and motor characteristics in accordance with their own age group and maturational status. Plotz and Spamer (2006:101-107) compared talented South African and English youth rugby players (18 years old) and found that the South African players performed the best in game-specific skills. They concluded that differences in game-specific skills could be attributed to more exposure to rugby training and physical conditioning. It is crucial to

understand when these characteristic changes will occur and at which age category these changes will take place to train players optimally (Darrall-Jones *et al*., 2015:2086).

One example of differing requirements is the varying levels of exposure to physical contests between forwards and backs (Pook, 2012:12). Another example is how the physical demands change as age groups change, highlighting the effect of growth and maturation on the player's development (Read *et al*., 2017:1297). With regard to the physique of rugby players, major shifts occurred from 1975 to 2000 as players have become taller, heavier and more athletically built with well-developed muscles when compared to players before 1975 (Olds, 2001:258). These shifts in the physique of players are also evident from research done after 2000. Macedonio and Dunford (2009:32) concur that there has been a change towards increasing levels of fitness and conditioning. These changes can be attributed to the ever-increasing competitiveness of the sport. However, requirements also differ according to the type of rugby involved, and to prevent confusion, one should clearly distinguish between the various different rugby codes that currently exist and continue to emerge such as Rugby Union (RU), Rugby League (RL), Rugby Sevens (RS), Touch Rugby (TR), Rugby Tens (RT) etc. Following the clarification of the different rugby codes, the chapter pays attention to positional characteristics and age group differences, primarily focussing on RU. Rugby League (RL) and RS will only be discussed briefly to highlight different game and physical characteristics and the influence the type of game has on these characteristics. The primarily focus is on age group differences from u/15 to u/18 players and to highlight the different anthropometric and physical characteristics that occur at different age groups. The aim of this study is to identify position- and age-specific anthropometric, physical and motor characteristics of 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province. Therefore the main focus is on RU players. Previous research on RU is in table format to demonstrate the age group differences that already exist in RU. Finally, a discussion of growth and maturation follows, with specific emphasis on the effect of growth and maturation on the male adolescent rugby player. The goal of the discussion regarding growth and maturation, is to highlight how growth and maturation changes over developmental years to indicate the importance to establish age-specific performance indicators. Growth and maturation were not measured in this study, but will be used as a scientific base-line for the importance of implementing and for better understanding of age-specific performance indicators. This chapter concludes with a summary of the main findings related to the aim of this dissertation.

2.2 DIFFERENT RUGBY CODES

A thorough discussion of the different rugby variations falls outside the scope of this dissertation. Subsequently only three codes are discussed, namely Rugby Union (RU), Rugby League (RL) and Rugby Sevens (RS), primarily focussing on RU. Although all codes originate from RU, there are notable differences concerning the rules, equipment, playing field, playing time etc. that cannot be ignored (Hogarth *et al.*, 2016:451; Ross *et al.*, 2014:357). RS in particular is played with fewer players per team and shorter match durations compared to all other rugby codes, whereas the laws of RL differ extensively from those of RU and RS pertaining to the breakdown of tackles (formation of rucks) and scrummaging (Hogarth *et al*., 2016:452). The similarities and differences consequently affect the characteristics of each code. Consideration of these similarities and differences may shed light on the possible similarities and differences in the characteristics of the players involved in each code.

2.2.1 RUGBY UNION

2.2.1.1 Game characteristics

Rugby Union is a field-based team sport that is played over two 40-minute halves separated by a break no longer than 10 minutes (Duthie *et al*., 2003:974). The game is intermittent in nature, requiring players to compete in a challenging contest comprising intense bouts of sprinting and tackling, separated by short bouts of lower intensity activities (Gabbett, 2005b:675). In the space of an 80-minute game, players cover distances of six to eight kilometres at varying running speeds and distances. This requires strength, power, speed, agility and an ability to repeat and recover from game movements (Pook, 2012:1). In a review by Chiwaridzo *et al.* (2016:2), the authors acknowledge that the players engage in physically demanding contests such as tackles, rucks and mauls to gain possession of the ball. This means that players have to possess a wide range of physical attributes such as strength, speed and agility, allowing them to be fatigue-resistant and stronger in physical contests. It is therefore understandable that there is more emphasis on the level of fitness and conditioning of players to meet these demands and to keep up with competitive nature of RU (Macedonio & Dunford, 2009:32). Physical characteristics play a vital part in performance behaviours associated with success (Hughes *et al*., 2017:3) and it is therefore important to identify what these physical characteristics entail. Certain anthropometric, physical and motor attributes of RU players are unique to their playing positions because of the different

levels of physicality between forwards and backs (Pook, 2012; Spamer & De la Port, 2006). These anthropometric, physical and motor attributes are influenced by the number of tackles, rucks and set pieces in which the players are involved (Pook, 2012:12).

2.2.1.2 Physical and motor ability characteristics

As a result of the physical demands of the game, the physiological qualities of players have to be highly developed, requiring high levels of aerobic fitness, speed, muscular strength, power and agility (Gabbett, 2005b:675). Speed is fundamental to success in RU at the top level and enables players to move quickly to position themselves during both attacking and defensive plays (Chiwaridzo *et al.,* 2016; Duthie *et al.*, 2003). A study done by Austin *et al*. (2011:262) investigated the match-play demands of RU players competing in Super 14 matches during the 2008 and 2009 seasons and found that the average number of sprints for all positional groups was 40, which was significantly greater than the average reported by Duthie *et al*. (2005:527) earlier. Another physical characteristic essential in rugby is agility, since players are required to make quick decisions while performing rapid movements in the form of accelerations, decelerations and change in direction (Chiwaridzo *et al.*, 2016:2). Plotz and Spamer (2006:101-107) compared talented South African and English youth rugby players (18-years old) and concluded that speed and agility can be influenced by excess body mass, which makes players slower and less agile. Strength expressed in both absolute terms (regardless of body mass) and relative to body mass is critical to RU success (Duthie, 2006:4). High levels of muscular power are required to effectively perform lifting, pushing and pulling tasks as well as line-out jumping and breaking tackles to beat defenders in a match (Coetzee & Pienaar, 2013; Gabbett, 2005a; Gabbett, 2005b). Concerning the energy systems, RU players use both aerobic and anaerobic energy systems, covering between 5 500 and 9 929 metres per match depending on the level of competition, the pace of the game and playing position (Chiwaridzo *et al.,* 2016:2). High levels of aerobic fitness also aid recovery after high-intensity bouts of activities (Gabbett, 2005a:401). It is therefore clear why the early study of Duthie *et al*. (2003:980) recommends that an improvement in strength, power and speed qualities might result in higher work capacities together with optimal physical development among RU players.

2.2.1.3 Anthropometric characteristics

One of the determining factors for success in RU for international competitions is the anthropometric profile of the RU players (Delahunt *et al*., 2013:3252). The anthropometric qualities that play a definite role in player selection are body mass and stature (Norton & Olds, 2001:764). Research indicated that teams consisting of greater stature and body mass perform better in RU (Duthie *et al*., 2003:976; Olds, 2001:257). The importance of having the appropriate physique to perform optimally in a specific sport is well documented (De Ridder, 2011:9). The combination of physical and functional characteristics, like percentage body fat and speed, appear to be the most influential predictors in rugby (Fontana *et al*., 2017:413) and they can also influence each other where excess body mass makes players slower (Plotz & Spamer, 2006:105). An explicit physique will direct a player towards a particular position due to the different positional requirements as mentioned earlier (Duthie *et al*., 2003:975). When comparing forward to the back line players, the groups have different anthropometric profiles and there is also anthropometric differentiation within specific playing positions (Delahunt *et al*., 2013:3252).

2.2.2 POSITIONAL CHARACTERISTICS IN RUGBY UNION

In a convoluted and highly structured sport such as RU, there are notable discrepancies in position-specific roles, technical capacity and anthropometry. This leads to variations in players' physical performance and player match loads (McLaren *et al*., 2016; Duthie *et al*., 2003). Two major positional groups exist, namely forwards and backs (Duthie *et al.*, 2003:975). The differences between forward and back line players are largely the result of varying activities, such as the different number and duration of individual activities and different total time in play during competition (Duthie *et al*., 2005:524,529).

Forwards spend more time in static exertions such as lifting or tackling (Duthie *et al*., 2005:524,529). They produce better strength and aerobic endurance results when measured, regardless of their muscle or body size (Duthie *et al*., 2005; Duthie *et al*., 2003; Nicholas, 1997; Quarrie *et al*., 1996). When specific forward positions were analysed, previous studies concurred that props are in continual close contact with opposition to gain possession of the ball and therefore require strength and power. This results in pre-eminent total work, increases in heart rates and blood lactate levels (Duthie *et al*., 2003:987). The bigger physiques of the props reflect the strength and power demands placed on them in contact-related contest situations to compete for

the ball in the scrums, rucks and mauls (Duthie *et al*., 2005; Duthie *et al*., 2003; Nicholas, 1997; Quarrie *et al*., 1996). The need for strength during scrums and mauls have become inevitable for hookers with the increasing competitiveness of the game (Duthie *et al*., 2003:975). Hookers also perform better than props on the aerobic shuttle run test (ES=1.8), but props have greater body mass than the hookers (ES=1.6) (Duthie *et al*., 2005; Duthie *et al*., 2003; Nicholas, 1997; Quarrie *et al*., 1996). Locks (position 4 and 5) are generally tall (ES=1.6) with a large body mass. They need good leg power and jumping ability to win possession at the lineouts (Nicholas, 1997; Quarrie *et al*., 1996). Locks are quicker than props and hookers on the 30 m sprint from a running start (ES=1.0) (Nicholas, 1997; Quarrie *et al*., 1996). The loose forwards (position 6, 7 and 8) need strength, power, acceleration, endurance, speed and have to be mobile in open play to successfully meet their positional requirements, such as sprinting to breakdowns and competing for ball possession (Duthie *et al*., 2005; Nicholas, 1997).

Concerning the back line players, Duthie *et al*. (2003:987) conclude in their review article that backs tend to be leaner, shorter, faster, more aerobically fit relative to body mass and more explosive than forwards. They also execute higher proportions of high-intensity sprinting efforts than forwards (Duthie *et al*., 2005:524,529). The back line players have to secure possession of the ball in tackles and rucks and evade defenders while carrying the ball in open space (Delahunt *et al*., 2013:3252). When specific back line positions are analysed, scrum halves are expected to have adequate speed and endurance to enable them to firstly control possession and secondly accelerate away from defenders (Nicholas, 1997:378). Inside and outside backs should possess the required strength, speed and power to out-manoeuvre, to run support lines, to chase down kicks and to dominate collisions against opponents during attack or defence (Nicholas, 1997; Quarrie *et al*., 1996). Also important to note is that the scrum half and fly half are generally shorter with less body mass than the rest of the backs, which also explains why they are not able to generate the same amount of momentum over 30 m compared to their fellow back line players (Nicholas, 1997; Quarrie *et al*., 1996). A brief summary of the descriptive statistics of different studies is given in table format (Table 1), followed by a brief discussion of the positional differences mentioned.

Table 1: Comparison of anthropometrical, physical and motor performance characteristics in elite adolescent RU players as reported by different authors.

AUTHORS	PARTICIPANTS	AGE GROUPS	POSITIONAL GROUPS	FINDINGS
Van Gent & Spamer (2005:53–56)	Elite male rugby players N = 61	u/13	Tight forwards (TF) (props, hookers and locks) Loose forwards (LF) (flankers and eight man) Halves (H) (scrum half and fly half) Back line (BL) (centres, wings and fullback)	Fat %: TF>LF (d=1.44) Fat %: H>LF Sum of skinfolds: TF>LF (d=1.45) Body mass: BL>H (d=1.07) Stature: BL>H (d=1.28) Speed endurance: TF>LF (d=1.69) Speed endurance: H>BL (d=0.83) Illinois agility test: H>BL (d=0.91)
		u/16		Stature: BL>H (d=0.81) Fat %: TF>LF (d=0.48) Sum of skinfolds: TF>LF (d=0.55) Explosive power: H>BL (d-3.5) Pull-ups: H>BL (d=0.97) Speed endurance: BL>H (d=2.62)

Note: large practical significance, $d \geq 0.8$; medium practical significance, $d \geq 0.5$; small practical significance, $d < 0.5$; statistical significance, $p < 0.001$; 1RM = one repetition maximum.

AUTHORS	PARTICIPANTS	AGE GROUPS	POSITIONAL GROUPS	FINDINGS
		u/18		Body mass: TF>LF (d=1.67) Body mass: BL>H (d=1.13) Stature: BL>H (d=1.45) Fat %: TF>LF (d=1.92) Sum of skinfolds: TF>LF (d=0.83)
Durandt *et al*. (2006:40–41)	Elite male junior South African rugby players N = 174	u/16 and u/18	Prop Hooker Lock Loose forward Scrum half Fly half Wing Centre Fullback	Stature: Locks > all positions (p<0.00004) Body mass: Props > all positions (p<0.0001) Fat %: Props > all positions (p<0.00001) Sum of skinfolds: Props > all positions (p<0.00204) 1RM bench press: Props > Scrum half (p<0.00231) 1RM bench press of props > Fly half (p<0.02941) 1RM bench press: Props > Wing (p<0.00094) Pull-ups: Props < Scrum half (p<0.009) Pull-ups: Props < Wing (p<0.02) Pull-ups: Props < Centre (p<0.006) Pull-ups: Locks < Scrum half (p<0.03) Speed 10 m: Props < Lock (p<0.003) Speed 10 m: Props < Loose Forward (p<0.00002) Speed 10 m: Props < Scrum half (p<0.00001) Speed 10 m: Props < Fly half (p<0.0002) Speed 10 m: Props < Wing (p<0.00001) Speed 10 m: Props < Centre (p<0.00001)

Note: large practical significance, d≥0.8; medium practical significance, d≥0.5; small practical significance, d<0.5; statistical significance, p < 0.001; 1RM = one repetition maximum.

AUTHORS	PARTICIPANTS	AGE GROUPS	POSITIONAL GROUPS	FINDINGS
				Speed 10 m: Props < Fullback ($p<0.00005$) Speed 10 m: Locks < Wing ($p<0.05$) Speed 40 m: Props < all positions ($p<0.01$) Illinois agility test: Props < Scrum half ($p<0.04$) Illinois agility test: Props < Fly half ($p<0.007$) Illinois agility test: Props < Wing ($p<0.0002$) Illinois agility test: Props < Centre ($p<0.0007$) Illinois agility test: Props < Fullback ($p<0.04$) Multistage shuttle run: Props < Loose Forwards ($p<0.0007$) Multistage shuttle run: Props < Scrum half ($p<0.03$) Multistage shuttle run: Props < Fly half ($p<0.03$) Multistage shuttle run: Props < Wing ($p<0.03$)
Spamer & De la Port (2006:178)	Green squad of the South African Rugby Union N = 146	u/16	2003 rugby season 2004 rugby season	Stature: 2003 < 2004 ($d = 0.34$) Body mass: 2003 < 2004 ($d = 0.24$) Sum of skinfolds: 2003 < 2004 ($d = 0.15$) Muscle %: 2003 > 2004 ($d = 0.35$) Fat %: 2003 < 2004 ($d = 0.17$) Speed 10 m: 2003 > 2004 ($d = 0.67$) Speed 40 m: 2003 > 2004 ($d = 0.55$) Illinois agility test: 2003 > 2004 ($d = 0.33$)

Note: large practical significance, $d \geq 0.8$; medium practical significance, $d \geq 0.5$; small practical significance, $d < 0.5$; statistical significance, $p < 0.001$; 1RM = one repetition maximum.

AUTHORS	PARTICIPANTS	AGE GROUPS	POSITIONAL GROUPS	FINDINGS
				Speed endurance: 2003 < 2004 (d = 0.50) Bench press: 2003 < 2004 (d = 0.46) Pull-ups: 2003 < 2004 (d = 0.40) Push-ups: 2003 < 2004 (d = 0.73)
		u/18		Stature: 2003 < 2004 (d = 0.02) Body mass: 2003 < 2004 (d = 0.13) Sum of skinfolds: 2003 < 2004 (d = 0.17) Muscle %: 2003 > 2004 (d = 0.03) Fat %: 2003 < 2004 (d = 0.12) Speed 10 m: 2003 > 2004 (d = 0.18) Speed 40 m: 2003 < 2004 (d = 0.06) Illinois agility test: 2003 > 2004 (d = 0.41) Speed endurance: 2003 > 2004 (d = 0.17) Bench press: 2003 < 2004 (d = 0.50) Pull-ups: 2003 > 2004 (d = 0.37) Push-ups: 2003 < 2004 (d = 0.27)

Note: large practical significance, d≥0.8; medium practical significance, d≥0.5; small practical significance, d<0.5; statistical significance, $p < 0.001$; 1RM = one repetition maximum.

The first study conducted by Van Gent and Spamer (2005) investigated u/13 RU players and found that the forwards differed from the back line players in terms of anthropometric components. The back line players outperformed the forwards in the physical and motor components. Research on u/16 and u/18 RU players yielded similar results with significant differences between forward and back line players with regard to the anthropometric, physical and motor components. Durandt *et al*. (2006) found that locks were taller than all other positions and that props had a larger body mass, fat percentage and sum of skinfolds than all other positions. Props outperformed the scrum halves, fly halves and wings in one repetition maximum (1RM) bench press and were slower in 10 and 40 m speed, the Illinois agility test and the multistage shuttle run test (Durandt *et al*., 2006; Spamer & De la Port, 2006; Van Gent & Spamer, 2005).

The results obtained in the above-mentioned studies reflect the demands placed on the players regarding their respective positions. The above findings correlates with a study done by Hughes *et al*. (2017:3), who found that motor ability characteristics such as speed plays a critical part in a rugby players' match success and correlates with line breaks, tackles and tries scored during RU games (Smart *et al.*, 2014:S16). Possessing a certain type of physique and a typical set of physical performance characteristics to best meet the demands imposed by each of the positions in rugby is widely accepted by selectors, coaches and players of the game (Quarrie *et al*., 1996:55). Duthie *et al*. (2003:975) also mention that a certain physique will direct a player towards a certain position instead of others. It is therefore important to give attention to the key game behaviours during competition for each position and to reflect on the importance of physical and motor ability characteristics such as speed, repeated sprint ability and body composition (Smart *et al*., 2014:S8).

2.2.3 AGE GROUP DIFFERENCES IN RUGBY UNION

Physical and motor abilities, as well as anthropometrical characteristics change during the development years of young sportsmen (Du Plessis, 2007:57). This is evident from most related research involving comparisons between different age groups in RU. When comparing u/18 players with u/16 players, statistically significant differences were observed with the u/18 group testing taller in stature ($p<0.001$) and body mass ($p<0.0001$). Absolute ($p<0.00001$) and relative ($p<0.001$) 1RM bench press measures for upper body strength, push-up test ($p<0.000009$) and shuttle run test ($p<0.05$) also showed that the u/18 players outperformed the

younger age groups (Durandt *et al*., 2006; Spamer & De la Port, 2006; Van Gent & Spamer, 2005). A recent study by Read *et al*. (2017) quantified the physical demands of representative adolescent English RU match play and investigated the differences between playing positions and age groups. These researchers found that both the relative distance and low- and high-speed running per minute tended to be lower in older age groups (u/18 compared to u/16) for all positions. PlayerLoad™ per minute (PL.min $^{-1}$) (accumulated accelerations from the three axes of movement) was greater in u/18 than u/16 for all positions and PlayerLoad™ slow per minute ($PL_{slow}.min^{-1}$) (accumulated accelerations from the three axes of movement where velocity is <2 $m.s^{-1}$) was greater for older age groups. These findings indicate that physical demands change as the age groups change, which indicates that adolescent RU players engage in a greater amount of activity from collisions and static exertions as they get older. These findings also highlight the importance of adolescent growth and the effect it has on athletic development.

The target population in the above-mentioned studies consisted of adolescent players with an age range between 14 and 18 years. Teenagers (13 to 19 years) represent 22%–39% of registered players in the top five rugby-playing nations (Bleakley *et al.,* 2011:555). The fact that very few differences were found in terms of anthropometric components of different positions among the u/16 players proves that at this age all players seemed relatively similar, irrespective of their position (Van Gent & Spamer, 2005:59). The u/18 players differed significantly in stature, body mass, upper body strength and aerobic fitness. This shows that differences could be attributed to maturation and could be the result of normal growth and development of the adolescents at that age (Durandt *et al*., 2006; Spamer & De la Port, 2006; Van Gent & Spamer, 2005). It is evident from the above-mentioned literature that the positional requirements of adolescent rugby players differ more between age groups and positions as the players progress in age. The period between 14 and 18 years of age might be crucial for athletes' career development. Therefore, factors such as growth and maturation cannot be ignored as activity, performance and fitness can be influenced (Malina, 2014:157).

2.2.4 RUGBY LEAGUE

Rugby League (RL) is a collision sport played in several countries. Apart from the absence of lineouts, RL has similar rules and movement patterns to RU. These movements involve immediate play-the-ball after each tackle (Gabbett *et al*., 2011b:72), while each team is allowed

six tackles with the ball (Gabbett *et al*., 2008:121). A typical RL match lasts 80 minutes (Gabbett *et al*., 2011a:210) with a 10-minute rest interval between two 40-minute halves. A RL team consists of 13 players, with junior and amateur RL matches typically played with an unlimited interchange rule (substitutes going on and off the field), whereas professional RL teams are permitted a maximum of 12 interchange movements during the course of a match (Gabbett *et al*., 2008:121). The two major playing groups within a RL team are the forwards and backs.

Forwards are predominantly involved in many physical collisions and tackles, while backs spend more time in free running (Gabbett *et al*., 2008:121). The backs are players number 1 (Full back), 3 and 4 (Centres), 2 and 5 (Wings), 6 (Stand-off) and 7 (Scrum half). The forwards are players number 8 and 10 (Props), 9 (Hooker), 11 and 12 (Second row) and 13 (Loose forward). Numbers 14 to 17 are the substitutes that may replace any other position on the field (All Sports Deal, 2017). The game of RL require players to compete in a challenging contest, comprising intense bouts of sprinting and tackling, separated by short bouts of lower intensity activity (Gabbett *et al*., 2011a:210). Gabbett *et al*. (2007:1131–1132) investigated the skill characteristics of junior RL players (u/13 to u/16) and senior RL (u/20 to senior level) players and found that the ability to beat a player, to exhibit skills under fatigue, to successfully create a 2 versus 1 and to carry the ball effectively, were skill characteristics that could effectively discriminate between top and lower class RL players. Various differences exist in training experience, anthropometric and physiological characteristics (Gabbett, 2006:1276; Gabbett, 2005b:677–678). Physical qualities are important for the career advancement of RL players and the development of strength and body size should be favoured to ensure success (Till *et al*., 2016:588).

The body mass of RL players increases significantly with age and training experience and therefore they become inherently stronger per kilogram body mass (Baker, 2002:582–583). High body mass would assist in the development of greater momentum along with impact forces. For this reason, Gabbett *et al*. (2007:1131) reached congruity with Baker (2002) regarding body mass and training experience. They concluded that mature players with the body mass to tolerate physical collisions and tackles should be considered when selecting first-grade teams. Gabbet *et al*. (2007:1129) investigated the physiological, anthropometric and

skills characteristics of RL players and found that the ability to hit, spin and pass out of the tackle were statistically significantly ($p<0.05$) associated with higher body mass.

Rugby League players require well-developed speed and agility to enhance their ability to perform cover-defending tackles along with muscular power to increase their playing ability (Gabbett *et al*., 2007:1132). Previous investigations (Morehen *et al*., 2015:527; Gabbett *et al*., 2007:1129) found similar results and indicated that a high aerobic endurance capacity (VO_2 max) would facilitate recovery between high-intensity bouts of exercise, allowing aerobically fit players to perform better ($p<0.05$). A review conducted by Gabbett (2013:212) found that physical qualities such as speed, muscular power, strength and maximal aerobic power increase as the competitive standard increases, which confirm the previous results found by Gabbett *et al*. (2007:1131–1132).

Collectively, the research suggests that physical qualities improve with age and training experience, and this is beneficial for both player and team.

2.2.5 RUGBY SEVENS

Rugby Sevens (RS) has increased in popularity in recent years (Higham *et al*., 2013:19) and is now played at domestic and international level all over the world. It is also the only rugby code to be included as part of the Olympic Games as of 2016 (Higham *et al*., 2012:277). RS is an abbreviated variant of RU in which two teams, each with seven players (three designated as forwards and four designated as backs), compete for two 7-minute halves with a 2-minute half-time interval. Forwards and backs are involved in similar contact situations throughout matches (Ross *et al*., 2015:1040).

RS is played under the same laws as RU and on a full dimension rugby field (Higham *et al*., 2012:277; Meir, 2012:76). It is generally played in a tournament format with each team playing five to six matches over the course of two or three days (Ross *et al*., 2014:357). The differences in competition structure have implications for training and performance characteristics. Players must be prepared to compete multiple times a day and have to cover greater parts of the field than in RU since there is only seven players on the field (Ross *et al*., 2014:360). As a result of the modified laws of RS, it is played at a greater running intensity and requires superior aerobic and anaerobic endurance capacity to tolerate the higher running demands when compared to

RU (Higham *et al*., 2012:280,281). Irrespective of playing position, all RS players require speed, ball-handling skills, agility skills, defensive skills, strength, and power to secure the ball in contact situations (Higham *et al*., 2013:25). Players must possess the ability to pass the ball accurately while running at speed. They have to defend more space and be able to cover more ground in order to defend their try line (Meir, 2012:77). Due to the intermittent nature of this field-based team sport characterised by frequent bouts of high intensity activity and collision, RS players require highly developed speed, power and endurance qualities (Ross *et al*., 2014:357; Higham, 2013:122).

Investigations of the physical characteristics of RS players show that backs are lighter and shorter than forwards (lower body mass and stature), while players across all positions possess a lean body composition (Ross *et al*., 2014:357). Higham (2013:122) concludes that elite male RS players have anthropometric characteristics similar to RU back line players. When position is reported, RS forwards are similar in body mass to loose forwards in RU (mean ~98 and 102 kg, respectively) while RS backs are similar in body mass to RU outside backs (mean ~87 and 89 kg, respectively) (Ross *et al*., 2014:361–362). In a study done by Zandberg (2015:138), elite RS u/18 forward players showed greater values in stature, body mass, body mass index (BMI), percentage fat mass, sum of six skinfolds, skeletal mass and muscle mass than back line players. Having players greater in stature and body mass are an advantage for contesting the ball in lineouts and scrums (Meir, 2012:77). Backs benefit from a lower body mass because of the high demands placed on their positional play in accelerating and sprinting (Meir, 2012:77).

Forwards cover a greater total distance during a match, are involved in a greater number of defensive rucks and have more restart contests than backs. Back line players perform a greater number of ball carries, have more line breaks and more passes are thrown from hand than the forward players (Ross *et al*., 2015:1037). With a relatively greater area for players to cover, tackles and rucks occur less frequently than in RU (Ross *et al*., 2014:360). Acceleration, speed, lower-body muscular power and relative maximal aerobic power are also similar to, or exceed, those of RU players (Ross *et al*., 2014; Higham *et al*., 2013). International RS players have been shown to cover a mean distance of 120 m min^{-1}, a 69% greater relative distance compared with RU backs (mean 71 m min^{-1}) and loose forwards (mean 65 m min^{-1}) (Ross *et al*., 2014:359,360).

Collectively, the difference in competition structure requires players to be able to tolerate higher running demands, irrespective of playing position. Having a greater stature and body mass is an advantage for RS players in lineouts and scrums and backs especially benefit from a lower body mass because of the high accelerating and sprinting demands place on them.

2.3 EFFECT OF GROWTH AND MATURATION ON THE MALE ADOLESCENT RUGBY PLAYER

Growth and maturation are biological processes that dominate the daily lives of children and adolescents for approximately the first two decades of life. These processes occur simultaneously and can be influenced by physical activity, which also influences activity, performance and fitness (Malina, 2014:157). In elite sports, growth and maturation are important preconditions for advancing performance and athletic development (Schubring & Thiel, 2014:78). Another aspect not to be ignored is the fact that elite athletes pass through a vulnerable developmental stage during adolescence (Schubring & Thiel, 2014:78). During these vulnerable developmental stages, adolescents' musculoskeletal systems are developing (generally between 12–18 years) and many hormonal changes occur (Schubring & Thiel, 2014:78). Schoolboys also mature at different growth rates, which directly influences their anthropometric, physical and motor characteristics (Noakes & Du Plessis, 1996:222). This statement also correlates with the statement of De La Port (2004:17) that different growth rates might affect the optimal playing potential and becoming a successful rugby player. It is important to fully understand the influence of adolescents' growth, maturation and motor development.

The timing (when specific events in growth and maturation occur) and tempo at which the processes of growth and maturation occur vary considerably between individuals (Malina, 2014:158). Growth (refers to the increase in the size of the body as a whole) refers to size while maturation refers to progress in, or rate of, attaining size (Malina & Bouchard, 1991:4). As children grow, stature and body mass increase, while different segments of the body grow at different rates and times, resulting in altered body proportions, including changes in skeletal mass, muscle mass, fat mass and bodily organs (Malina, 2014:157). Physical performance characteristics are related to a child's growth, maturation and development (Malina & Boucherd, 1991:5). The development of basic movement patterns such as walking, running and

jumping and when the basic movement patterns are established influence performance. Experience, learning and practice are significant factors affecting motor competence (Malina & Boucherd, 1991:5). Both growth and maturation are important in motor activities that require bursts of strength, power and speed (Malina & Boucherd, 1991:5).

Maturation is the progress towards the biologically mature state and occurs in all bodily organs and systems (Malina, 2014:157-158). Maturation indicates the tempo and timing of progress to a mature biological state (Malina *et al*., 2004:5). Variation in progress over time implies variation in rate of change (Malina *et al*., 2004:5). People differ considerably in their rate of maturation. For example, two children may be the same size (have the same level of attained growth), but they can be in different places on the path to maturity (Malina, 2014:157–158). The fundamental distinction between growth and maturation is that individuals all end up as adults skeletally, but they do so at different times and heights (Malina & Boucherd, 1991:4). The ages of onset and termination of adolescence in boys range from 10 to 22 years and these ages are often given as limits for normal variation (Malina & Boucherd, 1991:6). Structurally, adolescence begins with an acceleration in the rate of growth in stature and reaches a peak, then begins to decelerate and finally terminates with the attainment of adult stature (Malina & Boucherd, 1991:6).

Early maturing boys within an age group have an advantage in strength, power and speed tasks compared with average and late maturing boys (Malina, 2014:161–166) and most exercise and sport programmes favour early over late maturing males (Cumming *et al*., 2009:684). Malina (2014:165) also states that components of fitness change as a function of growth, maturation, development and interactions between the three processes. However, it is important to note that the best performers during adulthood are not necessarily early developing boys (Philippaerts *et al*., 2006:229). Physical characteristics change as players grow older and Pearson *et al*. (2006:282) found that the greatest increase in stature, total body mass and muscle mass for boys, occurs at the age of 13.5 years of age. There is a 17–18% change in stature during puberty and a 40% change in total body mass (Pearson *et al*., 2006:279–282). During adolescence, stature is related to pubertal status and can therefore be unreliable for talent identification because of the large alteration in growth potential during and following puberty (Pearson *et al*., 2006:279). The alteration in growth is rapid during infancy, early childhood and adolescent spurt and slows down as adult stature is attained (Manna, 2014:48). Muscle mass changes with

as much as 20% during puberty and there is a steady increase of total fat. Percentage body fat has a small decrease between the ages 14 and 16 years (Pearson *et al*., 2006:279–282).

Early maturing males have significantly greater muscle mass than late maturing males and a large portion of the growth during adolescence leads to these increases in muscle mass (Pearson *et al*., 2006:279). A slight delay can be expected for muscle weight gain as boys reach their most rapid height gain, which leads to little muscle tissue and strength potential for the next year or two (Manna, 2014:48). VO_2 peak (L min $^{-1}$) shows a steady increase throughout adolescence related to increased fat free mass (FFM) and improved cardiovascular system. Between the ages of 12 and 13 years, Vo_2 peak (L min $^{-1}$) is at its greatest increase and has a 70% approximate change during puberty. VO_2 peak (mLkg^{-1} min $^{-1}$) has a small decrease during early adolescence but remains steady during later adolescence. Anaerobic power is at the greatest increase between the ages 14 and 16 years. Strength has a dramatic increase associated with body size and has a 150% approximate change during puberty. It is at the greatest increase between the ages of 14 and 16 years. The development of strength affects motor skill performances and these performances optimally increase during the post-puberty period (Manna, 2014:49). Agility also has a 20% approximate change during puberty and a possible further increase during adolescence.

It is evident from the above-mentioned research that physical characteristics (stature, body mass and muscle mass) and performance characteristics (strength, agility, aerobic and anaerobic power) change as the player develops. In addition to these changes, Wylleman and Reints (2010:88) note that training load, greater competitive requirements and performance pressures increase from youth to professional level. Consequently, it seems important to develop or adapt training programmes and performance characteristics specifically to the players' own age group to avoid measures of growth-related variables to be confounders on characteristics such as body composition (Pearson *et al*., 2006:279). When working with young rugby players, growth and maturation factors should always be kept in mind, especially when it is one of the key elements of sport participation (Manna, 2014:50).

2.4 CONCLUSION

It is clear from the literature discussed that there are anthropometric, motor and physical differences in most, if not all, age groups as the players develop. The period between 14 and 18 years of age is in the majority of cases decisive for athletes' career development. Factors such as growth and maturation can also influence activity, performance and fitness, which also influence physical activity (Malina, 2014:157). Males start to develop by 15 years and the effect of growth and maturity should be considered, especially with regard to physical characteristics. Early maturing males are heavier than their age-matched peers (Pearson *et al*., 2006:279). The effect of puberty on speed will give a rapid increase for such a performance characteristic and will also have a dramatic increase when associated with body size (Pearson *et al*., 2006:282). This is also in accordance to what Hughes *et al*. (2017:3) found, namely that performance characteristics such as speed for example, plays a critical part in a rugby players' match success and correlates with line breaks, tackles and tries scored during RU games (Smart *et al*., 2014:S16). Selectors, coaches and players of the game widely accept the requirement of possessing a certain type of physique and a typical set of physical performance characteristics to best meet the demands imposed by each of the positions in rugby (Quarrie *et al*., 1996:55). As mentioned by Duthie et al. (2003:975), an explicit physique will direct a player towards a particular position instead of another.

It is important for coaches, selectors and sport scientists to acknowledge that players are still developing and have varying maturity statuses. According to Philippaerts *et al*. (2006:229) and Malina *et al*. (2004:337), coaches and trainers should be familiar with the features associated with the adolescent growth spurt. They should take note that the changes occurring in growth and performance during this time are extremely individualised. Stature, for example, is primarily attributed to altered hormone activity and is therefore unreliable for talent identification because of the growth potential during and following puberty (Pearson *et al*., 2006:279). However, important physical and physiological qualities, as mentioned in the literature review, should be developed at junior level and can be adjusted and tweaked at a later stage (Duthie, 2006:2). It is therefore very important to acknowledge that players are still developing and that these factors have an influence on their performance characteristics and huge differences might exist between age-matched peers. If coaches are informed on age and position-specific requirements of a sport such as rugby, they will be better equipped to direct

and coach young players in those positions where they are most likely to succeed. For this to happen, norms with regard to age and position-specific physical profiles should be established and adapted continually in order to keep up with the evolution of the game of rugby.

2.5 REFERENCES

All Sports Deal. 2017. National rugby league positions.

http://www.allsportsdeal.com/national-rugby-league-positions-nrl/ Date of access: 1 November. 2017.

Austin, D., Gabbett, T., & Jenkins, D. 2011. The physical demands of Super 14 rugby union. *Journal of science and medicine in sport*, 14:259–263.

Baker, D. 2002. Differences in strength and power among junior-high, senior-high, college-aged and elite professional rugby league players. *Journal of strength and conditioning research*, 16(4):581–585.

Bleakley, C., Tully, M., & O'Connor, S. 2011. Epidemiology of adolescent rugby injuries: A systematic review. *Journal of athletic training*, 46(5):555–565.

Chiwaridzo, M., Ferguson, G.D. & Smits-Engelsman, C.M. 2016. A systematic review protocol investigating tests for physical or physiological qualities and game-specific skills commonly used in rugby and related sports and their psychometric properties. *Systematic Reviews*, 5:122.

Coetzee, B. & Pienaar, C. 2013. Changes in selected physical, motor performance and anthropometric components of university level rugby players after one microcycle of a combined rugby conditioning and plyometric training programme. *Journal of strength and conditioning research*, 27(2):398–415.

Cumming, S.P., Standage, M., Gillison, F.B., Dompier, T.P., & Malina, R.M. 2009. Biological maturity status, body size and exercise behaviour in British youth: A pilot study. *Journal of sport sciences*, 27(7):677–686.

Darrall-Jones, J.D., Jones, B. & Till, K. 2015. Anthropometric and physical profiles of English academy Rugby Union players. *Journal of strength and conditioning research*, 29(8):2086–2096.

Delahunt, E., Byrne, R.B., Doolin, R.K., McInerney, R.G., Ruddock, C.T.J. & Green, B.S. 2013. Anthropometric profile and body composition of Irish adolescent Rugby Union players aged 16–18. *Journal of strength and conditioning research*, 27(12):3252–3258.

De La Port, Y. 2004. The physical and game skills profile of the elite South African schoolboy rugby player. Potchefstroom: NWU. (Dissertation – M.Ed).

De Ridder, J.H. 2011. Kinanthropometry in exercises and sport. 4th ed. Potchefstroom: North-West University.

Du Plessis, D.J. 2007. Comparative characteristics of elite New Zealand and South African U/16 rugby-players with reference to game specific skills, physical abilities and anthropometric data. Pretoria: University of Pretoria. (Dissertation – MA).

Durandt, J., Du Toit, S., Borresen, J., Hew-Butler, T., Masimla, H., Jakoet, I. & Lambert, M. 2006. Fitness and body composition of elite junior South African rugby players. *South African journal of sports medicine*, 18(2):38–45.

Duthie, G.M. 2006. A framework for the physical development of elite rugby union players. *Journal of sports physiology and performance*, 1:2–13.

Duthie, G.M., Pyne, D., & Hooper, S. 2005. Time motion analysis of 2001 and 2002 super 12 rugby. *Journal of sport sciences*, 23(5):523–530.

Duthie, G.M., Pyne, D., & Hooper, S. 2003. The applied physiology and game analysis of rugby union. *Sports medicine*, 33(13):973–991.

Fontana, F.Y., Colosio, A.L., Da Lozzo, G.D., & Pogliaghi, S. 2017. Players' success prediction in rugby union: From youth performance to senior level placing. *Journal of science and medicine in sport*, 20:409–414.

Gabbett, T., King, T., & Jenkins, D. 2008. Applied physiology of rugby league. *Sports medicine*, 38(2):119–138.

Gabbett, T.J. 2005a. Changes on physiological and anthropometric characteristics of rugby league players during a competitive season. *Journal of strength and conditioning research*, 19(2):400–408.

Gabbett, T.J. 2005b. A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players. *Sports medicine*, 39:675–680.

Gabbett, T.J. 2006. A comparison of physiological and anthropometric characteristics among playing positions in sub-elite rugby league players. *Journal of sport sciences*, 24(12):1273–1280.

Gabbett, T.J. 2013. Influence of playing standard on the physical demands of junior rugby league tournament match-play. *Journal of science and medicine in sport*, 17(2014):212–217.

Gabbett, T.J., Jenkins, D.G., & Abernethy, B. 2011a. Physical collisions and injury in professional rugby league match-play. *Journal of science and medicine in sport*, 14:210–215.

Gabbett, T.J., Jenkins, D.G., & Abernethy, B. 2011b. Correlates of tackling ability in high-performance rugby league players. *Journal of strength and conditioning research*, 25(1):72–79.

Gabbett, T.J., Kelly, J., & Pezet, T. 2007. Relationship between physical fitness and playing ability in rugby league players. *Journal of strength and conditioning research*, 21(4):1126–1133.

Higham, D.G. 2013. Applied physiology of rugby sevens: Performance analysis and elite player development. Canberra: University of Canberra. (Thesis – PhD).

Higham, D.G., Pyne, D.B., Anson, J.M., & Eddy, A. 2012. Movement patterns in rugby sevens: Effects of tournament level, fatigue and substitute players. *Journal of science and medicine in sport*, 15(3):277–282.

Higham, D.G., Pyne, D.B., Anson, J.M., & Eddy, A. 2013. Physiological, anthropometric, and performance characteristics of rugby sevens players. *International journal of sports physiology and performance*, 8:19–27.

Hogarth, L.W., Burkett, B.J., & McKean, M.R. 2016. Match demands of professional rugby football codes: A review from 2008 to 2015. *International journal of sport science and coaching*, 11(3):451–463.

Hughes, A., Barnes, A., Churchill, S.M., & Stone, J.A. 2017. Performance indicators that discriminate winning and losing in elite men's and women's rugby union. *International journal of performance analysis in sport*, 1–11.

Macedonio, M.A. & Dunford, M. 2009. The athlete's guide to making weight. Champaign, IL: Human Kinetics.

Malina, R.M. 2014. Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research quarterly for exercise and sport*, 85:157–173.

Malina, R.M. & Bouchard, C. 1991. Growth, maturation and physical activity. Champaign, IL: Human Kinetics.

Malina, R.M., Bouchard, C. & Bar-Or, C. 2004. Growth, maturation and physical activity. 2nd ed. Champaign, IL: Human Kinetics.

Manna, I. 2014. Growth development and maturity in children and adolescent: Relation to sports and physical activity. *American journal of sport science and medicine*, 2(5A):48–50.

McLaren, S.J., Weston, M., Smith, A., Cramb, R. & Portas, M.D. 2016. Variability of physical performance and player match loads in professional rugby union. *Journal of science and medicine in sport*, 19:493–497.

Meir, R.A. 2012. Training for and competing in sevens rugby: Practical considerations from experience in the International Rugby Board World Series. *Strength and conditioning journal*, 34(4):76–86.

Morehen, J.C., Routledge, H.E., Twist, C., Morton, J.P., & Close, G.L. 2015. Position-specific differences in anthropometric characteristics of elite European Super League rugby player. *European journal of sport science*, 15(6):523–529.

Nicholas, C.W. 1997. Anthropometric and physiological characteristics of rugby union football players. *Sports medicine*, 23(6):275–396.

Noakes, T. & Du Plessis, M. 1996. Rugby without risk. A practical guide to the prevention and treatment of rugby injuries. Pretoria: J.L. van Schaik.

Norton, K. & Olds, T. 2001. Morphological evolution of athletes over the 20th Century: Causes and consequences. *Sport medicine*, 31(11):763–783.

Olds, T. 2001. The evolution of physique in male rugby union players in the twentieth century. *Journal of sport sciences*, 19(4):253–262.

Pearson, D.T., Naughton, G.A. & Torode, M. 2006. Predictability of physiological testing and the role of talent identification for adolescent team sports. *Journal of science and medicine in sport*, 9:277–287.

Philippaerts, R.M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., Bourgois, J., Vrijens, J., Beunen, G. & Malina, R.M. 2006. The relationship between peak height velocity and physical performance in youth soccer players. *Journal of sport sciences*, 24(3):221–230.

Plotz, A.F. & Spamer, M.J. 2006. A comparison of talented South African and English youth rugby players with reference to game-specific-, anthropometric-, physical and motor variables. *South African journal for research in sport, physical education and recreation*, 28(1):101–107.

Pook, P. 2012. Complete conditioning for rugby. Champaign, IL: Human Kinetics.

Quarrie, K.L., Handcock, P., Toomey, M.J. & Waller, A.E. 1996. The New Zealand rugby injury and performance project IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *British journal of sports medicine*, 30:53–56.

Read, D.B., Jones, B., Phibbs, P.J., Roe, G.A.B., Darral-Jones, J., Weakley, J.J.S. & Till, K. 2017. Physical demands of representative match play in adolescent rugby union. *Journal of strength and conditioning research*, 31(5):1290–1296.

Ross, A., Gill, N. & Cronin, J. 2014. Match analysis and player characteristics in rugby sevens. *Sports medicine*, 44:357–367.

Ross, A., Gill, N. & Cronin, J. 2015. The match demands of international rugby sevens. *Journal of sport sciences*, 33(10):1035–1041.

Schubring, A. & Thiel, A. 2014. Growth problems in youth elite sports. Social conditions, athletes' experiences and sustainability consequences. *Reflective practice*, 15(1):78–91, Nov.

Smart, D., Hopkins, W.G., Quarrie, K.L. & Gill, N. 2014. The relationship between physical fitness and game behaviours in rugby union players. *European journal of sport science*, 14(S1):S8–S17.

Spamer, E.J. & De la Port, Y. 2006. Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18 year-old South African schoolboy rugby players. *Kinesiology*, 38(2):176–184.

Till, K., Jones, B & Brown, T.G. 2016. Do physical qualities influence the attainment of professional status within elite 16- to 19-year-old rugby league players? *Journal of science and medicine in sport*, 19:585–589.

Van Gent, M.M. & Spamer, E.J. 2005. Comparisons of positional groups in terms of anthropometric, rugby-specific skills, physical and motor components among U 13, U 16, U 18 and U 19 elite rugby players. *Kinesiology*, 37(1):50–63.

Wylleman, P. & Reints, A. 2010. A lifespan perspective on the career of talented and elite athletes: Perspectives on high-intensity sports. *Scandinavian journal of medicine & science in sports*, 20(2):88–94.

Zandberg, A. 2015. A kinanthropometric profile of elite u/18 sevens rugby players in Southern Africa. Potchefstroom: North-West University. (Dissertation – MA).

CHAPTER 3:

POSITION-SPECIFIC ANTHROPOMETRIC CHARACTERISTICS OF ELITE ADOLESCENT MALE SOUTH AFRICAN RUGBY UNION PLAYERS

TITLE: POSITION-SPECIFIC ANTHROPOMETRIC CHARACTERISTICS OF ELITE ADOLESCENT MALE SOUTH AFRICAN RUGBY UNION PLAYERS

TITEL: POSISIE-SPESIFIEKE ANTROPOMETRIESE EIENSKAPPE VAN ELITE ADOLESENTE MANLIKE SUID-AFRIKAANSE RUGBY-UNIE SPELERS

RUNNING HEAD: ANTHROPOPOMETRY: ADOLESCENT RUGBY UNION PLAYERS

LABORATORY: INSTITUTE FOR SPORT SCIENCE AND DEVELOPMENT, FNB PUK HIGH PERFORMANCE INSTITUTE OF SPORT, NORTH-WEST UNIVERSITY, POTCHEFSTROOM CAMPUS, POTCHEFSTROOM, SOUTH AFRICA

AUTHORS: SUMARI BRAND, HANS DE RIDDER, RETIEF BROODRYK, YOLANDI WILLEMSE

CORRESPONDING AUTHORS:

PROFFESSOR HANS DE RIDDER
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
POTCHEFSTROOM
2520
SOUTH AFRICA
PHONE: +2718 299 4206
FAX: +2718 299 2022
EMAIL: hans.deridder@nwu.ac.za

MR. RETIEF BROODRYK
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
2520

SOUTH AFRICA
PHONE: +2718 299 1863
FAX: +2718 299 2022
EMAIL: retief.broodryk@nwu.ac.za

DR. YOLANDI WILLEMSE
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
2520
SOUTH AFRICA
PHONE: +2718 299 1811
FAX: +2718 299 1234
EMAIL: yolandi.willemse@nwu.ac.za

(Prepared for submission to: South African Journal for Research in Sport, Physical Education and Recreation)

POSITION-SPECIFIC ANTHROPOMETRIC CHARACTERISTICS OF ELITE ADOLESCENT MALE SOUTH AFRICAN RUGBY UNION PLAYERS

Sumari BRAND [1], Johannes H. DE RIDDER [1], Retief BROODRYK [1], and Yolandi WILLEMSE [1]

Physical Activity, Sport and Recreation, Research Focus Area, PhASRec, Faculty of Health Sciences, North-West University, Potchefstroom, South Africa

ABSTRACT

The aim of this study was to compile a profile of the anthropometric characteristics (body mass, stature, selected skinfolds, girth measurements, sum of skinfolds, percentage body fat and percentage muscle mass) of u/15 (n=190), u/16 (n=164) and u/18 (n=192) elite adolescent male South African Rugby Union (RU) players in the North West province. A quantitative cross-sectional design was used to compile anthropometric profiles to determine if anthropometric characteristics differ between playing positions and age groups. This design was repeated in two consecutive years (2014 and 2015). Practically significant differences were found in the anthropometrical characteristics of participants' playing position and age group. Forward players showed greater values in most of the anthropometric characteristics compared to the back line players, in particular body mass, stature, triceps skinfold, subscapular skinfold, supraspinale skinfold, abdominal skinfold, thigh skinfold, calf skinfold, relaxed upper arm girth, thigh girth, calf girth, $\sum$ 6 skinfolds and percentage body fat. The u/15 players did not show large practically significant differences when compared to the u/16 players. Large practically significant differences occurred when the u/15 players were compared with the u/18 players. Results are individualized per position and per age group to serve as normative data to compile a scale for players in this particular age group in the North West province.

Keywords: adolescence; anthropometry; growth and maturation; positional characteristics; rugby union

INTRODUCTION

Rugby is a popular sport that is played professionally around the world at the domestic, national and international level (Hogarth *et al*., 2016). Rugby is played from primary school up to senior level in more than a hundred countries (Van Gent & Spamer, 2005). RU is an intriguing sport that entails various demands unique to playing positions (Pook, 2012). Apart from the reported differences in positional requirements, previous research also identified age group differences (Van Gent & Spamer, 2005), which can be ascribed to the different maturation rates between individuals (Noakes & Du Plessis, 1996; Durandt *et al*., 2006).

As adolescents grow, their stature and body mass increase, although different segments of the body grow at different rates. This in turn results in altered body proportions that may cause changes in skeletal mass, muscle mass, fat mass and bodily organs (Malina, 2014). Individuals pass through a vulnerable developmental stage during adolescence (Schubring & Thiel, 2014). Adolescents' musculoskeletal systems develop rapidly during these vulnerable developmental stages. This growth generally occurs between 12 and 18 years, with the greatest increase in stature, total body mass and muscle mass occurring at the age of 13.5 years (Pearson *et al*., 2006; Schubring & Thiel, 2014). There is a 17-18% rapid increase in stature during puberty (between 12 and 16 years) and a 40% increase in total body mass (Pearson *et al*., 2006). Puberty is when adolescence progress through stages of growth to reach mature adult reproductive function (Fisher & Eugster, 2014). During adolescence, height is related to pubertal status, causing large alterations in growth potential. Therefore, one should be cautious when using height as an indication of talent during the pubertal stage (Pearson *et al*., 2006). Muscle mass increases with as much as 20% during puberty develops and there is a steady increase of total fat, while percentage body fat has a small decrease between the ages 14 and 16 years and a 50% approximate change during puberty (Pearson *et al*., 2006). The increase in muscle mass is due to the rapid growth that adolescence experience and contributes to the fact that early maturing males have significantly greater muscle mass than late maturing males (Pearson *et al*., 2006). Certain physical characteristics are crucial for success in rugby such as anthropometric deficiencies that may expose some weaknesses (Meir, 2012).

The anthropometric qualities that play a definite role in player selection are body mass and stature (Norton & Olds, 2001). Research indicates that teams consisting of greater stature and body mass perform better in RU (Olds, 2001; Duthie *et al*., 2003). The importance of having the appropriate physique to perform optimally in a specific sport is well documented (De Ridder, 2011). Van Gent

and Spamer (2005) investigated u/13 RU players and found that the forwards differed from the back line players in terms of anthropometric components. Research on u/16 and u/18 RU players yielded similar results with significant differences between forward and back line players with regard to the anthropometric, physical and motor components. Durandt *et al*. (2006) found that locks were taller than all other positions ($p<0.00004$) and that props had a larger body mass, fat percentage and sum of skinfolds than all other positions. When comparing u/18 players with u/16 players, statistically significant differences were observed with the u/18 group testing taller in stature ($p<0.001$) and body mass ($p<0.0001$) (Van Gent & Spamer, 2005; Durandt *et al*., 2006; Spamer & De la Port, 2006).

The key to elite success is to develop a pathway for talent identification and development from the moment the players enter junior rugby level (Duthie, 2006; Spamer & De la Port, 2006). Physical development guidelines will help to create a pathway for talent identification and development that can help adolescents reach their optimal sporting potential (Hendricks, 2012). It is therefore important for coaches, selectors and sport scientists to acknowledge that players are still developing and have varying maturity and growth rates. The aim of this study is to compile a profile of anthropometric characteristics (body mass, stature, selected skinfolds, girth measurements, sum of skinfolds, percentage body fat and percentage muscle mass) to determine if anthropometric characteristics differ between playing positions and age groups for u/15, u/16 and u/18 players in the North West province. Scientifically compiled positional and age group anthropometric results could assist selectors, teachers, sport scientists and coaches to evaluate each player's age and position specific anthropometric profile. Profiles of this nature can contribute to the existing and new talent identification pathways used in rugby development programmes. This has the potential to direct players to playing positions in which they have the highest possibility of optimal performance.

METHODOLOGY

Research design

In this study, a quantitative cross-sectional design was used to compile the anthropometric profiles of elite u/15, u/16 and u/18 male RU players in the North West province. All the players were submitted to an anthropometric assessment during which each player's body mass, stature, selected skinfolds, girth measurements, sum of skinfolds, percentage body fat and percentage muscle mass were measured (Appendix D). This design was repeated for two consecutive years (2014 and 2015).

The methodology was explained beforehand and all the players participated on a voluntary basis with the option to withdraw at any stage. All the players were requested to complete a consent form and to provide written consent from a parent or guardian for players younger than 18 years (Appendix C).

Subjects

A group of rugby players from different schools in the North West province was selected. These players were selected by a group of provincial selectors from the LRU to form part of the High-Performance Programme. The players were selected from different participating schools (affluent and disadvantage schools) in the North West province. The group consisted of 14- to 18-year-old elite male rugby players and was divided into the following age groups: u/15 (N=190), u/16 (N=164) and u/18 (N=192). The respective age groups were also divided into six positional groups, namely front row players (N=109), locks (N=56), loose forwards (N=142), centres (N=74), halves (N=69) and outside backs (N=96). These positional groups consisted of: front row players (positions 1, 2 and 3), locks (positions 4 and 5), loose forwards (positions 6, 7 and 8), centres (positions 12 and 13), halves (positions 9 and 10) and outside backs (positions 11, 14 and 15).

Ethics

Ethics permission was granted by the Health Research Ethics Committee of the North-West University – NWU-00097-17-A1 (Appendix A).

Anthropometric measurements

Anthropometric measurements included body mass, stature, triceps-, subscapular-, supraspinale-, abdominal-, thigh- and calf skinfolds for the determination of percentage body fat, while relaxed upper arm-, mid-thigh- and calf circumferences were measured for the determination of percentage muscle mass (Appendix E). All measures were taken by trained level II kinanthropometrists in accordance with the procedures of the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart *et al.,* 2011).

Body mass was measured with a calibrated electronic scale (Precision, A&D Company, Saitama, Japan) and recorded to the nearest 0.1 (one-tenth) of a kilogram (kg). Following the guidelines of

Stewart *et al*. (2011), the subject stood still barefoot on both feet, with his weight distributed equally on the calibrated scale, eyes to the front and arms next to the side of his body.

Stature was measured with a portable stadiometer where the aim was to obtain the maximum distance from the surface on which the subject stands to its vertex (Stewart *et al*., 2011). Stature was recorded to the nearest 0.1 (one-tenth) of a centimetre.

Skinfolds were measured using a Harpenden Skinfold Caliper (10.g.mm²). The following skinfolds were measured to determine body fat percentage: triceps-, subscapular-, supraspinale-, abdominal-, thigh- and calf skinfolds. The area where the skinfold was measured, was clearly marked with a marker. The skinfold was pulled away from the underlying muscle on which the mouth of the skinfold calliper was put, 1–2 cm below the fingers holding the skinfold. The reading was taken after approximately 2–3 seconds, after which the skinfold was released. A minimum of two readings were taken as proposed by ISAK. If there was a reading difference of more than 1 mm, the skinfold was measured for a third time. The skinfolds were measured to the nearest 0.5 mm. The different skinfolds were measured according to Stewart *et al*. (2011). The sum of the six skinfolds (Σ6 skinfolds, triceps, subscapular, supraspinale, abdominal, thigh and calf), were calculated, whereas percentage body fat ((495/Body Density) – 450) and percentage muscle mass ((STAT x (0.0553 x CMTG² + 0.0987 x FG² + 0.0331 x CCG²) – 2445)/1000) were obtained according to the formula of Withers *et al*. (1989) and Martin *et al*. (1990).

Girths were measured using a flexible Lufkin Steel measuring tape. The following girths were measured for the prediction of muscle mass percentage: relaxed upper arm, mid-thigh and calf girths. The body parts that were measured were encircled by the crossover hand method, where the left hand crosses the right hand. The measuring tape was held parallel over the body part that was going to be measured and was pulled tight and the girth was taken to the nearest 0.1 cm. All girth measurements followed the procedures of Stewart *et al*. (2011).

Statistical analysis

The Statistical Consultation Services of the North-West University determined the statistical methods and procedures for the analyses of the obtained data. The IBM SPSS Statistics (Version 25) software was used to process the data. Descriptive statistics (means, standard deviations, percentiles) were calculated from cross-sectional data for anthropometric characteristics in the

different playing positions and ages. A hierarchical linear model (mixed model) was used to determine if any positional and age group differences were practically significant by means of Cohen's effect size (ES). Effect sizes of 0.2 were considered as small, 0.5 as medium and 0.8 as large (Cohen, 1988). The mean ($\bar{x}$) for each playing position for each age group (u/15, u/16 and u/18) were calculated and used to evaluate each player according to their own age group and player position.

RESULTS

The comparison of anthropometric characteristics between different playing positions is summarized in Table 1 and Table 2 for the forward and back line players respectively.

Table 1: Comparison of anthropometric characteristics between different playing positions and age groups in the forward players

		FRONT ROW			PRACTICAL SIGNIFICANCE			LOCKS			PRACTICAL SIGNIFICANCE			LOOSE FORWARDS			PRACTICAL SIGNIFICANCE		
		u/15 (N=38)	u/16 (N=30)	u/18 (N=41)	ES			u/15 (N=16)	u/16 (N=19)	u/18 (N=21)	ES			u/15 (N=49)	u/16 (N=42)	u/18 (N=51)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Body mass (kg)	x̄	87.87	93.31	99.23	0.49*	1.02**	0.53*	78.14	83.67	87.17	0.50*	0.81**	0.31	73.91	79.08	86.18	0.46*	1.10**	0.64*
	SD	11.13	15.37	13.81				7.80	15.79	12.60				9.58	8.92	12.74			
Stature (cm)	x̄	1.74	1.76	1.76	0.24	0.37	0.13	1.83	1.84	1.86	0.18	0.37	0.19	1.76	1.78	1.80	0.46*	1.10**	0.64*
	SD	0.05	0.05	0.04				0.05	0.06	0.06				0.05	0.07	0.05			
Triceps (mm)	x̄	17.02	15.17	13.86	0.47*	0.81**	0.34	11.37	11.06	11.09	0.08	0.07	0.01	10.13	10.04	9.82	0.02	0.08	0.06
	SD	6.25	4.57	4.41				4.05	4.85	3.56				3.37	3.36	3.51			
Subscapular (mm)	x̄	16.30	17.62	16.48	0.32	0.04	0.27	10.10	11.38	11.21	0.31	0.27	0.04	9.41	10.22	10.66	0.19	0.30	0.11
	SD	6.08	6.57	8.64				3.29	4.93	3.21				2.95	3.29	3.72			
Supraspinale (mm)	x̄	18.65	19.73	18.87	0.21	0.04	0.17	10.49	10.78	10.70	0.06	0.04	0.02	9.72	10.32	10.09	0.12	0.07	0.04
	SD	7.71	6.34	8.86				4.13	4.90	3.86				4.67	5.48	5.25			
Abdominal (mm)	x̄	23.80	26.06	23.81	0.34	0.00	0.34	14.09	15.10	14.51	0.15	0.06	0.09	13.16	14.34	15.68	0.18	0.38	0.20
	SD	8.90	8.25	10.52				5.87	6.36	6.01				6.58	6.76	7.82			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5*

		FRONT ROW			PRACTICAL SIGNIFICANCE			LOCKS			PRACTICAL SIGNIFICANCE			LOOSE FORWARDS			PRACTICAL SIGNIFICANCE		
		u/15 (N=38)	u/16 (N=30)	u/18 (N=41)	ES			u/15 (N=16)	u/16 (N=19)	u/18 (N=21)	ES			u/15 (N=49)	u/16 (N=42)	u/18 (N=51)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Thigh (mm)	x̄	21.80	22.94	19.70	0.23	0.42*	0.65*	14.79	14.38	15.49	0.08	0.14	0.22	13.57	14.75	14.45	0.24	0.18	0.06
	SD	6.46	6.34	5.93				5.42	5.93	5.07				4.77	4.82	5.05			
Calf (mm)	x̄	18.19	18.45	15.62	0.06	0.60*	0.66*	10.99	11.59	10.87	0.14	0.03	0.17	10.77	11.02	10.41	0.06	0.08	0.14
	SD	6.81	5.82	5.06				4.22	4.33	4.30				3.97	3.54	4.19			
Relaxed upper arm (cm)	x̄	33.28	34.57	36.65	0.44*	1.15**	0.71**	29.61	31.74	33.04	0.73**	1.17**	0.45*	30.18	31.79	33.94	0.55*	1.29**	0.74**
	SD	2.92	2.82	2.92				2.54	3.46	3.16				2.77	2.67	2.80			
Thigh (cm)	x̄	59.75	62.19	63.96	0.56*	0.97**	0.41*	55.13	57.57	56.97	0.56*	0.42*	0.14	55.10	56.25	58.59	0.27	0.80**	0.54*
	SD	5.27	5.47	4.39				3.61	5.29	4.18				4.41	3.94	4.66			
Calf (cm)	x̄	39.50	41.27	42.04	0.61*	0.88**	0.26	37.74	39.04	39.34	0.45*	0.55*	0.10	37.20	38.10	39.09	0.31	0.65*	0.34
	SD	4.95	3.42	3.05				2.44	3.22	2.94				2.56	2.05	2.99			
∑ 6 skinfolds	x̄	116.64	119.11	108.46	0.10	0.32	0.42*	72.47	74.35	73.08	0.07	0.02	0.05	67.03	70.77	70.61	0.15	0.14	0.01
	SD	37.72	31.55	35.35				25.12	28.46	22.95				23.53	24.10	26.01			
Percentage body fat	x̄	18.50	19.05	17.51	0.14	0.25	0.38	11.55	11.97	11.91	0.10	0.09	0.02	10.67	11.41	11.52	0.18	0.21	0.03
	SD	6.03	5.05	5.66				3.89	4.47	3.54				3.64	3.74	4.07			
Percentage muscle mass	x̄	40.14	39.94	40.16	0.08	0.01	0.09	43.91	43.41	42.70	0.20	0.49*	0.29	44.83	43.76	43.10	0.43*	0.70**	0.27
	SD	2.67	2.65	2.47				2.08	2.84	2.25				2.45	2.20	2.66			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5*

The majority of the large and medium practically significant differences were found when comparing the u/15 front row players, locks and loose forwards, with the u/18's forward players. Limited large and medium practically significant differences were evident when the u/16 front row and loose forwards were compared with the u/18 players. The only medium practically significant difference between the u/16 and u/18 locks, were relaxed upper arm girth.

As expected, the u/18 forwards presented greater values in most of the measurements when compared to the u/15 players, showing large practically significant differences in the following measurements: Front row: body mass (d=1.02), triceps skinfold (d=0.81), relaxed upper arm girth (d=1.15), thigh girth (d=0.97) and calf girth (d=0.88). Locks: body mass (d=0.81) and relaxed upper arm girth (d=1.17); Loose forwards: body mass (d=1.10), stature (d=1.10), relaxed upper arm girth (d=1.29), thigh girth (d=0.80) and percentage muscle mass (d=0.70). Interestingly, the u/16 and u/18 front row players showed the same mean value for stature ($\bar{x}$ = 1.76 cm). The u/15 front row players also had a higher mean muscle mass percentage in comparison with the u/16 front row players. The u/15 locks and loose forwards had the highest mean percentage muscle mass between the forward players and the u/15 and u/16 loose forwards had the lowest mean percentage body fat between the forward players.

Table 2: Comparison of anthropometric characteristics between different playing positions and age groups in the back line players

		CENTRES			PRACTICAL SIGNIFICANCE			HALVES			PRACTICAL SIGNIFICANCE			OUTSIDE BACKS			PRACTICAL SIGNIFICANCE		
		u/15 (N=29)	u/16 (N=21)	u/18 (N=24)	ES			u/15 (N=23)	u/16 (N=20)	u/18 (N=26)	ES			u/15 (N=35)	u/16 (N=32)	u/18 (N=29)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Body mass (kg)	x̄	70.24	73.56	79.26	0.30	0.81**	0.51*	65.02	68.76	71.58	0.34	0.59*	0.25	66.08	68.41	78.16	0.21	1.09**	0.88**
	SD	7.65	8.74	7.94				9.37	13.42	6.25				8.65	9.12	8.37			
Stature (cm)	x̄	1.75	1.76	1.76	0.12	0.25	0.13	1.72	1.72	1.73	0.04	0.09	0.05	1.74	1.74	1.77	0.13	0.50*	0.36
	SD	0.05	0.06	0.05				0.06	0.05	0.05				0.07	0.05	0.05			
Triceps (mm)	x̄	9.24	8.84	8.53	0.10	0.18	0.08	8.63	8.68	7.98	0.01	0.17	0.18	7.29	6.95	9.44	0.09	0.55*	0.64*
	SD	3.33	3.06	2.52				2.77	5.87	2.35				1.70	2.20	2.77			
Subscapular (mm)	x̄	8.77	8.81	9.30	0.01	0.13	0.12	7.52	9.58	8.82	0.49	0.31	0.18	7.41	7.90	9.78	0.12	0.57*	0.45*
	SD	2.96	1.86	1.33				1.60	6.37	1.62				1.33	1.83	2.08			
Supraspinale (mm)	x̄	8.26	7.44	7.96	0.16	0.06	0.10	7.32	8.41	7.11	0.21	0.04	0.25	6.76	6.52	8.04	0.05	0.25	0.29
	SD	3.46	2.52	2.38				2.14	8.68	1.78				1.68	2.06	2.65			
Abdominal (mm)	x̄	11.38	11.25	12.43	0.02	0.16	0.18	9.68	11.65	10.60	0.30	0.14	0.16	8.75	9.62	12.22	0.13	0.52*	0.39
	SD	4.74	4.77	4.25				3.36	9.70	3.47				2.45	3.80	5.22			
Thigh (mm)	x̄	13.07	11.24	11.81	0.37	0.25	0.11	10.70	12.71	12.17	0.40*	0.29	0.11	10.38	10.88	12.00	0.10	0.32	0.23
	SD	4.19	4.11	4.81				2.89	6.92	3.36				2.42	3.37	4.07			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.

		CENTRES			PRACTICAL SIGNIFICANCE			HALVES			PRACTICAL SIGNIFICANCE			OUTSIDE BACKS			PRACTICAL SIGNIFICANCE		
		u/15 (N=29)	u/16 (N=21)	u/18 (N=24)	ES			u/15 (N=23)	u/16 (N=20)	u/18 (N=26)	ES			u/15 (N=35)	u/16 (N=32)	u/18 (N=29)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Calf (mm)	x̄	10.98	7.91	9.09	0.71**	0.44	0.27	8.58	10.35	9.23	0.41*	0.15	0.26	7.55	7.48	8.71	0.01	0.27	0.28
	SD	3.16	3.07	2.59				2.31	6.53	2.97				2.13	1.77	2.80			
Relaxed upper arm (cm)	x̄	29.42	30.19	32.78	0.27	1.15**	0.89**	27.78	29.49	31.57	0.59*	1.30**	0.71**	28.06	29.50	31.95	0.49*	1.33**	0.84**
	SD	2.24	2.52	2.63				3.37	3.02	2.87				2.10	3.03	2.87			
Thigh (cm)	x̄	53.51	55.14	56.48	0.38	0.68*	0.31	51.20	54.10	53.83	0.67*	0.60*	0.06	52.21	52.83	56.09	0.14	0.89**	0.75**
	SD	3.76	3.60	3.17				4.44	5.32	3.13				3.17	3.58	3.68			
Calf (cm)	x̄	36.96	37.49	38.70	0.18	0.60*	0.42*	35.24	36.75	36.75	0.52*	0.52*	0.00	35.43	36.57	37.40	0.39	0.68*	0.28
	SD	2.58	2.00	1.61				2.89	2.77	1.86				2.48	2.99	2.52			
∑ 6 skinfolds	x̄	62.20	54.80	58.91	0.29	0.13	0.16	53.28	60.51	56.01	0.28	0.11	0.18	48.27	48.71	60.87	0.02	0.49*	0.48*
	SD	19.35	16.45	15.43				13.51	43.27	13.29				9.04	12.26	16.57			
Percentage body fat	x̄	9.91	8.92	9.70	0.25	0.05	0.20	8.55	9.89	9.30	0.33	0.19	0.14	7.80	7.97	10.04	0.04	0.55*	0.51*
	SD	3.01	2.54	2.37				2.07	7.02	2.02				1.38	1.88	2.54			
Percentage muscle mass	x̄	45.61	45.38	44.66	0.10	0.38	0.29	47.09	46.30	46.05	0.32	0.42*	0.10	47.18	46.79	44.44	0.16	1.11**	0.95**
	SD	2.10	2.18	1.61				2.49	3.53	1.92				2.53	2.01	1.68			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.

Similar to the forwards, the backs also produced large and medium practically significant differences, predominantly when comparing the u/15 centres, halves and outside backs with the u/18 centres, halves and outside backs. Although less frequently, differences were also observed when comparing the u/16 and u/18 age groups, while the comparison of u/15 and u/16 age groups scarcely yielded significant differences. Large and medium practically significant differences were also evident between the u/16 centres and outside backs. Only relaxed upper arm girth (d=0.71) showed a large practically significance between the halves of the u/16 players when compared with the u/18 players.

Interestingly, the only large effect between the u/15 and u/16 age group was found for the calf skinfold among the centres (d=0.71). Body mass (d=0.81) and relaxed upper arm girth (d=1.15) showed large practical significance when the u/15 centres were compared to the u/18 centres. Only relaxed upper arm girth (d=0.89) showed large practical significance between the u/16 and u/18 centres. When the halves were compared, relaxed upper arm girth showed a large practically significant difference between the u/15 and u/18 players (d=1.30) and between the u/16 and u/18 players (d=0.71). Body mass (d=1.09), relaxed upper arm girth (d=1.33), thigh girth (d=0.89) and percentage muscle mass (d=1.11) showed large practically significant differences between the u/15 and u/18 outside backs.

The u/16 outside backs were compared to the u/18 outside backs and showed large practically significant differences between the following measurements: body mass (d=0.88), relaxed upper arm girth (d=0.84), thigh girth (d=0.75) and percentage muscle mass (d=0.95). Interestingly, the u/16 and u/18 centres showed the same mean value for stature ($\bar{x}$ = 1.76 cm) as did the u/15 and u/16 halves ($\bar{x}$ = 1.72 cm) and u/15 and u/16 outside backs ($\bar{x}$ = 1.74 cm). The u/15 halves and outside backs also had a higher mean percentage muscle mass in comparison with the u/16 and u/18 halves and outside backs. The u/15 and u/16 outside backs also showed the lowest mean percentage body fat between the back line players.

DISCUSSION

The objective of this study, which was to identify position- and age-specific anthropometrical characteristics of u/15 to u/18 RU players in the North West province, was reached with the results obtained. Not all results obtained showed large practically significant differences. When the forward and back line players were compared in this study, the forward players showed

greater values in most of the anthropometric characteristics compared to the back line players, in particular body mass, stature, triceps skinfold, subscapular skinfold, supraspinale skinfold, abdominal skinfold, thigh skinfold, calf skinfold, relaxed upper arm girth, thigh girth, calf girth, $\sum$ 6 skinfolds and percentage body fat. The previous mentioned variables were higher for the forward players. These anthropometric differences between forward and back line players have been observed in RU literature previously (Quarrie *et al*., 1996; Nicholas, 1997; Duthie *et al*., 2003; Duthie *et al.*, 2005; Van Gent and Spamer, 2005).

Forwards are exposed to contact-related contests more frequently when they compete for ball possession in rucks and mauls (Quarrie *et al*., 1996). Research indicates that size (stature and body mass) benefit players during contact situations, explaining why all research concurs that forwards are usually bigger than backs (Duthie *et al*., 2003; Duthie *et al*., 2005). Specialization of positions has led to specific anthropometric characteristics, which are essential for optimal performance for different playing positions (Nicholas, 1997). Previous literature found that forward players possess a higher percentage muscle mass than back line players (Quarrie *et al*., 1996; Nicholas, 1997; Duthie *et al*., 2003; Duthie *et al*., 2005). This was not the case in this study, where percentage muscle mass favoured the back line players. According to Deurenberg *et al*. (1999), possible reasons for this phenomenon could be attributed to differences in physical activity between groups, where groups with a higher activity level might have higher proportions of muscle mass in the body. However, this might be a possible reason for the back line players displaying higher percentage muscle mass in this study. This was not tested in this study and is recommended for future research. Another possible reason for the back line players having a higher percentage muscle mass might be that they had smaller skinfold measurements than the forward players.

When the u/15, u/16 and u/18 players were compared in this study, practical age group and positional differences existed. When Table 1 and Table 2 are compared, the u/15 players did not show large practically significant differences in all the anthropometrical components when compared to the u/16 players, but medium to small practically significant differences are evident. As the players get older, more differences occur, especially when u/15 players are compared with u/18 players. In terms of anthropometric components, very few differences were found among the u/15 and u/16 players, which prove that at this age the players are relatively similar. It should also be taken into account that there is just one-year difference

between the u/15 and u/16 players and two to three years difference between u/15 and u/18 players.

Large practically significant differences occurred when the u/15 players were compared to the u/18 players, which could be ascribed to the 2- to 3-year age difference. These large differences could be due to maturation and could also be the result of normal growth and development of the adolescents at that age, which is in line with previous research (Van Gent and Spamer, 2005; Durandt *et al*., 2006; Spamer and De la Port, 2006; Malina, 2014). The u/16 and u/18 front row players showed the same mean value for stature ($\bar{x}$ = 1.76 cm) and the u/16 and u/18 centres ($\bar{x}$ = 1.76 cm), which is interesting since there is an age difference of two years between the u/16 and u/18 players. This appearance of the u/16 players being the same in stature as the u/18 players could be explained by the fact that the timing (when specific events in growth and maturation occur) and tempo at which the processes of growth and maturation occur vary considerably among individuals (Malina, 2014) and that they do so at different times and heights (Malina & Boucherd, 1991).

The u/15 loose forwards and outside backs had a higher mean percentage muscle mass than the u/16 and u/18 loose forwards and outside backs. Practical significance occurred for percentage muscle mass when it was compared between the u/15 and u/16 loose forwards, the u/15 and u/18 loose forwards and outside backs and between the u/16 and u/18 outside backs. This phenomenon is interesting, for when the mean percentage muscle mass is compared to the age groups for the different positions, it shows that the younger age group (u/15) had the highest percentage muscle mass, while literature shows that muscle mass increases with age (Duthie *et al*., 2003; Malina *et al*., 2004). One possible explanations for this could be, that there was a few early maturing players in the u/15 age group. Early maturing males have significantly greater muscle mass than late maturing males and a large portion of the growth during adolescence leads to these increases in muscle mass (Pearson *et al*., 2006:279). A slight delay can be expected for muscle weight gain as boys reach their most rapid height gain, which leads to little muscle tissue and strength potential for the year or two following height gain (Manna, 2014:48). There is a clear indication in Table 1, that the u/16 and u/18 loose forwards and outside backs were taller in stature than the u/15 players.

PRACTICAL APPLICATIONS

The anthropometric data reported in this study can serve as a valuable normative data scale for RU players in this particular age groups in the North West province. Mean ($\bar{x}$) scores reported in this study can be used as guidelines to assist coaches, selectors, sport scientists and trainers for team selection and physical preparation. Furthermore, these normative data scales are individualized per position and age group, which in turn enables coaches, selectors, sport scientists and trainers to identify position specific anthropometric characteristics. This should lead to better position selection for RU players for the age groups u/15, u/16 and u/18 in the North West province. Lastly, pathways for talent identification models for RU players in the North West province can be developed to help scientists to identify and develop talented young RU players in the age groups u/15, u/16 and u/18.

CONCLUSION

Researchers such as Spamer *et al*. (2009), Durandt *et al*. (2006), Plotz and Spamer (2006), Spamer and De la Port (2006) and van Gent and Spamer (2005), documented comparisons of positional groups (u/13, u/16, u/18, u/19) of players in the North West province. This study, however, compares the playing positions of six different positional groups using a large number of participants (front row players (N=109), locks (N=56), loose forwards (N=142), centres (N=74), halves (N=69) and outside backs (N=96) and includes comparisons focussing on u/15, u/16 and u/18 players in the North West province. In conclusion, there are practically significant differences between the different playing positions and age groups. The forward players showed greater values in most of the anthropometric characteristics compared to the back line players, in particular body mass, stature, triceps skinfold, subscapular skinfold, supraspinale skinfold, abdominal skinfold, thigh skinfold, calf skinfold, relaxed upper arm girth, thigh girth, calf girth, $\sum$ 6 skinfolds and percentage body fat. The u/15 players did not show large practically significant differences when compared to the u/16 players. Large practically significant differences occurred when the u/15 players were compared with the u/18 players.

From the results in this study, it is clear that as players get older, adolescent growth spurts vary among players in the different age groups, also previously reported by Malina *et al*. (2004). Children of the same chronological age (categorized as early, average or late maturers) can

differ greatly in biological maturity status (Malina *et al*., 2004). Even though there were practically significant differences between the u/15 players were compared to the u/18 players, the results obtained between the u/15 and u/16 players and between the u/16 and u/18 players demonstrate that adolescent growth spurts vary among age groups. The reason for this could be that early maturing children stop growing in stature first and lose the muscular advantage they had over late maturing counterparts in adulthood, and late maturing boys always catch up with or even exceed their early maturing counterparts (Beunen *et al*., 1997; Malina *et al*., 2004; Pearson *et al*., 2006). This could be one of the reasons why the u/16 and u/18 front row players and centres showed the same mean value for height and why the u/15 front row players, centres, halves and outside backs had a higher percentage muscle mass than the u/16 and u/18 front row players, centres, halves and outside backs. However, further testing is needed to confirm this.

This study made use of an elite group of RU players in the North West province who has already been selected by a group of provincial selectors from the LRU to partake in the development of elite players for the ages u/15 to u/18. The results obtained by this study clearly indicate that there are differences between players' playing position and age group. Previous studies documented that in some sports, youths are selected or excluded based on body size and maturity status (Simmons and Paul, 2001; Malina, 2002; Malina *et al*., 2004; Malina, 2012), but is this fair where the timing (when specific events in growth and maturation occur) and tempo at which the processes of growth and maturation occur vary considerably among age-related peers? Coaches and trainers should be familiar with the effect of growth and maturation (Philippearts *et al*., 2006). The results obtained in this study are individualized per position per age group and can serve as valuable normative data to compile a scale of anthropometric characteristics for coaches and trainers for RU players in the North West province for the age groups u/15, u/16 and u/18.

REFERENCES

BEUNEN, G.P.; MALINA, R.M.; LEFEVRE, J.; CLAESSENS, A.L.; RENSON, R. & SIMONS, J. (1997). Prediction of adult stature and noninvasive assessment of biological maturation. *Medicine and Science in Sport & Exercise*, 29(2): 225-230, Nov.

COHEN, J. (1988). *Statistical power analysis for behavioural sciences* (2nd ed.). Hillsdale, N.Y.: Erlbaum.

DEURENBERG, P.; DEURENBERG YAP, M.; WANG, J.; LIN, F.P. & SCHMIDT, G. (1999). The impact of body build on the relationship between body mass index and percent body fat. *International Journal of Obesity*, 23: 537-542.

DE RIDDER, J.H. (2011). *Kinanthropometry in exercises and sport* (4th ed.). Potchefstroom: North-West University.

DURANDT, J.; DU TOIT, S.; BORRESEN, J.; HEW-BUTLER, T.; MASIMLA, H.; JAKOET, I. & LAMBERT, M. (2006). Fitness and body composition of elite junior South African rugby players. *South African Journal of Sports Medicine*, 18(2): 38-45.

DUTHIE, G.M. (2006). A framework for the physical development of elite rugby union players. *Journal of Sports Physiology and Performance*, 1: 2-13.

DUTHIE, G.M.; PYNE, D. & HOOPER, S. (2005). Time motion analysis of 2001 and 2002 super 12 rugby. *Journal of Sport Sciences*, 23(5): 523-530.

DUTHIE, G.M.; PYNE, D. & HOOPER, S. (2003). The applied physiology and game analysis of rugby union. *Sports Medicine*, 33(13): 973-991.

FISHER, M.M. & EUGSTER, E.A. (2014). What is in our environment that effects puberty? *Journal of Reproductive Toxicology*, 44: 7-14.

HENDRICKS, S. (2012). Trainability of junior rugby union players. *South African Journal of Sports Medicine*, 24(4): 122-126.

HOGARTH, L.W.; BURKETT, B.J. & MCKEAN, M.R. (2016). Match demands of professional rugby football codes: A review from 2008 to 2015. *International Journal of Sport Science and Coaching*, 11(3): 451-463.

MALINA, R.M. (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research Quarterly for Exercise and Sport*, 85: 157-173.

MALINA, R.M. (2012). Professor James M. Tanner and the sport sciences. *Annals of Human Biology*, 39(5): 372-381, Sep.

MALINA, R.M. (2002). The young athlete: Biological growth and maturation in a biocultural context. In F.L. Smoll, & R.F. Smith (Eds.), *Children and youth in sports: A biopsychosial perspective* (2nd ed., pp. 261–292). Dubuque, IA: Kendall Hunt.

MALINA, R.M.; BOUCHARD, C. & BAR-OR, C. (2004). *Growth, maturation and physical activity* (2nd ed.). Champaign, I.L: Human Kinetics.

MARTIN, A.D.; SPENST, L.F.; DRINKWATER, D.T. & CLARYS, J.P. (1990). Anthropometric estimation of muscle mass in men. *Journal of Medicine and Science in Sports and Exercise*, 22(5): 729-733.

MEIR, R.A. (2012). Training for and competing in Sevens Rugby: Practical considerations from experience in the International Rugby Board World Series. *Strength and Conditioning Journal*, 34(4): 76-86.

MALINA, R.M. & BOUCHARD, C. (1991). *Growth, maturation and physical activity*. Champaign, I.L: Human Kinetics.

NICHOLAS, C.W. (1997). Anthropometric and physiological characteristics of rugby union football players. *Sports Medicine*, 23(6): 275-396.

NOAKES, T. & DU PLESSIS, M. (1996). Rugby without risk. A practical guide to the prevention and treatment of rugby injuries. Hatfield, Pretoria: J.L. van Schaik publishers.

NORTON, K. & OLDS, T. (2001). Morphological evolution of athletes over the 20th Century: Causes and consequences. *Sport Medicine*, 31(11): 763–783.

OLDS, T. (2001). The evolution of physique in male rugby union players in the twentieth century. *Journal of Sport Sciences*, 19(4): 253–262.

PEARSON, D.T.; NAUGHTON, G.A. & TORODE, M. (2006). Predictability of physiological testing and the role of talent identification for adolescent team sports. *Journal of Science and Medicine in Sport*, 9: 277-287.

PHILIPPEARTS, R.M.; VAEYENS, R.; JANSSENS, M.; VAN RENTERGHEM, B.; MATTHYS, D.; CRAEN, R.; BOURGOIS, J.; VRIJENS, J.; BEUNEN, G. & MALINA, R.M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Sciences*, 24(3): 221-230.

PLOTZ, A.F. & SPAMER, M.J. (2006). A comparison of talented South African and English youth rugby players with reference to game-specific-, anthropometric-, physical and motor variables. *South African journal for research in sport, physical education and recreation*, 28(1): 101–107.

POOK, P. (2012). *Complete conditioning for rugby*. Champaign, I.L: Human Kinetics.

QUARRIE, K.L.; HANDCOCK, P.; TOOMEY, M.J. & WALLER, A.E. (1996). The New Zealand rugby injury and performance project IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *British Journal of Sports Medicine*, 30: 53-56.

SCHUBRING, A. & THIEL, A. (2014). Growth problems in youth elite sports. Social conditions, athletes' experiences and sustainability consequences. *Reflective Practise*, 15(1): 78-91, Nov.

SIMMONS, C. & PAUL, G.C. (2001). Season-of-birth bias in association in football. *Journal of Sports Sciences*, 19: 677-686.

SPAMER, E.J., DU PLESSIS, D.J. & KRUGER, E.H. (2009). Comparative characteristics of elite New Zealand and South African u/16 rugby players with reference to game-specific skills, physical abilities and anthropometric data. *South African journal of sports medicine*, 21(2): 53–57.

SPAMER, E.J. & DE LA PORT, Y. (2006). Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18-year-old South African schoolboy rugby players. *Kinesiology*, 38(2): 176-184.

STEWART, A.; MARFELL-JONES, M.; OLDS, T. AND DE RIDDER, H. (2011). International Standards for Anthropometric Assessment. Lower Hutt, New Zealand: International Society for the Advancement of Kinanthropometry.

VAN GENT, M.M. & SPAMER, E.J. (2005). Comparisons of positional groups in terms of anthropometric, rugby-specific skills, physical and motor components among U 13, U 16, U 18 and U 19 elite rugby players. *Kinesiology*, 37(1): 50-63.

WITHERS, R.T.; CRAIG, N.P.; BOURDON, P.C. & NORTON, K.I. (1987). Relative body fat and anthropometric prediction of body density of male athletes. *European Journal of Applied Physiology*, 56(2): 191-200.

CHAPTER 4:

POSITION-SPECIFIC PHYSICAL AND MOTOR CHARACTERISTICS OF ELITE ADOLESCENT MALE SOUTH AFRICAN RUGBY UNION PLAYERS

TITLE: POSITION-SPECIFIC PHYSICAL AND MOTOR CHARACTERISTICS OF ELITE ADOLESCENT MALE SOUTH AFRICAN RUGBY UNION PLAYERS

AUTHORS, NAMES AND AFFILIATIONS:

MISS SUMARI BRAND
PHYSICAL ACTIVITY, SPORT AND RECREATION RESEARCH FOCUS AREA
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
POTCHEFSTROOM
2520
SOUTH AFRICA
PHONE: +2718 299 4354
EMAIL: sumaribrandr8@gmail.com

PROFFESSOR HANS DE RIDDER
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
POTCHEFSTROOM
2520
SOUTH AFRICA
PHONE: +2718 299 4206
FAX: +2718 299 2022
EMAIL: hans.deridder@nwu.ac.za

MR. RETIEF BROODRYK
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
2520

SOUTH AFRICA
PHONE: +2718 299 1863
FAX: +2718 299 2022
EMAIL: retief.broodryk@nwu.ac.za

DR YOLANDI WILLEMSE
SCHOOL OF BIOKINETICS, RECREATION AND SPORT SCIENCE
INTERNAL BOX 494
FACULTY OF HEALTH SCIENCES NORTH-WEST UNIVERSITY
POTCHEFSTROOM CAMPUS
2520
SOUTH AFRICA
PHONE: +2718 299 1811
FAX: +2718 299 1234
EMAIL: yolandi.willemse@nwu.ac.za

(Prepared for submission to: The South African Journal of Sports Medicine)

RUNNING HEAD: PHYSICAL AND MOTOR CHARACTERISTICS: ADOLESCENT RUGBY UNION PLAYERS

Position-specific physical and motor characteristics of elite adolescent male South African Rugby Union players

S Brand, [1] Hons (Sport Science)
J H De Ridder, [1] PhD (Sport Science)
R Broodryk, [1] MA (Sport Science)
Y Willemse, [1] PhD (Sport Science)

Physical Activity, Sport and Recreation, Research Focus Area, PhASRec, Faculty of Health Sciences, North-West University, Potchefstroom, South Africa

Objectives: To compile a profile of the physical (explosive power, strength, strength endurance) and motor (speed and aerobic endurance) characteristics of u/15, u/16 and u/18 elite male South African Rugby Union (RU) players in the North West province. A quantitative cross-sectional design was used to compile physical and motor ability profiles to determine if physical and motor characteristics differ regarding playing positions and age groups.

Methods: A group of rugby players from different schools in the North West province was selected (2014 and 2015) by a group of provincial selectors from the LRU to form part of the High-Performance Programme. The players were selected from a range of participating schools (affluent and disadvantage schools) in the North West province and was divided into the following age groups: u/15 (N=190), u/16 (N=164) and u/18 (N=192). These respective age groups were also divided into six positional groups, namely front rows (positions 1, 2 and 3) (N=109), locks (positions 4 and 5) (N=56), loose forwards (positions 6, 7 and 8) (N=142), halves (positions 9 and 10) (N=69) centres (positions 12 and 13) (N=74), and outside backs (positions 11, 14 and 15) (N=96). Descriptive statistics (means, standard deviations, percentiles) were calculated from cross-sectional data for physical and motor characteristics in the different playing positions and ages. A hierarchical linear model (mixed model) was used to determine if any positional and age group differences were practically significant by means of Cohen's effect size (ES). ES of 0.2 was considered as small, 0.5 as medium and 0.8 as large (Cohen, 1988). The mean ($\bar{x}$) for each playing position for each age group (u/15, u/16 and u/18) was calculated and used to evaluate each player according to their own age group and player position.

Results: The forward players showed superior values compared to the back-line players in all age groups for strength (1 RM bench press, 1 RM back squat and 1 RM RFE left and right leg). The u/18 players performed better in the upper and lower body strength tests when compared to the younger age groups (u/15 and u/16). The u/16 players performed better than the u/18 players in the following positional groups: front row players performed better in the aerobic endurance test ($\bar{x}$=14.3), locks and loose forwards performed better in the 10- (locks) ($\bar{x}$=1.86) (loose forwards) ($\bar{x}$=1.84) and 40 m (locks) ($\bar{x}$=5.75) (loose forwards) ($\bar{x}$=5.59) speed test, centres performed better in the 40 m speed ($\bar{x}$=5.51) and aerobic endurance ($\bar{x}$=15.8) test and halves and outside backs performed better in the 10 m speed (halves)($\bar{x}$=1.79) (outside backs) ($\bar{x}$=1.84) and aerobic endurance (halves) ($\bar{x}$=15.8) (outside backs) ($\bar{x}$=16) test.

Conclusions: Physical and motor ability data reported in this study can serve as a valuable normative data scale for RU players in this particular age groups in the North West province. The physical and motor ability requirements differ among playing position and age groups.

Keywords: adolescents; growth and maturation; physical characteristics; playing positions; rugby union

INTRODUCTION

Coaches and sport practitioners used adult-based methods of training for adolescents in the past. These methods were adapted to target the key stages during childhood and to optimize training and sporting potential for adolescents.[1] RU is played from primary school up to senior level[2] and adolescents represent 22% to 39% of registered players in the top five rugby-playing nations.[3] Players are required to compete in a challenging contest, comprising intense bouts of sprinting and tackling, separated by short bouts of lower intensity activities because of the intermittent nature of RU.[4] Players cover distances of six to eight kilometres at varying running speeds, which requires physical characteristics such as strength, power, speed, agility and an ability to repeat and recover from game movements.[5] Physical characteristics play a vital part in performance behaviours associated with success[6] and it is therefore important to know what these demands and physical characteristics entails.

As a result of the physical demands (for example intense bouts of sprinting and tackling) of the game, the physical qualities of players are highly developed, requiring high levels of aerobic fitness, speed, muscular strength, power and agility.[4] There are varying levels of exposure to physical contests between forwards and backs[5] and this different levels of physicality between forwards and backs require certain physical and motor attributes of RU players and are distinctive to their playing positions.[5,7]

Another example of how the physical demands change is the varying demand of different positions and age groups.[2] As age groups change, the importance of growth and maturation on the player's development are highlighted.[8] Game-related skills and physical and motor abilities change during the development years of young sportsmen.[9] Factors such as growth and maturation cannot be ignored as activity, performance and fitness can be influenced during this development period between 14 and 18 years and might be crucial for players' career development.[10] Previous research on adolescent RU players revealed that absolute ($p<0.00001$) and relative ($p<0.001$) one repetition maximum (1RM) bench press measures for upper body strength, push-up test ($p<0.000009$) and shuttle run test ($p<0.05$) showed that the u/18 players outperformed the younger age groups.[2,7,11] A recent study by Read *et al*.[8] quantified the physical demands of representative adolescent English RU match-play and investigated the differences between playing positions and age groups. These researchers found that both the relative distance and low- and high-speed running per minute had a trend

to be lower in older age groups (u/18 compared to u/16) for all positions. PlayerLoad™ per minute (PL.min $^{-1}$) (accumulated accelerations from the three axes of movement) was greater in u/18 than u/16 for all positions, and PlayerLoad™ slow per minute (PLslow.min^{-1}) (accumulated accelerations from the three axes of movement where velocity is <2 m. s^{-1}) was greater for older age groups. These findings indicate that physical demands change as age group changes, which indicates that a greater amount of activity exists from collisions and static exertions in adolescent RU as players get older.

It is therefore very important for coaches, selectors and sport scientists to acknowledge that players are still developing and have varying maturity and growth rates. The aim of this study is to compile a profile of physical and motor characteristics among u/15 to u/18 elite male RU players of the North West. These profiles are used in order to determine if physical and motor characteristics differentiates between playing positions and age groups. Scientifically compiled positional and age group physical and motor ability profiles can assist selectors, teachers, sport scientists and coaches to evaluate each player's physical and motor ability profile according to their own age group and playing position. This might have the potential to direct players to playing positions in which they have the highest possibility to perform and help to establish talent identification pathways, which are position and age specific.

METHODOLOGY

Research design

In this study, a quantitative cross-sectional design was used to compile the physical and motor ability profiles of elite u/15, u/16 and u/18 male RU players in the North West. All the players completed a physical and motor ability assessment, whereby each player's explosive power, muscle strength, muscle endurance, speed and aerobic endurances were measured. This design was repeated for two consecutive years (2014 and 2015). The methodology was explained beforehand and all the players participated on a voluntary basis, with the option to withdraw at any stage. All the players were requested to complete a consent form and to provide written consent from a parent or guardian for the players that were younger than 18 years.

Subjects

A group of rugby players from different schools in the North West province was selected, consisting of 14- to 18-year-old elite male rugby players. These players were selected by the Leopards Rugby Union (LRU) to form part of the High-Performance Programme. The players were selected from several participating schools (affluent and disadvantage schools) in the North West province. The group was divided into the following age groups: u/15 (N=190), u/16 (N=164) and u/18 (N=192). These respective age groups were also divided into six positional groups namely: front rows (N=109), locks (N=56), loose forwards (N=142), centres (N=74), halves (N=69) and outside backs (N=96). These positional groups consisted of front rows (positions 1, 2 and 3), locks (positions 4 and 5), loose forwards (positions 6, 7 and 8), centres (positions 12 and 13), halves (positions 9 and 10) and outside backs (positions 11, 14 and 15).

Ethics

Ethics permission was granted by the Health Research Ethics Committee of the North-West University – NWU-00097-17-A1.

Physical fitness components

The physical components included explosive power, muscle strength and muscle endurance. The motor ability components included speed and aerobic endurance. The tests used to determine upper and lower extremity strength made use of a one to ten repetition maximum (1-10 RM) testing scale. Estimating the 1 RM load were used in accordance with Baechle and Earle[12].

Explosive power

A vertical jump test was used to determine the explosive power in the legs and the ability to jump in a vertical direction according to the guidelines of Baechle & Earle.[12] The vertical jump was taken to the nearest 0.5 cm.

Muscle strength

A back squat was used to determine the u/16 and u/18 players' lower extremity strength using the guidelines of Baechle and Earle.[12]

The bench press was used to determine the u/16 and u/18 players' upper extremity strength using the guidelines of Baechle and Earle.[12]

Maximum push-ups were used to determine the u/15 players' upper extremity strength in accordance with the guidelines of Baechle and Earle.[12] The player had to perform as many push-ups as possible without any rest periods in between. The maximum push-up test was used for the u/15 players instead of the bench press test, for the players were too young to perform the bench press test.

The rear foot elevation (RFE) was used to determine the u/15 players' lower extremity strength following the guidelines provided by Dos Remedios.[13]

Muscle endurance

Maximum pull-ups using a pull-up rack or bar were used to determine the players' upper extremity endurance.[14] The total number of pull-ups done correctly before the player stopped or was disqualified, was used.

Speed

10 m and 40 m speed test was used to determine the players' maximum sprint speed using a 50 m measuring tape and the Brower timing system (Utah., U.S.A.). The speed test was done by following the guidelines provided by Tanner and Gore.[15] The time was automatically recorded to the nearest 0.1 seconds.

Aerobic endurance

Yo-yo Intermittent Recovery Test Level One was used to determine the players' aerobic (with oxygen) fitness using an audio CD, 50 m measuring tape and cones by following the guidelines of Bangsbo *et al.*[16] The score was taken at the last completed lap.

Statistical analysis

The Statistical Consultation Services of the North-West University determined the statistical methods and procedures for the analyses of the obtained data. The IBM SPSS Statistics (Version 25) software was used to process the data. Descriptive statistics (means, standard deviations, percentiles) were calculated from cross-sectional data for physical and motor characteristics in the different playing positions and ages. A hierarchical linear model (mixed model) was used to determine if any positional and age group differences were practically significant by means of Cohen's ES. ES of 0.2 was considered as small, 0.5 as medium and 0.8 as large.[17] The mean ($\bar{x}$) for each playing position for each age group (u/15, u/16 and u/18) were calculated and used to evaluate each player according to their own age group and player position.

RESULTS

The comparison of physical and motor ability characteristics between different playing positions are summarized in Table 1 and Table 2 for the forward and back-line players respectively.

Table 1: Comparison of physical and motor ability characteristics between different playing positions and age groups in the forward players.

		FRONT ROW			PRACTICAL SIGNIFICANCE			LOCKS			PRACTICAL SIGNIFICANCE			LOOSE FORWARDS			PRACTICAL SIGNIFICANCE		
		u/15 (N=37)	u/16 (N=25)	u/18 (N=31)	ES			u/15 (N=15)	u/16 (N=19)	u/18 (N=16)	ES			u/15 (N=47)	u/16 (N=37)	u/18 (N=39)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Vertical jump (cm)	x̄	42.97	44.03	47.60	0.16	0.68*	0.53*	50.96	49.81	52.91	0.17	0.29	0.46*	49.32	51.88	54.99	0.38	0.84**	0.46*
	SD	6.84	5.81	8.05				6.66	6.96	7.07				6.41	6.41	5.94			
1 RM bench press (kg)	x̄	76.74	88.51	103.43	0.71**	0.62**	0.91**	74.32	78.75	81.72	0.27	0.45*	0.18	75.31	85.25	99.69	0.60*	1.48**	0.88**
	SD	16.41	15.18	21.21				9.16	16.30	16.05				14.39	15.72	16.81			
1 RM back squat (kg)	x̄	127.44	151.56	181.23	0.81**	1.81**	1.00**	115.83	134.10	148.04	0.62*	1.09**	0.47*	135.72	147.61	158.57	0.40*	0.77**	0.37*
	SD	28.51	22.84	45.46				15.35	24.03	24.39				30.04	35.49	29.31			
1 RM RFE (left) (kg)	x̄	48.90	46.10	65.10	0.18	1.03**	1.21**	40.60	47.40	50.2	0.44*	0.62*	0.18	50.9	57.2	61.9	0.40*	0.70**	0.30
	SD	18.17	14.81	18.63				8.74	13.01	9.62				15.41	17.48	18.91			
1 RM RFE (right) (kg)	x̄	49.42	44.40	65.64	0.32	1.05**	1.37**	43.87	45.16	50.24	0.08	0.41*	0.33	51.64	57.18	62.05	0.36*	0.67*	0.31
	SD	17.53	12.65	18.07				10.73	12.78	10.13				14.26	17.14	17.59			
Push-ups (reps)	x̄	16	0	0				2	0	0				22	0	0			
	SD	7.87	-	-				-	-	-				7.75	-	-			
Pull-ups (reps)	x̄	7	5	6	0.39*	0.23	0.16	6	7	9	0.11	0.67*	0.56*	9	9	9	0.05	0.11	0.06
	SD	5.32	4.89	4.23				5.25	5.21	4.21				5.23	4.68	4.73			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.

Note: Blank values cannot be compared, due to the different protocols of the test

		FRONT ROW			PRACTICAL SIGNIFICANCE			LOCKS			PRACTICAL SIGNIFICANCE			LOOSE FORWARDS			PRACTICAL SIGNIFICANCE		
		u/15 (N=37)	u/16 (N=25)	u/18 (N=31)	ES			u/15 (N=15)	u/16 (N=19)	u/18 (N=16)	ES			u/15 (N=47)	u/16 (N=37)	u/18 (N=39)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Speed 10m (sec)	x̄	1.95	1.93	1.91	0.21	0.41*	0.20	1.88	1.86	1.90	0.19	0.15	0.35	1.87	1.84	1.85	0.27	0.22	0.04
	SD	0.15	0.12	0.10				0.09	0.07	0.10				0.09	0.09	0.08			
Speed 40m (sec)	x̄	6.05	5.86	5.78	0.58*	0.82**	0.24	5.83	5.75	5.80	0.24	0.08	0.15	5.67	5.59	5.63	0.24	0.13	0.11
	SD	0.51	0.37	0.33				0.33	0.33	0.31				0.29	0.26	0.26			
Yo-yo (level)	x̄	13.8	14.3	14.2	0.43*	0.38*	0.05	14.5	14.6	15	0.09	0.45*	0.36*	14.9	15.2	15.4	0.32	0.51*	0.19
	SD	0.94	1.06	0.72				0.91	1.40	1.09				0.91	1.07	1.17			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.

Note: Blank values cannot be compared, due to the different protocols of the test

Large practically significant differences were found when the u/15 players were compared to the u/18 players in the following measurements: Front row: 1 RM bench press (d=0.62), 1 RM back squat (d=1.81), 1 RM RFE left leg (d=1.03) and right leg (d=1.05), and speed over 40 m (d=0.82); Locks: 1 RM back squat (d=1.09); Loose forwards: vertical jump height (d=0.84), 1 RM bench press (d=1.84), 1 RM back squat (d=0.77) and 1 RM RFE left leg (d=0.70). Only a few large and medium practically significant differences were evident when the u/15 front row players, locks and loose forwards were compared with the u/16 players of similar positions. 1 RM bench press (d=0.71) and 1 RM back squat (d=0.81) showed large practically significant differences for the front row players.

Large practically significant differences were also evident between the front row players when the u/16 age group were compared to the u/18 age group for 1 RM bench press (d=0.91), 1 RM back squat (d=1.00), 1 RM RFE left leg (d=1.21), and 1RM RFE right leg(d=1.37). The only large practically significant difference between the loose forwards was for 1 RM bench press (d=0.88) when the u/16 players were compared with the u/18 players. The u/15 front row players had a higher mean value ($\bar{x}$) for 1 RM RFE left leg ($\bar{x}$=48.90) and right leg ($\bar{x}$=49.42) and locks had a higher mean value for vertical jump ($\bar{x}$=50.96) compared to the u/16 forward players. The u/18 front row players had a lower mean value for aerobic endurance ($\bar{x}$=14.2) when compared to the u/16 front row players and the u/18 locks and loose forwards had a slower time for speed over 10- (locks) ($\bar{x}$=1.90) (loose forwards) ($\bar{x}$=1.85) and 40 m (locks) ($\bar{x}$=5.80) (loose forwards) ($\bar{x}$=5.63) than the u/16 locks and loose forwards

Table 2: Comparison of physical and motor ability characteristics between different playing positions and age groups in the back-line players

		CENTRES			PRACTICAL SIGNIFICANCE			HALVES			PRACTICAL SIGNIFICANCE			OUTSIDE BACKS			PRACTICAL SIGNIFICANCE		
		u/15 (N=29)	u/16 (N=19)	u/18 (N=17)	ES			u/15 (N=21)	u/16 (N=15)	u/18 (N=21)	ES			u/15 (N=35)	u/16 (N=25)	u/18 (N=22)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Vertical jump (cm)	x̄	51.61	57.08	54.89	0.81**	0.48*	0.32	51.98	53.80	54.47	0.27	0.37	0.10	53.33	54.34	55.17	0.15	0.27	0.12
	SD	7.93	5.75	6.12				4.86	5.10	4.33				7.17	7.04	7.85			
1 RM bench press (kg)	x̄	76.83	80.31	94.51	0.21	1.07**	0.86	65.84	76.47	86.48	0.65*	1.25**	0.61*	68.67	81.39	95.20	0.77**	1.61**	0.84**
	SD	13.84	11.22	17.37				15.24	19.69	18.47				9.95	18.30	16.86			
1 RM back squat (kg)	x̄	141.00	141.27	135.18	0.01	0.20	0.21	110.62	142.60	148.09	1.08**	1.26**	0.19	108.09	141.74	155.27	1.13**	1.59**	0.46*
	SD	21.00	28.23	25.63				27.35	20.25	23.41				17.86	41.37	29.22			
1 RM RFE (left) (kg)	x̄	47.9	55.8	55.6	0.51*	0.49*	0.02	50.8	49.0	52.2	0.11	0.08	0.20	44.6	54.9	58.0	0.66*	0.86**	0.20
	SD	11.36	15.72	17.38				12.05	18.31	16.40				12.56	15.02	16.18			
1 RM RFE (right) (kg)	x̄	48.54	55.13	55.78	0.43*	0.47*	0.04	50.02	47.82	53.64	0.14	0.23	0.38*	45.50	54.77	57.23	0.60*	0.76**	0.16
	SD	11.60	14.86	21.62				12.63	17.84	19.88				13.12	13.40	15.78			
Push-ups (reps)	x̄	22	0	0				21	0	0				38	0	0			
	SD	6.73	-	-				1.41	-	-				3.53	-	-			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.
Note: Blank values cannot be compared, due to the different protocols of the test.

		CENTRES			PRACTICAL SIGNIFICANCE			HALVES			PRACTICAL SIGNIFICANCE			OUTSIDE BACKS			PRACTICAL SIGNIFICANCE		
		u/15 (N=29)	u/16 (N=19)	u/18 (N=17)	ES			u/15 (N=21)	u/16 (N=15)	u/18 (N=21)	ES			u/15 (N=35)	u/16 (N=25)	u/18 (N=22)	ES		
TEST COMPONENT					u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18				u/15 vs u/16	u/15 vs u/18	u/16 vs u/18
Pull-ups (reps)	x̄	8	9	9	0.24	0.12	0.12	10	9	12	0.04	0.37*	0.41*	10	11	11	0.09	0.06	0.03
	SD	5.35	4.21	5.16				5.34	4.55	4.79				5.88	5.94	4.42			
Speed 10m (sec)	x̄	1.85	1.86	1.83	0.10	0.13	0.23	1.88	1.79	1.83	0.79**	0.44*	0.35	1.85	1.84	1.85	0.08	0.04	0.12
	SD	0.08	0.07	0.08				0.96	0.21	0.08				0.10	0.09	0.10			
Speed 40m (sec)	x̄	5.61	5.51	5.56	0.32	0.15	0.17	5.63	5.59	5.50	0.12	0.37*	0.25	5.58	5.54	5.53	0.12	0.15	0.03
	SD	0.38	0.18	0.33				0.33	0.28	0.27				0.24	0.28	0.29			
Yo-yo (level)	x̄	15.2	15.8	15	0.51*	0.22	0.73**	15.3	15.8	15.7	0.43*	0.39*	0.04	15.3	16	15.4	0.61*	0.16	0.45*
	SD	1.13	1.14	1.17				1.13	1.27	1.61				1.13	1.03	1.15			

Note: x̄= mean; SD= standard deviation; **= large practical significance, d≥0.8; *= medium practical significance, d≥0.5.
Note: Blank values cannot be compared, due to the different protocols of the test.

.

Similar to the forward players, the back-line players also produced large and medium practically significant differences, predominantly when comparing the u/15 back-line players with the u/18 back-line players. These large and medium practically significant differences differentiate to a much lesser extent between back-line players (centres, halves and outside backs) than when it was compared between the forward players (front row players, locks and loose forwards). Greater values in most of the measurements occurred among the outside backs when the u/15 age group was compared to the u/18 age group, showing a large practical significance in the following measurements; 1 RM bench press (d=1.61), 1 RM back squat (d=1.59), 1 RM RFE left leg (d=0.86) and 1 RM RFE right leg (d=0.76).

Large practically significant differences occurred in the following measurements when the u/15 players were compared to the u/16 players: Centres: vertical jump height (d=0.81); Halves: 1 RM back squat (d=1.08) and speed over 10 m (d=0.79); Outside backs: 1 RM bench press (d=0.77) and 1 RM back squat (d=1.13). When the mean value ($\bar{x}$) was compared between the different age groups (u/15, u/16 and u/18), the u/15 centres had a higher mean value for 1 RM back squat ($\bar{x}$=141) and for the aerobic endurance test ($\bar{x}$=15.2) in comparison with the u/18 centres. The u/15 outside backs had the same mean value for speed over 10 m ($\bar{x}$=1.85) than the u/18 outside backs.

When the different age groups for all positions were compared, the u/18 players performed better in the upper and lower body strength tests when compared to the younger age groups (u/15 and u/16), which correlates with the results found by previous studies.[2,7,11] Not all components favoured the older age group (u/18). In this study the u/16 age group outperformed the u/18 age group in the following playing positions: front row players performed better in the aerobic endurance test, locks and loose forwards performed better in the 10- and 40 m speed test, centres performed better in the 40 m speed and aerobic endurance test and halves and outside backs performed better in the 10 m speed and aerobic endurance test.

DISCUSSION

The objective of this study, which was to identify position- and age-specific physical (explosive power, strength, strength endurance) and motor (speed and aerobic endurance) characteristics for u/15 to u/18 RU players in the North West, was met by the results obtained. Not all results obtained showed large practically significant differences. The forward players showed higher

values than the back-line players in all age groups for strength (1 RM bench press, 1 RM back squat and 1 RM RFE left and right leg). Collectively, previous studies also concurred that the forward players require more strength and power than the back-line players to compete for the ball in scrums, rucks and mauls.[18,19,20] The back-line players were faster, more aerobically fit and more explosive than the forward players for all age groups in this study, which correlates with previous studies that found that back-line players have to be able to accelerate away from defenders, control possession and run support lines and that is why they tend to be faster, more aerobically fit and more explosive than the forward players.[19,21,22]

The various physical and motor characteristics obtained in this study were not only position-specific, but also age-specific. Large practically significant differences occurred in this study when the u/15 players were compared to the u/18 players and when the u/15 and u/16 players were compared with each other. Less practically significant differences occurred between the u/16 and u/18 players when they were compared with each other. Not all results favoured the older age groups in this study. Front row players of the u/15 age group had a higher mean value ($\bar{x}$) for 1 RM RFE left leg ($\bar{x}$=48.90) and right leg ($\bar{x}$=49.42) and the locks had a higher mean value for vertical jump ($\bar{x}$=50.96) compared to the u/16 forward players. Possible reasons for this latter could be due to certain neural adaptations that occur at different times in adolescence while growth and maturation are taking place.

Previous research indicates that improvements in strength and power in adolescents are primarily due to neural adaptations, like an increase in firing frequency and motor unit recruitment[23, 24, 25] and that anaerobic power and strength are at its greatest increase between 14 and 16 years of age and affect motor skill performances.[26,27] However, these might be possible reasons for showing better results for the younger age groups for the physical characteristics (for example strength). Future research should be done on the influence of neural changes on strength between different adolescent age groups.

The u/18 front row players had a lower mean value for aerobic endurance ($\bar{x}$=14.2) when compared to the u/16 front row players and the u/18 locks and loose forwards had a slower time for speed over 10- (locks) ($\bar{x}$=1.90) (loose forwards) ($\bar{x}$=1.85) and 40 m (locks) ($\bar{x}$=5.80) (loose forwards) ($\bar{x}$=5.63) than the u/16 locks and loose forwards. The u/15 centres had a higher mean value for 1 RM back squat ($\bar{x}$=141) and for the aerobic endurance test ($\bar{x}$=15.2) in comparison with the u/18 centres. The u/15 outside backs had the same mean value for speed

over 10 m ($\bar{x}$=1.85) than the u/18 outside backs. It appears that as playing level (u/15 to u/18) increases, the motor characteristics (speed and aerobic endurance) decreased for the u/18 players. Possible reasons for this could be the changes in body composition the players encounter as they get older. In this study the u/18 players had a higher body mass in comparison with the u/15 and u/16 players. Another possible reason for this might be that maximal oxygen uptake is at its greatest rate of increase during maturation and is more sensitive to aerobic training when peak height velocity is reached.[28] Although this was not an objective of this study, some players may have already reached their peak height velocity and therefore their results could have been influenced by this appearance.

Researchers have attributed physical and motor variabilities between age groups to growth and maturation processes occurring in these players.[2,7,11] This could explain why some playing positions showed better results for the u/16 players than for the u/18 players. The results obtained in this study that show that some positions for the u/16 players had better speed results than the u/18 players, can also be attributed to the fact that a second period of increased adaptation for boys happen between the ages of 12 and 15 years, where increased speed adaptability may be a product of growth and maturation.[1] As the physical demands change with age, the importance of adolescence growth and the effect it has on athletic development are highlighted.[8]

CONCLUSION

This study shows and describe the physical and motor ability differences between playing positions and age groups for elite u/15, u/16 and u/18 RU players in the North West. It is evident from the results that age group differences do exist between the different playing positions, which is in line with previous literature. As the players gets older, more differences occur, especially when u/15 players are compared with u/18 players. Although growth and maturational processes were not measured in this study, previous literature did contribute age-related differences regarding physical and motor characteristics to these processes. Previous research indicated that with mature age, these large differences could be attributed to maturation and could also be the result of normal growth and development of the adolescents at that age.[2,7,10,20] Some physical characteristics also showed better results for u/16 players when compared to u/18 players in this study. In the review study of Hendricks,[1] he concluded that some physical changes occurring in adolescent boys could be contributed to growth and

maturation processes being higher for boys between 12 and 15 years and that they go through a second period of adaptation regarding their biological and metabolic changes that may be a product of growth and maturation. However, a full review of these aspects is beyond the scope of this dissertation and is suggested for future research. Coaches and trainers should be familiar with the features associated with adolescent growth spurt and must take note of the changes that occur during growth. [29]

The physical and motor characteristics of RU players should be used as guidelines to assist coaches, selectors, sport scientists and trainers for team selection, talent identification and physical preparation. Therefore, the objective of this study was to compile a physical and motor characteristic profile for elite u/15, u/16 and u/18 RU players in the North West to use as a normative data scale to identify position specific physical and motor ability characteristics. This will lead to better position selection for RU players for the age groups u/15, u/16 and u/18 in the North West. Lastly, pathways for talent identification models for RU players in the North West can be developed to help scientists to identify and develop talented young RU players in the age groups u/15, u/16 and u/18.

REFERENCES

1. Hendricks S. Trainability of junior Rugby Union players. S Afr J Sports Med 2012;24(4):122–126.
2. Van Gent MM, Spamer EJ. Comparisons of positional groups in terms of anthropometric, rugby-specific skills, physical and motor components among U 13, U 16, U 18 and U 19 elite rugby players. Kinesiology, 2005;37(1):50–63.
3. Bleakley C, Tully M, O'Connor S. Epidemiology of adolescent rugby injuries: A Systematic Review. Journal of Athletic Training 2011;46(5):555–565.
4. Gabbett TJ. A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players. Sports Med 2005;39:675–680.
5. Pook P. Complete conditioning for rugby. Champaign, IL: Human Kinetics; 2012.
6. Hughes A, Barnes A, Churchill SM, & Stone JA. Performance indicators that discriminate winning and losing in elite men's and women's rugby union. International Journal of Performance Analysis in Sport 2017;1–11.
7. Spamer EJ, De la Port Y. Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18-year-old South African schoolboy rugby players. Kinesiology 2006;38(2):176–184.
8. Read DB, Jones B, Phibbs PJ, Roe GAB, Darral-Jones J, Weakley JJS, Till K. Physical demands of representative match play in adolescent rugby union. Journal of Strength and Conditioning Research 2017;31(5):1290–1296.
9. Du Plessis DJ. Comparative characteristics of elite New Zealand and South African U/16 rugby players with reference to game specific skills, physical abilities and anthropometric data. (Magister Artium thesis, University of Pretoria); 2017.
10. Malina RM. Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. Research Quarterly for Exercise and Sport, 2014;85:157–173.
11. Durandt J, Du Toit S, Borresen J, Hew-Butler T, Masimla H, Jakoet I, Lambert M. Fitness and body composition of elite junior South African rugby players. S Afr J Sports Med 2006;18(2):38–45.
12. Baechle TR, Earle RW. Essentials of strength training and conditioning. 3rd ed. Champaign, IL: Human Kinetics; 2008.

13. Dos Remedios R. Men's health power training: build bigger, stronger muscles through performance-based conditioning. NY: Rodale; 2007.
14. Reiman MP, Manske RC. Functional testing in human performance. Champaign, IL: Human Kinetics; 2009.
15. Tanner RK, Gore CJ. Physiological tests for elite athletes. 2nd ed. Champaign, IL: Human Kinetics; 2013.
16. Bangsbo J, Laia FM, Krustrup P. The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. Sports Med 2008;38(1):37–51.
17. Cohen J. Statistical power analysis for behavioural sciences. 2nd ed. Hillsdale, NY: Erlbaum; 1988.
18. McLaren SJ, Weston M, Smith A, Cramb R, Portas MD. Variability of physical performance and player match loads in professional rugby union. Journal of Science and Medicine in Sport 2016;19:493–497.
19. Duthie GM, Pyne D, Hooper S. The applied physiology and game analysis of rugby union. Sports Med 2003;33(13):973–991.
20. Duthie GM, Pyne D, Hooper S. Time motion analysis of 2001 and 2002 super 12 rugby. J Sport Sci 2005;23(5):523–530.
21. Nicholas CW. Anthropometric and physiological characteristics of rugby union football players. Sports Med 1997;23(6):275–396.
22. Quarrie KL, Handcock P, Toomey MJ, Waller AE. The New Zealand rugby injury and performance project IV. British Journal of Sport Medicine 1996;30:53-56.
23. Reilly T, Stratton G. Children and adolescents in sport: physiological considerations. Sports Exercise & Injury 1995;1(4):207–213.
24. Blimkie CJR. Resistance training during pre- and early puberty: efficacy, trainability, mechanisms and persistence. Canadian Journal of Sport Sciences 1992;17(4):264–279.
25. Ramsey JA, Blimkie CJR, Smith K, Garner S, MacDougall JD, Sale DG. Strength training effects in prepubescent boys. Medicine and Science in Sports & Exercise 1990;22(5):605–614.
26. Manna I. Growth development and maturity in children and adolescent: Relation to sports and physical activity. American Journal of Sport Science and Medicine 2014;2(5A):48–50.

27. Pearson DT, Naughton GA, Torode M. Predictability of physiological testing and the role of talent identification for adolescent team sports. Journal of Science and Medicine in Sport 2006;9:277–287.
28. Baxter-Jones ADG, Eisenmann JC, Sherar LB. Controlling for maturation in pediatric exercise science. Pediatric Exercise Science 2005;17(1):18–30.
29. Philippearts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, Bourgois J, Vrijens J, Beunen G, Malina RM. The relationship between peak height velocity and physical performance in youth soccer players. Journal of Sports Sciences 2006;24(3): 221–230.

CHAPTER 5:

SUMMARY, CONCLUSION, LIMITATIONS, RECOMMENDATIONS AND FUTURE RESEARCH

5.1 SUMMARY

The aims of this study were firstly, to investigate the differences that exist between playing positions and age groups among 15- to 18-year-old elite adolescent male South African Rugby Union (RU) players in the North West province regarding their anthropometric characteristics (body mass, stature, selected skinfold measurements, girth measurements, sum of skinfolds, percentage body fat and percentage muscle mass). The second aim was to investigate the differences that exist between playing position and age groups regarding their physical (explosive power, strength, strength endurance) and motor (speed and aerobic endurance) characteristics. The problem statement in Chapter 1 outlines the inconsistency of research findings with regard to age group differences in the different playing positions for anthropometric, physical and motor characteristics, with emphasis on the limited data available. To date no study containing information on 15- to 18-year-old elite adolescent male South African RU players in the North West province could be found. When taking into account that schoolboys mature at different rates and that this directly influences their anthropometric, physical and motor characteristics and their optimal playing potential (Noakes & Du Plessis, 1996:222), it is certainly an aspect that should not be disregarded. The lack of information resulted in the formulation of the following research questions for this study: What are the position-specific anthropometric characteristics of 15- to 18-year-old elite adolescent male South African RU players in the North West province? What are the position-specific physical and motor characteristics of 15 to 18-year-old elite adolescent male South African RU players in the North West province?

Therefore, the objectives of the investigation were to:

- Identify position and age-specific anthropometrical characteristics of 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province;

- Identify position- and age-specific physical and motor characteristics of 15- to 18-year -old elite adolescent male South African Rugby Union players in the North West province.

Chapter 2 offered a literature review of the available research on the various different rugby codes that currently exist and continue to expand, such as Rugby Union (RU), Rugby League (RL) and Rugby Sevens (RS). Following the clarification of the different rugby codes, RU was examined in more detail. The game characteristics, physical and motor characteristics, anthropometric characteristics and positional characteristics of RU players in general were highlighted. It is important to know what kind of demands the game of RU makes, since these demands influence player development and team selection. Physical demands such as tackles, rucks and mauls require players to possess a wide range of physical characteristics, such as strength, speed and agility. It is therefore understandable why more emphasis is placed on these performance characteristics (Hughes *et al*., 2017:3; Chiwaridzo *et al*., 2016:2; Macedonio & Dunford, 2009:32). Important to acknowledge is that different levels of physicality and specific game-related skills exist between positions, meaning that some performance characteristics might be position-specific (Pook, 2012; Spamer & De la Port, 2006). It is therefore important to determine clear position-specific performance characteristics. Apart from positional differences, age group differences have also been observed previously.

The review also considered age group differences in RU and the effect of growth and maturation on the male adolescent rugby player, focusing on adolescent RU players. As adolescence is a sensitive time in life (Malina, 2014:160). Adolescents pass through a vulnerable development stage and mature at different growth rates (Schulbring & Thiel, 2014:78; Noakes & Du Plessis, 1996:222). Therefore, it important to consider the changes adolescents encounter during growth and maturation to determine its effect on the performance characteristics of elite male adolescent RU players. Physical performance characteristics such as various anthropometric characteristics and strength are related to adolescents' growth and maturation. Early maturing boys have an advantage in stature, body mass, muscle mass, strength, power and speed tasks compared to late maturing boys (Malina, 2014:161 – 166; Pearson *et al*., 2006:282; Malina & Boucherd, 1991:5). Possessing a certain type of physique and a typical set of performance characteristics is widely accepted by selectors, coaches and players of the game and an explicit physique will direct a player towards a particular position over others (Duthe *et al*., 2003:975; Quarrie *et al.,* 1996:55).

In order to achieve the first objective of this study, an anthropometric profile (body mass, stature, selected skinfolds, girth measurements, percentage body fat and percentage muscle mass) of the different playing positions of 15- to 18-year-old elite adolescent male South African RU players in the North West province was compiled in Chapter 3. This chapter will be submitted in article format to the *South African Journal for Research in Sport, Physical Education and Recreation.* Results indicated that the u/18 forwards presented greater values in most of the measurements when compared to the u/15 forwards, showing large practically significant differences in the following measurements: Front row (u/18): higher body mass (d=1.02), lower triceps skinfold (d=0.81), higher relaxed upper arm girth (d=1.15), higher thigh girth (d=0.97) and higher calf girth (d=0.88). Locks (u/18): higher body mass (d=0.81) and higher relaxed upper arm girth (d=1.17). Loose forwards (u/18): higher body mass (d=1.10), taller stature (d=1.10), higher relaxed upper arm girth (d=1.29), higher thigh girth (d=0.80) and lower percentage muscle mass (d=0.70). The u/15 front row players had higher means for percentage muscle mass in comparison with the u/16 front row players.

When the back line players were compared, the only large effect between the u/15 and u/16 age group was found for the calf skinfold among the centres (d=0.71), where the u/16 centres had a lower skinfold measurement. Body mass (d=0.81) and relaxed upper arm girth (d=1.15) was higher for the u/18 centres and showed large practical significance when the u/15 centres were compared to the u/18 centres. When the halves were compared, relaxed upper arm girth showed a large practically significant difference between the u/15 and u/18 players (d=1.30) and between the u/16 and u/18 players (d=0.71) where the u/18 players had higher values. Body mass (d=1.09), relaxed upper arm girth (d=1.33), thigh girth (d=0.89) and percentage muscle mass (d=1.11) showed large practically significant differences between the u/15 and u/18 outside backs where the u/18 players had the highest values. The u/16 outside backs were compared to the u/18 outside backs and showed large practically significant differences between the following measurements where the u/18 players had higher values that the u/16 players, except for percentage muscle mass: body mass (d=0.88), relaxed upper arm girth (d=0.84), thigh girth (d=0.75) and percentage muscle mass (d=0.95).

The anthropometric data reported in this study allowed the researcher to identify position- and age-specific anthropometric characteristics. These anthropometric characteristics differ between positions and age groups. Therefore, coaches, selectors, sport scientists and trainers

should keep in mind that as age groups change, anthropometric characteristics will vary during the development years of young rugby players. These anthropometric characteristics identified in the study can serve as a valuable normative data scale for RU players in this particular age groups in the North West province. This can help to identify position specific anthropometric characteristics that will lead to better position selection for RU players for the age groups u/15, u/16 and u/18 in the North West province.

In order to achieve the second objective of this study, a physical (explosive power, strength, strength endurance) and motor characteristic profile (speed and aerobic endurance measurements) of 15- to 18-year-old elite adolescent male South African RU players in the North West province was compiled in Chapter 4. This chapter will be submitted in article format to *The South African Journal of Sports Medicine.* The u/18 forwards outperformed the u/15 forwards, showing greater values in most of the physical and motor ability characteristics. Large practical significance was found in the following measurements, where the u/18 forwards obtained better values than the u/15 forwards: Front row: 1 RM bench press (d=0.62), 1 RM back squat (d=1.81), 1 RM RFE right leg (d=1.05), 1 RM RFE left leg (d=1.03) and speed over 40 m (d=0.82). Locks: 1 RM back squat (d=1.09); Loose forwards: vertical jump height (d=0.84), 1 RM bench press (d=1.84), 1 RM back squat (d=0.77) and 1 RM RFE left leg (d=0.70). Only few large and medium practical significances were evident when the u/15 front row, locks and loose forwards were compared with the u/16 players of similar positions. The u/15 front row players, locks and loose forwards had a higher mean value ($\bar{x}$) for explosive power, muscle strength, muscle endurance and speed over 10- and 40 m in comparison with the u/16 players of similar positions. The u/18 locks and loose forwards were slower than the u/16 locks and loose forwards over both the 10- and 40 m distances.

Less practically significant differences occurred between the u/15, u/16 and u/18 back line players. The greatest values in most of the measurements occurred between the u/15 and u/18 outside backs showing a large practical significance in the following measurements; 1 RM bench press (d=1.61), 1 RM back squat (d=1.59), 1 RM RFE left leg (d=0.86) and 1 RM RFE right leg (d=0.76) that was all higher for the u/18 outside backs. Large practically significant differences occurred when the u/15 players were compared with the u/16 players, showing better values for the u/16 age group; Centres; vertical jump height (d=0.81). Halves; 1 RM

back squat (d=1.08) and speed over 10 m (d=0.79). Outside backs: 1 RM bench press (d=0.77) and 1 RM back squat (d=1.13).

The data reported in Chapter 4 revealed differences between positions and age groups with regard to physical and motor characteristics. Since physical and motor abilities differ among positions and age groups, coaches, selectors, sport scientists and trainers should keep this in mind when they identify players for team selection, talent identification and physical preparation.

5.2 CONCLUSION

The conclusions that are drawn from this research are based on the hypothesis stated in Chapter 1.

Hypothesis 1: **A large practically significant difference exists between the different positions and age groups among 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province with regard to their anthropometrical characteristics.**

The fact that differences between playing positions and the different age groups did emerge, indicates that Hypothesis 1 can be partially accepted. Not all the results showed a large practically significant difference. Forward players had greater values in most of the anthropometric measurements when compared to the back line players with various practically significant differences occurring. When all the different positions were compared with each other (front row, locks, loose forwards, centres, halves and outside backs), various practically significant differences were discovered. Various practically significant differences occurred when the different age groups (u/15, u/16 and u/18) were compared with each other, with large practically significant differences discovered when the u/15 playing positions were compared with the u/18 playing positions. Not all the results showed a practically significant difference between player playing position and age group. Nonetheless, the discoveries made can serve as a valuable normative data scale for RU players in this particular age groups in the North West province.

Hypothesis 2: **A large practically significant difference exists between the different positions and age groups among 15- to 18-year-old elite adolescent male South African Rugby Union players in the North West province with regard to their physical and motor characteristics.**

The physical and motor characteristics measured in this study, differed among playing position and age groups. These differences indicate that Hypothesis 2 can be partly accepted. Not all the results showed a large practically significant difference. Large practically significant differences occurred between the u/15 and u/18 players and between the u/15 and u/16 players. Large practically significant differences between the u/16 and u/18 players were limited. The u/16 and u/18 players showed greater values in all of the physical (explosive power, strength, strength endurance) and motor ability (speed and aerobic endurance measurements) characteristics than the u/15 players. The forward players showed higher values than the back line players in all age groups for strength (1 RM bench press, 1 RM back squat and 1 RM RFE left and right leg). The u/18 players performed better in the upper and lower body strength tests when compared to the younger age groups (u/15 and u/16). Not all components favoured the u/18 players. In this study the u/16 players performed better than the u/18 players for the following positional groups: front row players performed better in the aerobic endurance test ($\bar{x}$=14.3), locks and loose forwards performed better in the 10- (locks $\bar{x}$=1.86; loose forwards $\bar{x}$=1.84) and 40 m (locks $\bar{x}$=5.75; loose forwards $\bar{x}$=5.59) speed test, centres performed better in the 40 m speed ($\bar{x}$=5.51) and aerobic endurance test ($\bar{x}$=15.8) and halves and outside backs performed better in the 10 m (halves $\bar{x}$=1.79; outside backs $\bar{x}$=1.84) speed and aerobic endurance test (halves $\bar{x}$=15.8; outside backs $\bar{x}$=16).

This study is the first to conduct such a comprehensive anthropometric, physical and motor ability profile for u/15, u/16 and u/18 elite adolescent male South African RU players in the North West province for all the different playing positions. In conclusion, there are practically significant differences between players' playing position among u/15, u/16 and u/18 RU players with regard to their anthropometric, physical and motor ability characteristics. However, as the players got older, the results obtained were more similar. It is evident from the data obtained that both age group and the position pertained by adolescent RU players, have an influence on anthropometric, physical and motor characteristics.

5.3 LIMITATIONS

- The players in this study are still at school and therefore participate in various extra-curricular activities. This could have influenced the anthropometric, physical and motor ability profiles obtained in this research.
- Players were tested before the rugby season started for schools. Usually the rugby season starts after the athletics season, but not all players who participate in rugby, do athletics. The rugby players who did participate in athletics just before the tests were conducted, could have obtained better anthropometric, physical and motor ability measurements.
- The study only included players from the North West province. The level of competition for the North West rugby unions are lower in comparison with other provinces' unions. Therefore, the compilation of an adequate norm scale to use for all RU players in South Africa was not possible.
- The players chosen for this study came from different schools in the North West province. Not all schools follow the same training programme and not all schools participate in the same competitions. For this reason, training discrepancies could have had an influence on the data obtained in this study.
- The sample size differed greatly between playing positions. There were more forward players than back line players.

5.4 RECOMMENDATIONS

Given the knowledge gained from this investigation, the following recommendations could address the limitations of this study:

- Rugby players in a particular training squad should be tested at the end of their rugby season to get accurate data from players only competing in rugby for that specific season for a specific school. Players who do not participate in athletics at the beginning of the year but does participate in rugby later that season, should receive a conditioning programme so that they can be on the same level physically as the players who participate in athletics.
- The sample size of this study could be better distributed so that all the age groups contain more or less the same number of participants for all the positional groups

- Age-specific match requirements between different playing positions could be measured to identify features associated with changes in anthropometrical characteristics, such as percentage body fat and percentage muscle mass.
- To compile an accurate norm scale for all Rugby Union players for the age groups u/15, u/16 and u/18, it is strongly recommended to use players from all provinces in South Africa.
- In order to compile a norm scale for all Rugby Union players for the age groups u/15, u/16 and u/18, it is recommended to use not only elite players already chosen for a specific age group, but also players who are not necessarily in a particular training squad. This would provide stronger and weaker results that may be useful for comparison.

5.5 FUTURE RESEARCH

Future research of a similar nature could consider the following research questions:

- What is the effect of date of birth on Rugby Union players in the ages u/15 to u/18? Answers to this question could possibly show the effect on players chosen prematurely or immaturely for a specific position or age group. Date of birth could be used to allocate players to a certain team for a certain age group.
- What are the different training regimes between forward and back line Rugby Union players in the ages u/15 to u/18? Answers to this question could possibly indicate specific reasons for anthropometric, physical and motor ability characteristics being different between forward and back line players in addition to the different levels of physicality these groups encounter in game specific situations.
- What are the position- and age -specific anthropometric, physical and motor ability characteristics of Rugby Union players in all the provinces in South Africa? Answers to this question will help to compile an accurate norm scale for all Rugby Union players for the age groups u/15, u/16 and u/18 in South Africa.

5.6 REFERENCES

Chiwaridzo, M., Ferguson, G.D. & Smits-Engelsman, C.M. 2016. A systematic review protocol investigating tests for physical or physiological qualities and game-specific skills commonly used in rugby and related sports and their psychometric properties. *Systematic Reviews*, 5:122.

Duthie, G.M., Pyne, D., & Hooper, S. 2003. The applied physiology and game analysis of rugby union. *Sports medicine*, 33(13):973–991.

Hughes, A., Barnes, A., Churchill, S.M., & Stone, J.A. 2017. Performance indicators that discriminate winning and losing in elite men's and women's rugby union. *International journal of performance analysis in sport*, 1–11.

Macedonio, M.A. & Dunford, M. 2009. The athlete's guide to making weight. Champaign, IL: Human Kinetics.

Malina, R.M. 2014. Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research quarterly for exercise and sport*, 85:157–173.

Malina, R.M. & Bouchard, C. 1991. Growth, maturation and physical activity. Champaign, IL: Human Kinetics.

Noakes, T. & Du Plessis, M. 1996. Rugby without risk. A practical guide to the prevention and treatment of rugby injuries. Pretoria: J.L. van Schaik.

Pearson, D.T., Naughton, G.A. & Torode, M. 2006. Predictability of physiological testing and the role of talent identification for adolescent team sports. *Journal of science and medicine in sport*, 9:277–287.

Pook, P. 2012. Complete conditioning for rugby. Champaign, IL: Human Kinetics.

Quarrie, K.L., Handcock, P., Toomey, M.J. & Waller, A.E. 1996. The New Zealand rugby injury and performance project IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *British journal of sports medicine*, 30:53–56.

Schubring, A. & Thiel, A. 2014. Growth problems in youth elite sports. Social conditions, athletes' experiences and sustainability consequences. *Reflective practice*, 15(1):78–91, Nov.

Spamer, E.J. & De la Port, Y. 2006. Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18 year-old South African schoolboy rugby players. *Kinesiology*, 38(2):176–184.

APPENDICES

APPENDIX A
LETTER OF ETHICAL APPROVAL

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Private Bag X6001, Potchefstroom,
South Africa, 2520

Tel: (018) 299-4900
Faks: (018) 299-4910
Web: http://www.nwu.ac.za

Research Ethics Regulatory Committee
Tel: +27 18 299 4849
Email : Ethics@nwu.ac.za

ETHICS APPROVAL CERTIFICATE OF STUDY

Based on approval by **Health Research Ethics Committee (HREC)** on **08 November 2017**, the North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby **approves** your study as indicated below. This implies that the NWU-RERC grants its permission that provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Position specific characteristics for elite adolescent male rugby players in the North West Province
Study Leader/Supervisor: Prof JH de Ridder
Student: S Brand-21054363

Ethics number:

N	W	U	-	0	0	0	9	7	-	1	7	-	A	1
Institution				Study Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Single study
Commencement date: 08/11/2017
Risk: **Minimal**

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The study leader (principle investigator) must report in the prescribed format to the NWU-RERC via HREC:*
  - *annually (or as otherwise requested) on the monitoring of the study, and upon completion of the study*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any changes to the proposal be deemed necessary during the course of the study, the study leader must apply for approval of these amendments at the HREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility the NWU-RERC and HREC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the HREC or that information has been false or misrepresented,*
    - *the required amendments, annual (or otherwise stipulated) report and reporting of adverse events or incidents was not done in a timely manner and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*
- *HREC can be contacted for further information or any report templates via Ethics-HRECApply@nwu.ac.za or 018 299 1206.*

The RERC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the RERC or HREC for any further enquiries or requests for assistance.

Yours sincerely,

Prof. Refilwe Phaswana-Mafuya
Chair NWU Research Ethics Regulatory Committee (RERC)

APPENDIX B
LANGUAGE EDITING CERTIFICATE

cumlaude
languagepractitioners

Director: CME Terblanche - BA (Pol Sc), BA Hons (Eng), MA (Eng), TEFL

22 Strydom Street
Baillie Park, 2531

Tel 082 821 3083
cumlaudelanguage@gmail.com

DECLARATION OF LANGUAGE EDITING

I, Christina Maria Etrecia Terblanche, hereby declare that I edited the research study titled:

Position-specific characteristics of elite adolescent male rugby players in the North West province

for **Sumari Brand** for the purpose of submission as a postgraduate study for examination. Changes were indicated in track changes and implementation was left to the author.

Regards,

CME Terblanche

Cum Laude Language Practitioners (CC)

SATI accreditation no: 1001066 (South African Translators Institute)

Full member of PEG (Professional Editor's Guild)

APPENDIX C
GENERAL INFORMATION AND INFORMED CONSENT FORM

GENERAL INFORMATION

NAME AND SURNAME					
DATE OF BIRTH	YYYY/MM/DD				
PLAYERS ID NUMBER					
CURRENT AGE					
RACE	White	Black	Colored	Indian	Other, specify
EMAIL ADRESS					
CELL NUMBER					
SCHOOL					

INFORMED CONSENT

PLEASE READ THE FOLLOWING CAREFULLY:

1. EXPLANATION OF THE TESTING PROCEDURE

You will undergo a battery of tests to evaluate various physical and motor components associated with elite performance in your sport. The intensity of these tests will vary from comfortable to strenuous. The exercise tester may terminate testing at any point if she/he deems it necessary. You may also stop the testing at **any time** if you feel uncomfortable.

2. RESPONSIBILITIES OF THE PARTICIPANT

Any information you possess about your health status, or previous experiences of unusual feelings with physical effort, may affect the safety and value of the testing procedure. Your prompt reporting of feelings with effort during the test is also of great importance. You are responsible to fully disclose such information.

3. RESULTS

The results from the different testing procedures will reveal some of your physical and motor strengths and weaknesses. In order to permit the tester to formulate a comprehensive program for improvement, your complete co-operation and compliance is essential.

4. CONFIDENTIALITY

The results from your test are strictly confidential. However, the information obtained may be used for statistical analysis or scientific purpose with your right to privacy retained.

5. PHOTOGRAPHS AND VIDEOS

Your picture may also be taken for still photographs, videos, motion pictures or television at such times and at such places as the ISSD may designate. Your name will be used in connection therewith. You hereby also permit your name, portrait, picture and voice to be used by ISSD on all writings or audio-visual displays relating to promotional, endorsement and publicity activities, and all rights to the foregoing shall belong exclusively to the ISSD. The ISSD may assign such rights, for its sole benefit, during the term of this agreement.

I hereby declare that:

- The ISSD tester has explained the testing procedures to me and I understand them.
- To the best of my knowledge I am currently free from existing medical condition/other complaint or injury that would preclude me from full participation in this program.
- I give my written consent to the ISSD tester, to conduct the battery of test, which form part of the program.

- I indemnify ISSD testers against any injury, death or damage, which might stem from my participation in the program.

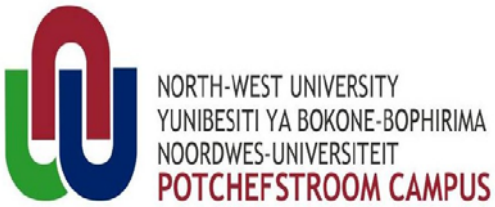
This consent form is valid for the year 2014 and 2015

Player's signature _____ Date: _____

Parent/Guardian name _____

Parent/Guardian signature _____ Date _____

APPENDIX D
ANTHROPOMETRIC, PHYSICAL AND MOTOR ABILITY DATA COLLECTION FORM



RUGBY PROTOCOL:

NAME AND SURNAME	
CURRENT AGE	
MAIN POSITION	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

BODY COMPOSITION

SKINFOLDS

STATURE (cm)	CM	
BODY MASS (kg)	KG	
TRICEP (mm)	MM	MM
SUBSCAPULAR (mm)	MM	MM
SUPRA-SPINAL (mm)	MM	MM
ABDOMINAL (mm)	MM	MM
THIGH (mm)	MM	MM
MEDIAL CALF (mm)	MM	MM

GIRTHS

RELAXED UPPER ARM (cm)	CM	CM
THIGH (cm)	CM	CM
CALF (cm)	CM	CM

FAT PERCENTAGE (%)

MUSCLE MASS PERCENTAGE

%	KG

EXPLOSIVE POWER

VERTICAL JUMP (cm)

POLE		POLE
REACH	1	2

MUSCLE STRENGTH

1-10 RM BENCH PRESS	REPS	WEIGHT
1-10 RM BACK SQUAT	REPS	WEIGHT
3 – 6 RM RFE	R REPS	R WEIGHT
	L REPS	L WEIGHT

MUSCLE ENDURANCE

PULL-UPS (MAX)- underhand grip with full extension	MAX

SPEED

	TRIAL 1	TRIAL 2
10m	SEC	SEC
40m	SEC	SEC

AEROBIC ENDURANCE

YO-YO LEVEL	LEVEL
DISTANCE (m)	m

Speed level	**Repetitions**							
5	1 (40)							
9	1 (80)							
11	1 (120)	2 (160)						
12	1 (200)	2 (240)	3 (280)					
13	1 (320)	2 (360)	3 (400)	4 (440)				
14	1 (480)	2 (520)	3 (560)	4 (600)	5 (640)	6 (680)	7 (720)	8 (760)
15	1 (800)	2 (840)	3 (880)	4 (920)	5 (960)	6.(1000)	7.(1040)	8.(1080)
16	1(1120)	2(1160)	3(1200)	4(1240)	5(1280)	6 (1320)	7 (1360)	8 (1400)
17	1(1440)	2(1480)	3(1520)	4(1560)	5(1600)	6 (1640)	7 (1680)	8 (1720)
18	1(1760)	2(1800)	3(1840)	4(1880)	5(1920)	6 (1960)	7 (2000)	8 (2040)
19	1(2080)	2(2120)	3(2160)	4(2200)	5(2240)	6 (2280)	7 (2320)	8 (2360)
20	1(2400)	2(2440)	3(2480)	4(2520)	5(2560)	6 (2600)	7 (2640)	8 (2680)
21	1(2720)	2(2760)	3(2800)	4(2840)	5(2880)	6 (2920)	7 (2960)	8 (3000)
22	1(3040)	2(3080)	3(3120)	4(3160)	5(3200)	6 (3240)	7 (3280)	8 (3320)
23	1(3360)	2(3400)	3(3440)	4(3480)	5(3520)	6 (3560)	7 (3600)	8 (3640)

APPENDIX E
ANTHROPOMETRIC METHODS

1. *Anthropometric variables*

The anthropometric variables that were used are body mass, stature, triceps-, subscapular-, supraspinal-, abdominal-, thigh- and calf skinfolds (for the determination of body fat percentage) and relaxed upper arm-, mid-thigh- and calf circumferences (for the determination of muscle mass percentage). These were measured according to the procedures of the International Society for the Advancement of Kinanthropometry (Stewart *et al.,* 2011).

1.1. *Body Mass*

Equipment: Calibrated electronic scale

Technique: The subject was dressed in training clothes. Following the guidelines of Stewart *et al*. (2011:52), the subject stood still barefoot on both feet, with his weight distributed equally on the calibrated scale, eyes to the front and arms next to the side of his body. The body weight was then recorded to the nearest 0.1 (one-tenth) of a kilogram.

1.2. *Stature*

Equipment: Portable stadiometer

Technique: According to Stewart *et al*. (2011:53) the aim is to strive to obtain the maximum distance from the surface on which the subject stands on, to its vertex, by using a portable stadiometer. The subjects were barefoot in an upright position with their heels together and weight evenly distributed on both feet and arms hanging at their sides. Heels, buttocks, top of the back and the head were pressed against the portable stadiometer with the head in the Frankfort level (horizontal line between the inferior edge of the eye socket and the notch above the tragus of the ear). The head plank of the portable stadiometer was then placed on the hair of the subject, in contact with the vertex and the body height was recorded to the nearest 0.1 (one-tenth) of a centimeter.

1.3. *Skinfolds*

Equipment: Harpenden Skinfold Caliper

Technique: The following skinfolds were measured for the determination of body fat percentage: triceps-, subscapular-, supraspinal-, abdominal-, thigh- and calf skinfolds. The area

where the skinfold was measured, was clearly marked with a marker. The skinfold was pulled away from the underlying muscle on which the mouth of the skinfold caliper was put, 1-2 cm below the place where the fingers on the skinfold are. The reading was taken after approximately 2-3 seconds and the skinfold was released. A minimum of two readings was taken to eliminate any reading differences. If there was reading difference of more than 1 mm, the skinfold was measured for a third time. The skinfolds were measured to the nearest 0,1 mm and on a rotation basis. The different skinfolds were measured according to Stewart *et al*. (2011:58-69).

1.4. *Girths*

Equipment: Flexible Mabis-fibre measuring tape

Technique: The following girths were measured for the prediction of muscle mass percentage, relaxed upper arm, mid-thigh and calf girths. The body parts that were measured were encircled by the cross-over hand method, where the left hand crosses the right hand. The measuring tape was held parallel over the body part that was going to be measured and was pulled tight and the girth was taken to the nearest 0,5 cm. The different girths were measured according to Stewart *et al*. (2011:75, 83, 84).

APPENDIX F
PHYSICAL AND MOTOR ABILITY METHODS

1. *Physical fitness components*

The physical components that were tested included explosive power, muscle strength, muscle endurance, speed and aerobic endurance. For the purposes of this research design, the tests to determine upper and lower extremity strength made use of a one to ten repetition maximum (1-10 RM) testing scale. Where maximum strength was not warranted, testing with a 1-10 RM load and then estimating the 1 RM, was suitable. Estimating the 1 RM load were used in accordance with Baechle & Earle (2008:396-398). The players performed repetitions with a weight with which they could perform 1-10 repetitions with the proper exercise technique, until they couldn't continue increasing the load anymore. The players' 1 RM was measured within three to five testing sets and recorded as a percentage of his 1 RM.

1.1. *Explosive power*

Method: Vertical jump

Equipment: Vertex

Technique: The vertical jump test was used to determine the explosive power in the legs and the ability to jump in a vertical direction (Baechle & Earle, 2008:257). The player stood with his dominant hand, closest to the vertex, and lifted and stretched his hand upwards and pushed the blades of the vertex forward. The position of the initial mark was recorded and then the player jumped as high as possible and pushed the blades of the vertex at the highest jumping point. The players had to reach and jump with the same shoe type, preferably sport shoes. Each player was given two trails to jump as high as possible. The player was disqualified if he did not jump with his feet flat from the ground and if he took a step prior to the jumping. The different blades of the vertex indicated the distance reached. The vertical jump distance was taken in centimetres (cm) where the reaching height was subtracted from the vertical jump height. The calculated vertical jump height determined the explosive power in the player's legs that he had obtained. The vertical jump was taken to the nearest 0,5 cm.

1.2. Muscle strength

1.2.1. Back squat

Equipment: Standard squat rack, standard barbell and weight plates

Technique: The back squat was used to determine the sixteen to eighteen-year old players' lower extremity strength. As recommended by Baechle & Earle (2008:254), the player stepped under the bar and positioned his feet parallel to each other with the barbell in a balanced position on the upper back and shoulders. The chest was held up and out and the player extended the hips and knees to lift the bar off the rack. The player took one or two steps back and started bending his knees and hips until he reached a 90° angle with his knees and then he pushed upwards to the initial starting position. Two spotters along the sides of the barbell helped the player if he had any difficulty during the execution of the movement. The player was also instructed on the right breathing method to prevent any possibility of passing out during the squat movement. The player could squat between 1-10 repetitions with a specific weight, preferably with a weight with which he can reach his 1 RM.

1.2.2. *Bench press*

Equipment: Standard bench rack, bench chair, standard barbell and weight plates

Technique: The bench press was used to determine the sixteen- to eighteen-year-old players' upper extremity strength. According to Baechle & Earle (2008:254), the player lied with his back on a bench chair with his feet placed on the ground. He gripped the bar with his hands shoulder-width apart and his thumbs touching the outside edge of his shoulder. The player then lifted the bar off the rack with the assistance of the spotters and lowered it to his chest and then he pressed the bar to full extension. Two spotters were along the sides of the barbell to help the player if he had any difficulty during the execution of the movement. The player was also instructed on the right breathing method to prevent any possibility of passing out during the bench movement. The player could bench between 1-10 repetitions with a specific weight, preferably with a weight with which he could reach his 1 RM.

1.2.3. *Maximum push-ups*

Equipment: Exercise matt, small cone

Technique: The maximum push-up was used to determine the fifteen-year-old players' upper extremity strength. In accordance with the guidelines Baechle & Earle (2008:261), the player took a prone position on the floor with the body straight and raised his body from the floor until the arms were straight and then lowered his body until his chest touched the cone placed

beneath his sternum. The player had to perform as many push-ups as possible without any rest periods in between.

1.2.4. *Rear foot elevation (RFE)*

Equipment: Bench chair, dumbbells and RX pad

Technique: The RFE was used to determine the fifteen-year-old players' lower extremity strength. Following the guidelines provided by Dos Remedios (2007:68), the player had to put one foot on the bench, with his toes flat on the bench, and his other leg in front, with his heel on the ground. He had to take two dumbbells, one in each hand and start bending his knee and hips until he reached a 90° angle with his front knee. He then pushes upwards to the initial starting position. There were two spotters along the sides of the player to help the player if he had any difficulty during the execution of the movement. The player was also instructed on the right breathing method to prevent any possibility of passing out during the "lunge" movement. The player could "lunge" between 3-6 repetitions with a specific weight, preferably with a weight with which he could reach his 1RM. The player was disqualified if he used his back to push himself upward to the initial starting position. He had to be able to do a minimum of three repetitions with the specific weight. If he could not, his dumbbells' weight was lowered and he was given another chance to complete his repetitions.

1.3. *Muscle endurance*

Method: Maximum pull-ups (underhand grip)

Equipment: Pull-up rack or bar

Technique: The underhand grip maximum pull-up test was used to determine the players' upper extremity endurance strength. According to Reiman & Manske (2009:243), the players were going to use an underhand grip with their hands placed 40-60 cm apart (narrow grip). The player started from a hanging position, where his arms were fully extended, and pulled himself upwards towards the bar with his chin reaching above the bar and fully extended his arms again on the descent. The player continued the test effort until he could no longer lift his chin to the bar. The player was disqualified if he failed to pull himself upward and if he could not lift his chin above the bar or if he used his hips to swing upward. The total number of pull-ups done correctly before the player stopped or was disqualified, was used.

1.4. *Speed*

Method: 10 m and 40 m speed

Equipment: 50 m measuring tape and the Brower timing system (Utah., U.S.A.)

Technique: The 10 m and 40 m speed test was used to determine the players' maximum sprint speed. According to Tanner & Gore (2013:375), an electronic sprint timer with photo-electric sensors should be set out on the rugby field at chest height and placed at 10 and 40 m intervals from the starting line. The first set of light sensors were placed at the starting line, the second at the 10 m line and the third at the 40m line. The players sprinted maximally for 40 m through the sensors and were given two maximal effort runs. They were instructed to start in a crouch position, approximately 30 m from the starting line. The time was automatically recorded to the nearest 0.1 seconds.

1.5. *Aerobic endurance*

Method: Yo-Yo intermittent Recovery Test Level 1

Equipment: Audio CD, 50 m measuring tape and cones

Technique: The Yo-Yo intermittent Recovery Test Level 1 was used to determine the players' aerobic (with oxygen) fitness. Following the guidelines of Bangsbo *et al.* (2008:38) a 20 m line was marked out on the rugby field and a 5 m distance recovery piece for active rest. The players ran a total of 40 m distances with a 10 second active rest between each run. The intensity of the test progressively increased through pre-recorded acoustic signals. Players were not allowed not run wide circles; each player had to place one foot just over the line and then turn immediately to face the opposite direction. The timing between signals started off slowly, but became progressively faster. The player was allowed to voluntary withdraw when he was unable to maintain the pace dictated by the sound. The player could also be withdrawn from the test if he fails to complete the 20 m distances in time for two consecutive laps. The score was taken at the last completed lap.

APPENDIX G
INSTRUCTIONS FOR AUTHORS: SOUTH AFRICAN JOURNAL FOR RESEARCH IN SPORT, PHYSICAL EDUCATION AND RECREATION

INFORMATION FOR AUTHORS

The *South African Journal for Research in Sport, Physical Education and Recreation* is published by Stellenbosch University. Contributions from the fields of Sport Science, Physical Education, Recreation/Leisure Studies, Exercise Science and Dance Studies will be considered for publication. The articles submitted will be administered by the appropriate Subject Review Editor and evaluated by two or more referees. The decision as to whether a particular article is to be published or not, rests with the Editorial Board.

SUBMISSION

Manuscripts that do not comply with the following requirements regarding process, style and format will not be handled.

Manuscripts should be typed with **one and a half spacing** in 12-point Times New Roman letter size. The original manuscript can be submitted by e-mail. The length may not exceed 20 pages (tables, figures, references, etc. included). The **page setup** (cm) must be in the following format:

MARGINS		**PAPER SIZE**	
Top:	3.56 cm	*Width*:	17.5 cm
Bottom:	1.78 cm	*Height*:	24.5 cm
Left:	2.11 cm		
Right:	2.11 cm		
Gutter:	0.00 cm		
Header:	2.03 cm		
Footer:	0.89 cm		

Original manuscripts may be submitted in English or Afrikaans and should be sent to:

The Editor
South African Journal for Research in Sport,
Physical Education and Recreation
Department of Sport Science
Private Bag X1
7602 Matieland, STELLENBOSCH
Republic of South Africa

Editorial Office
Tel.: +27 (0)21-808 4915 / 4715
Fax.: +27 (0)21-808 4817
E-mail: sajrsper@sun.ac.za

CONDITIONS

Each manuscript must be accompanied by a cover letter in which the following is declared: (1) that the manuscript contains original research; (2) that the manuscript or parts of the manuscript has not been published elsewhere previously; (3) that the manuscript is not currently being presented elsewhere for publication; and (4) that all the authors have read and approved the manuscript. This signed declaration regarding the originality must accompany each manuscript.

Authors are also requested to name three (3) potential referees, of which one (1) **must** be an international referee (the journal is not bound to use these referees). Complete information regarding the referees (name, surname, e-mail address and telephone numbers) must be

provided in the cover letter.

We discourage the practice of parts of one study in different journals. Authors who submit a manuscript from a study of which some data has been or will be published elsewhere, must provide a strong justification in an accompanying letter to the Editor. The justification for not publishing all the data together in one paper must also be motivated in the covering letter.

Should the article be taken from a master's thesis or doctoral dissertation, academic ethic requires that the student will be the first author.

The author should also ensure that the ***LANGUAGE*** of the manuscript has been thoroughly edited at the time of submission (English [UK]). The name, address and telephone number of the person who has done the language editing must be provided. Any expenses incurred by the journal dealing with language editing will be added to the author's page fees.

The manuscript must have an ***ETHICAL CLEARANCE NUMBER*** that was supplied by authentic ethical committee of a specific institution. The process that was followed to obtain ethical clearance must be described in the manuscript under the heading **Ethical clearance**. No manuscript can be published without this declaration.

Any uncertainty regarding the ***STATISTICAL PROCEDURES*** that arise during the assessment of the manuscript will be referred to a local statistician. Any expenses incurred by the journal dealing with statistical procedures will be added to the author's page fees.

PREPARATION OF MANUSCRIPT

Manuscripts must be presented in a format that is compatible with *Microsoft Word for Windows* (PC). Tables, all figures (illustrations, diagrams, etc.) and graphs are also regarded as text and must be presented in a format that is compatible with *Word*. Photographs must be presented in *jpg* format.

Original manuscripts must contain the following sections in the following sequence: Title page, Abstract, Introduction, Methodology, Results, Discussion, Practical application, Conclusions, Acknowledgements and References.

Title page

The first page of each manuscript should indicate the *title* in English and Afrikaans (will be translated for foreign authors), the *names* (**title, first name in full and other initials, surname**) of the author(s), the *telephone* numbers (work & home [Mobile – for local authors]), *facsimile* number, *e-mail* address (if available) and the *field of study*. The **complete mailing address** of the first named author and the institution where the work was conducted should be provided in full. When more than one author and/or authors from various departments are involved the [1]**author(s)** must be numbered according to their [1]**department(s)**. If any of the above-mentioned information should change during the review process, please inform the subject editor. A **short title,** of not more than **45 characters** including the spaces, should be provided for use as a running head.

Abstract

Each manuscript must be accompanied by an abstract of approximately 150-200 words in *English* and should be set on a *separate page* as a SINGLE paragraph (one and a half

spacing). A list of three to seven **key words** in *English* is required for indexing purposes and should be typed below the abstract. Articles in Afrikaans must include an ***additional*** extended summary (500-1000 words) in English. This summary must start on a new page (just before the reference list) and also provide the English title of the article at the beginning.

Text

Start the text on a new page with the title of the article (centred and *without* the names of the authors). Follow the style of the most recent issue of the journal regarding the use of headings and subheadings. Use only **one space** after a paragraph. Only make use of ***section breaks*** and not ***page breaks***. The text, as well as the tables and figures, may under **no circumstances** be in any other format than **normal**. Thus, no ***style sheets*** may be used.

Tables and figures

Tables and figures should be numbered in *Arabic* numerals (1, 2, etc.). Tables require the heading at the *top* while figures a legend *below* and both separate from the table/figure. **Note:** Use the decimal POINT (**not** the decimal comma). The site where the table or figure must be placed in the text must be indicated clearly in the manuscript. ***Tables and figures are placed after the reference list with each on a separate page***.

References

In the *text* the Harvard method must be adopted by providing the author's surname and the date placed in parentheses. *For example:* Daly (1970); King and Loathes (1985); (Botha & Sonn, 2002); McGuines *et al.* (1986) or (Daly, 1970:80) when Daly is not part of the sentence. More than one reference must be arranged **chronologically** (Daly, 1970; King & Loathes, 1985). Note that *et al.* (italics) is used in the body of the text when there are **more than two authors**, but never in the list of references.

List of references

Only the references cited in the text should be listed alphabetically according to surname (last name) of authors (capitals) after the body of text under the heading, **References** (capitals) starting on a new page. In the case where the TITLE of an article, book, etc., is in any other language than English, the author must also provide an English translation of the title in parentheses.

In the case of articles published in ***JOURNALS***, references listed should include the surnames and initials (capitals) of all authors, the date of the publication in parentheses, the full title of the article, the full title of the journal (italics), the volume number, the serial number in parentheses (omitted **only** if the said journal does not use issue numbers), followed by a colon and a space with the first and last page numbers separated by a hyphen.

Example:

VAN WYK, G.J. & AMOORE, J.N. (1995). A practical solution for calculating instantaneous values of tension in the extensor muscles of the knee joint during extension and flexion. *South African Journal for Research in Sport, Physical Education and Recreation,* 18(1): 77-97.

If the reference is a ***BOOK***, the surname (last name) and initials of the author or editor (Ed.) must be given, followed by the date of publication in parentheses, the title of the book (italics) as given on the title page, the number of the edition (ed.) in parentheses, the city (and abbreviation for the state in the case of the USA OR the country [in curved parentheses]) where published, followed by a colon, a space and the name of the publisher.

Example:

JEWETT, A.E.; BAIN, L.L. & ENNIS, C.E. (1995). *The curriculum process in Physical Education* (2nd ed.). Madison, WI: WCB Brown & Benchmark.

For a ***CHAPTER*** from a book, the page numbers of the chapter cited must be provided in parentheses (not italics) after the title of the book. For further details, authors should consult the most recent publication of this Journal for other examples.

Example:

DE RIDDER, J.H. (1999). Kinanthropometry in exercise and sport. In L.O. Amusa, A.L. Toriola, I.U. Onyewadume (Eds.), *Physical Education and sport in Africa* (pp.235-263). Ibadan (Nigeria): LAP Publications.

If the reference is a THESIS (master's level) or DISSERTATION (doctoral level), italics is **not** used in the title as it is an unpublished work.

Example:

CRAVEN, D.H. (1978). The evolution of major games. Unpublished PhD-dissertation. Stellenbosch: Stellenbosch University.

For ***ELECTRONIC SOURCES***, all references start with the same information that would be provided for a printed source (if available). The web page information follows the reference. It will usually contain the name of the author(s) (if known), year of publication or last revision, title of complete work in inverted commas, title of web page in italics, Uniform Resource Locater (URL) or access path in text brackets (do not end the path statement with a full stop) and date of access. See *"How to cite information from the Internet and the Worldwide Web"* at http://www.apa.org/journals/webref.html1for specific examples. When citing a web site in the text, merely give the author and date (in this case: Ackermann, 1996).

Example of Web Page:

ACKERMANN, E. (1996). "Writing your own Web Pages. "*Creating Web Pages*. Hyperlink: [http://www.mwc.edu/ernie/writeweb/writeweb.html]. Retrieved on 22 October 1999.

When referencing an article in a ***NEWSPAPER*** the key word of the newspaper is typed in capitals, as this is how **it will appear in the alphabetical references**, namely *The CAPE ARGUS* will appear under "C" or *Die BURGER* will appear under "B".

Example:

CAPE ARGUS (The) (1980). 10 January, p.4.

INTERVIEWS

Example:

POTGIETER, J.R. (2003). Personal interview with the Chairperson of the Department of Sport Science. 31 January. Stellenbosch: Stellenbosch University.

CORRESPONDENCE

Example:

POTGIETER, J.J.J. (2003). Personal correspondence of the Director of the Sport Bureau, 5 February. Stellenbosch: Stellenbosch University.

CONGRESS PROCEEDINGS

Example:

RENSON, R. (Ed.) (1976). *The history, the evolution and diffusion of sport and games in different cultures*. Proceedings of the 4th International HISPA Congress, Leuven, Belgium, 1-5 April 1975. Brussels (Belgium): B.L.O.S.O.

APPENDIX H
INSTRUCTIONS FOR AUTHORS: SOUTH AFRICAN JOURNAL OF SPORTS MEDICINE

GUIDELINES

SOUTH AFRICAN JOURNAL OF SPORTS MEDICINE AUTHOR INSTRUCTIONS

All manuscripts should be submitted online: www.sajsm.org.za. If this is not feasible, the manuscript may be submitted, via e-mail, as a Microsoft Word attachment, to Mike Lambert, Editor-in-Chief, at Mike.Lambert@uct.ac.za.

COPYRIGHT

Material submitted for publication in the ***SOUTH AFRICAN JOURNAL OF SPORTS MEDICINE (SAJSM)*** is accepted provided it has not been published elsewhere. Copyright forms will be sent with acknowledgement of receipt and the ***SAJSM*** reserves copyright of the material published. The ***SAJSM*** does not hold itself responsible for statements made by the authors.

AUTHORSHIP

Authorship should be based only on substantial contribution to: (i) conception, design, analysis and interpretation of data; (ii) drafting the article or revising it critically for important intellectual content; (iii) final approval of the version to be published. All three of these conditions must be met by the authors (Uniform requirements for manuscripts submitted to biomedical journals; www.icmje.org/index.html).

CONFLICT OF INTEREST

Authors must declare all sources of support for the research and any association with the product or research topic that may constitute conflict of interest.

PROTECTION OF PATIENT'S RIGHTS TO PRIVACY

Identifying information about the patient or research subject should not be published in written descriptions or photographs unless the information is essential for scientific purposes and the patient/research subject (or parent or guardian) gives informed written consent for publication. Informed consent for this purpose requires that the patient/research subject be shown the manuscript to be published (www.icmje.org).

ETHNIC CLASSIFICATION

Work that is based on, or contains reference to ethnic classification, must indicate the rationale for this. For clarification authors are encouraged to refer to *Ncayiyana DJ: Racial profiling in medical research: what are we measuring? S Afr Med J 2007;97:1225-1226.*

TYPES OF MANUSCRIPTS

Original research articles of 3 000 words or less (*excluding references and tables*), with up to 6 tables or figures, should normally report observations or research of relevance to sports medicine and exercise science in South Africa. References should be limited to 20.

Short reports, Commentaries, or Case studies should be 1 000 words or less, with 1 table or illustration and no more than 6 references.

Review articles are rarely accepted unless invited.

Letters to the editor should be no longer than 400 words with only one illustration or table.

Obituaries should not exceed 400 words and may be accompanied by a photograph.

MANUSCRIPT PREPARATION

1. The page set-up should be as follows: 2.54 cm margins, 1.5 line spacing, Times Roman 12 Font.
2. Each line should be numbered starting at number 1 on the first page and continuing consecutively until the last page.
3. The **Title Page** should have: (a) the title of the article, which should be concise but informative (*85 characters or less, including spaces*); (b) first name, middle initial, and last name of each author, with highest academic degree; (c) institutional affiliation, name of department(s) and/or institution(s) to which the work should be attributed; (d) name and address of author responsible for correspondence about the manuscript; (e) a short running header of no more than 40 characters (including spaces) placed near the bottom of the title page and identified.
4. Research articles should have a structured **Abstract** not exceeding 250 words (50 for short reports) comprising information under the subheadings: Objectives, Methods, Results, and Conclusions.
5. The **Introduction** section should provide a clear background of the study. The justification, practical importance of the study, and specific purpose or research objective should also be clearly stated.
6. The **Methods** section should identify the methods, apparatus (manufacturer's name and address in parentheses), and procedures in sufficient detail to allow other researchers to reproduce the results. Give references to established methods, including statistical methods (see #7). When reporting experiments on human subjects, indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and whether the subjects gave their written informed consent.
7. Describe the **Statistical methods** with sufficient detail to enable a knowledgeable reader with access to the original data to verify

ALL CORRESPONDENCE TO:

The Editor,
South African Journal of Sports Medicine,
c/o ESSM,
P.O. Box 115,
Newlands,
7725
South Africa

the reported results. All data should be presented with appropriate indicators of measurement error or uncertainty (such as standard deviations or confidence intervals). Avoid sole reliance on statistical hypothesis testing, such as the use of *p* values, which fails to convey important quantitative information. Precise *p* values must be shown as indirect indications such as $p>0.05$ or *p*=NS are unacceptable and difficult for other researchers undertaking meta-analyses.

8. **Abbreviations** should be spelt out when first used in the text and thereafter used consistently. Scientific measurements should be expressed in SI units.
9. Present your **Results** in a logical sequence in the text, tables, and figures. Do not repeat the presentation of data in the text, tables or figures. Tables and figures should appear on separate pages. Do not discuss data in this section. Data should be presented so that the number of digits and decimals are scientifically relevant.
10. In the **Discussion** section emphasise the new and important aspects of the study and the conclusions that follow from them. Do not repeat in detail data or other material given in the Introduction or the Results section. Include in the Discussion section the implications of the findings and their limitations, including implications for future research. Relate the observations to other relevant studies. Link the conclusions with the goals of the study but avoid unqualified statements and conclusions not completely supported by your data. Wherever possible comment on the practical applications of the study.

REFERENCES

References should be inserted in the text as superior numbers, with the first reference being #1 and the next reference #2 etc. The references should be listed at the end of the article in numerical order (i.e. in order of appearance). Authors are responsible for verification of references from the original sources.

References should be set out in the Vancouver style and approved abbreviations of journal titles used; consult the List of Journals in *Index Medicus* for these details. Names and initials of all authors should be given unless there are more than six, in which case the first three names should be given followed by *et al*. First and last page numbers should be given.

Journal references should appear thus:

1. Reilly T, Edwards B. Altered sleep-wake cycles and physical performance in athletes. Physiol Behav 2007;90(2):274-284.
2. Lane KN, Wenger HA. Effect of selected recovery conditions on performance of repeated bouts of intermittent cycling separated by 24 hours. J Strength Cond Res 2004;18(4):855-860.
3. Borg G. Perceived exertion as an indicator of somatic stress. Scand J Rehabil Med 1970;2(2):92-98.

Book references should be set out as follows:

1. Jeffcoate N. Principles of gynaecology. 4th ed. London: Butterworth; 1975. p. 96-101.
2. Weinstein L, Swartz MN. Pathogenic properties of invading microorganisms. In: Sodeman WA jun, Sodeman WA, eds. Pathologic physiology: mechanisms of disease. Philadelphia: WB Saunders; 1974. p. 457-472.

Manuscripts accepted but not yet published can be included as references followed by (in press).

Unpublished observations and personal communications may be cited in the text, but not in the reference list.

COVER LETTER

All submissions must be accompanied by a cover letter including the following information:

1. This manuscript has been read and approved by all the listed co-authors and meets the requirements of co-authorship as specified above.
2. A declaration that the manuscript is not under review with any other journal and has not been published previously.
3. A statement that prior written permission has been obtained for reproduction of previously published material (where appropriate).
4. A statement detailing any potential conflicts of interest (where appropriate).

GALLEY PROOFS

Galley proofs will be forwarded to the author before publication. Please note that alterations to typeset articles are time-consuming and need to be kept to a minimum.

CHANGE OF ADDRESS

Please notify the editorial department of any address changes so that proofs and invoices may be mailed without delay.

CPD POINTS

Authors can earn up to 15 CPD points for published articles. Certificates will be provided on request after the article has been published.