

# A kinanthropometric profile of elite u/18 Sevens Rugby players in Southern Africa

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**THIS DISSERTATION IS DEDICATED TO**

**MY PARENTS**

To my Father, Andries, and Mother, Annette, thank you for all the support you gave me throughout my life. Thank you for shaping me into the man I am today. Most of, all thank you for all your love! The Lord truly blessed me with the best parents any one could ever ask for.

**MY BROTHER**

Thanks bro it was fun growing up with you. Thank you for believing in me and always motivating me.

**OUPA JAN AND OUMA ANNA**

Oupa Jan and Ouma Anna, although you are no longer with us, although you have gone to be with our Lord your presence still remains. Thank you for the part you also played in my life!

**MARIUS**

Rest in peace my friend, can't wait to see you again someday.

# FOREWORD

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With great thanks to my Lord God Jehovah for helping me to complete this dissertation. Your blessings have no boundaries, Your love is unconditional and Your heart is unfathomable.

## **My God is not dead**

I would like to thank the following people who also played a big role in the completion of this dissertation:

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**Courage does not always roar sometimes courage is that quiet voice  
at the end of the day saying, I'll try again tomorrow.**

# DECLARATION

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The co-authors of the two articles, which form part of this dissertation, Prof. Hans de Ridder (Supervisor) and Mr. Pieter van den Berg (Co-supervisor) hereby, give permission to the candidate, Mr. Andries Zandberg to include the two articles as part of a Master's dissertation. The contribution (advisory and supportive) of the co-author was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation, therefore, serves as partial fulfilment of the requirements for the Magister Scientiae degree in Sport Science within the School of Biokinetics, Recreation and Sport Science in the Faculty of Health Sciences at the North-West University (Potchefstroom Campus), South Africa.

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Prof. Hans de Ridder

Supervisor and co-author

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Mr. Pieter van den Berg

Co-supervisor and co-author

# SUMMARY

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The purpose of this study was to describe and compare the kinanthropometric variables of elite u/18 Southern Africa Sevens Rugby players. A comparison between the players was made to determine if differences in playing positions exists. A comparison was also made between successful and less successful players to determine if differences with regards to the player's kinanthropometrical characteristics will emerge. As no literature on adolescent Sevens Rugby players regarding kinanthropometry exists, this study also compiled a profile of the kinanthropometric characteristics of elite u/18 Sevens Rugby players.

A total number of 164 Sevens Rugby players with a mean age of 17.4 ( $\pm 0.7$ ) years participated in the South African Schools' Rugby Association u/18 Sevens Tournament in October 2014. In compiling the kinanthropometric profile of the adolescent Sevens Rugby players, kinanthropometric measurements were taken on each subject which consisted out of direct (stature, body mass, skinfolds, girths and breadths) and indirect (body mass index, body fat percentage, sum of 6 skinfolds, skeletal mass, muscle mass and somatotyping) measurements. The comparisons between the players in the different playing positions as well as between the playing successes were made by means of a one-way analysis of variance (ANOVA), independent t-test, and descriptive statistics were used for the calculation of the means and standard deviation for all the dependant variables. The level of significance was set at  $p \leq 0.05$ . Effect sizes (ES) were calculated for differences between the positional groups as well as between the successful and less successful players to determine practical significance for all the values.

While comparing the playing positions, practical significant differences occurred, with the forward players having greater kinanthropometric values compared to the backline players, with few to no differences emerging while compared to the all-rounder players. The backline players compared to the all-rounder players revealed a great deal of meaningful differences, but not to the same extent as when compared to the forward players. Differences between successful and less successful players regarding kinanthropometric measurements also emerged, although these differences were not very much, they were of statistical significant difference with the successful players being superior in these measurements compared to the less successful players. With regards to somatotype, all three playing positions as well as the successful players and less successful players indicated to have an

endomorph mesomorph somatotype which is consistent to Rugby Union where it was discovered that an endomorph mesomorph somatotype is most beneficial.

The results, therefore, indicate that differences in playing positions and playing success exist in adolescent Sevens Rugby players with regards to their kinanthropometric variables. However, more research need to be done to determine if further differences between successful and less successful players regarding their kinanthropometrical characteristics might occur as Sevens Rugby begins to enjoy more attention amongst researchers especially regarding adolescent players.

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# OPSOMMING

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Die doel van hierdie studie was om die kinantropometriese veranderlikes van elite o/18 Suid-Afrikaanse Sewesrugbyspelers te beskryf en te vergelyk. 'n Vergelyking tussen die spelers is gemaak om te bepaal of verskille in spelposisies bestaan. 'n Vergelyking is ook getref tussen suksesvolle en minder suksesvolle spelers om te bepaal of verskille ten opsigte van die spelers se kinantropometriese eienskappe na vore sal kom. Aangesien geen literatuur ten opsigte van adolessente Sewesrugbyspelers ten opsigte van kinantropometrie bestaan nie, stel hierdie studie ook 'n profiel saam van die eienskappe van elite o/18 Sewesrugbyspelers.

'n Totale syfer van 164 Sewesrugbyspelers met 'n gemiddelde ouderdom van 17.4 ( $\pm 0.7$ ) jaar het aan die Suid-Afrikaanse Skolerugbyvereniging se o/18-Sewestoernooi in Oktober 2014 deelgeneem. Met die samestelling van die kinantropometriese profiel van die adolessente Sewesrugbyspelers is kinantropometriese metings geneem van elke deelnemer, wat bestaan het uit direkte (liggaamslengte, liggaamsmassa, velvoue, omtrekke en deursneë) en indirekte (lengte-massa-indeks, liggaamsvetpersentasie, som van 6 velvoue, skeletmassa, spiermassa en somatotipering) metings. Die vergelykings tussen die spelers in die verskillende posisies sowel as tussen die spelsuksesse is getref deur middel van 'n eenrigting-analise van variansie (ANOVA), en onafhanklike t-toets; en beskrywende statistieke is gebruik vir die berekening van die gemiddeldes en standaardafwyking van al die afhanklike veranderlikes. Die vlak van beduidendheid is gestel as  $p \leq 0.05$ . Effekgroottes (EG) is bereken vir verskille tussen die posisionele groepe sowel as tussen die suksesvolle en minder suksesvolle spelers om die praktiese beduidendheid vir al die waarde te bepaal.

Met die vergelyking van die spelersposisies, het betekenisvolle verskille na vore gekom, met die voorryspelers wat superieur was in meeste van die kinantropometriese metings in vergelyking met die agterspelers, met min tot geen verskille wat na vore gekom het in vergelyking met die veelsydige spelers. Die agterlynspelers in vergelyking met die veelsydige spelers het 'n groot mate van praktiese betekenisvolle verskille onthul, maar nie in dieselfde mate as wanneer vergelyk word met die voorryspelers nie. Verskille tussen suksesvolle en minder suksesvolle spelers ten opsigte van kinantropometriese metings het ook na vore gekom, en hoewel daar nie baie verskille voorgekom het nie, was hulle van statisties beduidende belang met die suksesvolle spelers wat superieur in hierdie metings was in vergelyking met die minder suksesvolle spelers. Ten opsigte van somatotipe het al drie spelposisies sowel as die suksesvolle spelers en minder suksesvolle spelers getoon dat hulle 'n

endomorfiese mesomorfiese somatotipe het, wat konsekwent is met die Rugby Union, waar gevind is dat 'n endomorfiese mesomorfiese somatotipe meer voordelig is.

Die resultate toon dus dat verskille in spelposisies en spelsukses bestaan in adolessente Sewesrugbyspelers ten opsigte van hul kinantropometriese veranderlikes. Meer navorsing is egter nodig om te bepaal of verdere verskille tussen suksesvolle en minder suksesvolle spelers mag voorkom soos Sewesrugby meer aandag onder navorsers geniet, veral ten opsigte van adolessente spelers.

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# LIST OF ABBREVIATIONS

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<b>BB</b>	Blue Bulls
<b>BL</b>	Backline
<b>BMI</b>	Body mass index
<b>CA</b>	Chronological age
<b><i>d</i></b>	Practical Significance
<b>H</b>	Halves
<b>HSBC</b>	Hong Kong and Shanghai Banking Corporation
<b>IRB</b>	International Rugby Board
<b>IV</b>	Ivy Bridge
<b>LF</b>	Loose forwards
<b>LP</b>	Leopards
<b>LSG</b>	Less successful group
<b>NZ</b>	New Zealand
<b>PHV</b>	Peak height velocity
<b>SA</b>	South Africa
<b>SA</b>	Skeletal age
<b>SARU</b>	South African Rugby Union
<b>SG</b>	Successful group
<b>Sum of skinfolds</b>	$\Sigma$ skinfolds
<b>TF</b>	Tight forwards

# CHAPTER 1

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# **1 INTRODUCTION**

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**1.1. INTRODUCTION**

**1.2. PROBLEM STATEMENT**

**1.3. OBJECTIVES**

**1.4. HYPOTHESES**

**1.5. STRUCTURE OF DISSERTATION**

**1.6. REFERENCES**

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## 1.1 INTRODUCTION

The morphological characteristics of athletes are important and it can be assumed that sportsmen and woman must have a suitable physique towards the sport they partake in, to be able to perform optimally (De Ridder, 2011:9). The benefits of kinanthropometry in Rugby are well known and recognised by various researchers (Gabbett, 2000:306; Gabbett *et al.*, 2009:221; Gabbett *et al.*, 2011:1458; Nicholas, 1997:376; Olds, 2001:260; Quarrie *et al.*, 1995:263; Sedeaud *et al.*, 2012:583; Till *et al.*, 2011:266).

Early research have associated kinanthropometry with successful performance in adolescent Rugby Union and Rugby League, while no such evidence, according to this research team's knowledge, have proven such an association in adolescent Sevens Rugby.

The purpose of this Chapter is to present the problem statement that has led to the research questions that are posed in this dissertation. The objectives and hypotheses set to answer the research questions are further described and finally, the structure of the dissertation is given.

## 1.2 PROBLEM STATEMENT

The influence of body build, form and composition (morphology) on performance in sport has been researched intermittently since the fifth century BC and studies regarding the morphological characteristics of elite athletes help us to have a better understanding of the optimal physical requirements for successful participation and also the selection criteria for the identification of talented youth athletes (De Ridder *et al.*, 2000:38). The science used to research the morphological characteristics of man is called anthropometry and if the research is conducted on athletes it is called kinanthropometry. Kinanthropometry originated from the Greek words Kinéo (to move), Anthropos (human), and Metrein (to measure) (Ross, 1978:270). The importance and advantages derived from kinanthropometric data in Rugby with regard to the performance of the players and team selection are advocated by various researchers (Gabbett *et al.*, 2009:221; Nicholas, 1997:376; Olds, 2001:260; Quarrie *et al.*, 1995:263; Sedeaud *et al.*, 2012:583).

*The reader should notice that although past research referred to anthropometry, the research team of this specific study would rather use kinanthropometry, which was accepted as a new discipline in the midst of acknowledged sport sciences (Ross et al., 1972)*

In Rugby, specific kinanthropometric characteristics are required from the players, due to the physical demanding nature of the sport (Quarrie *et al.*, 1995:268). The game of Sevens Rugby, also a contact sport (Lopez *et al.*, 2012:179), has grown in popularity over the past few years and is now played all over the world, at domestic and international level (Higham *et al.*, 2013:19; Higham *et al.*, 20011:1; Rienzi *et al.*, 1999:161). The popularity of the game increased even more since it received Olympic status on the 9<sup>th</sup> of October 2009 (Higham *et al.*, 2013:19). As Sevens Rugby is similarly contact orientated, Rienzi *et al.* (1999:160) mentioned that players are required to sustain and cope with the impact of physical contact and collisions within the game. This is especially evident when taking into consideration that all three of the variants of rugby (Rugby Union, Rugby league and Sevens Rugby) are contact orientated (Suarez-Arrones *et al.*, 2012:3155).

In Rugby Union, Adendorff *et al.* (2004:450) compiled kinanthropometric profiles of thirty-four boys between ages 17 and 18 years and compared the successful group to the less successful group. Moderate practically significant differences between the 2 groups were found with regard to body mass and skeletal mass, while the body mass index (BMI) indicated a large practical significant difference. In Rugby League, Gabbett *et al.* (2009:221) compared kinanthropometric variables of 36 junior sub-elite and 28 junior elite players ( $\pm$  16 years of age) with regard to starters and non-starters. The junior elite starter's body mass was practical and statistical significantly higher than the non-starters while their height was statistically significant and only moderate practical significantly higher than the non-starters. In Sevens Rugby, Rienzi *et al.* (1999:162) gathered kinanthropometric data from 27 adult players from 14 different teams participating in an international Sevens Rugby Tournament held in Uruguay. Non-significant differences were found between the successful and less successful teams, while statistical significant differences in stature, body mass and muscle mass were discovered while comparing the forward players to the backline players, with the forward players having greater stature, body mass as well as muscle mass. Consistent with the latter were the findings of Fuller *et al.* (2010:182) who collected kinanthropometric data on 290 adult Sevens Rugby players representing the 12 countries that participated in the International Rugby Board (IRB) Sevens World Series and the IRB Rugby World Cup Sevens. It was further discovered that forward players were statistical significantly different from backline players, having greater stature and body mass.

A component of kinanthropometry underutilized by researchers is somatotyping, simply because of the difficulty in obtaining accurate somatotype data (Genovese, 2009:390). Somatotyping

plays an important role when human physique is evaluated, helping with the assessment of the human body's morphology and characteristics (Ventrella *et al.*, 2008:383).

Thus one should never underestimate the value of somatotyping as it can assist with the understanding of variability and composition in human body build (Ventrella *et al.*, 2008:383). In Rugby Union, Quarrie *et al.* (1995:266) found forwards to be statistically and practical significantly more endomorphic compared to the backs and only statistically significantly less ectomorphic compared to backs, which is consistent with what was found in Rugby League by Lundy *et al.* (2006:204). Quarrie *et al.* (1995:267) compared different grades with each other, and discovered senior A players to be statistically significantly more mesomorphic than senior B players. Adendorff and co-workers (2004:450) found a large practical significance with regard to ectomorphy, between the less successful players and the successful players in Rugby Union.

Body mass index (BMI), a method most commonly used during kinanthropometric measurements, evaluates the human body by providing a value that indicates whether an individual's body mass is in proportion to their height or stature (Walsh *et al.*, 2011:38). Although the value of BMI is debated due to the fact that it does not distinguish between fat mass and lean muscle mass, indicating that individuals with a high muscle mass will have a high BMI score, recent literature found an increase in BMI in Rugby Union players participating in the World Cup from 1987-2007, with forwards' BMI being statistically significantly higher than that of the backs (Sedeaud *et al.*, 2012:581). This finding concurs with that of Sedeaud *et al.* (2013:187) who did another study on French elite Rugby Union players, stretching across different seasons.

In light of the above-mentioned literature as well as Sevens Rugby obtaining Olympic status on the 9<sup>th</sup> of October 2009 (Higham *et al.*, 2013:19), the following research questions will be answered in this study. How do the positional kinanthropometrical profiles of elite u/18 Sevens Rugby players compare? How do the kinanthropometric profiles between successful and less successful elite u/18 Sevens Rugby players compare?

The results from this study will assist coaches and sport scientists to determine norms and profiles with regard to kinanthropometry of elite u/18 Sevens Rugby players. It may also support coaches and sport scientists to distinguish between successful and less successful elite u/18 Sevens Rugby players, which in turn may indicate flaws in certain players' kinanthropometric profiles as stated by Meir (2012:77).

### 1.3 OBJECTIVES

The objectives of this study are:

- To compare the positional kinanthropometrical profiles of elite u/18 Sevens Rugby players.
- To compare the kinanthropometric profiles between successful and less successful elite u/18 Sevens Rugby players.

### 1.4 HYPOTHESES

The study is based on the following hypotheses:

- Significant kinanthropometric differences will be found between playing positional profiles of elite u/18 Sevens Rugby players.
- Significant kinanthropometric profile differences will occur between the successful and less successful u/18 Sevens Rugby players.

### 1.5 STRUCTURE OF THE DISSERTATION

The dissertation will be presented in article format which has been approved by the Senate of the North-West University and consists of five Chapters. References are provided at the end of the Chapter in accordance with the guidelines of the North-West University:

**Chapter 1:** Introduction. The bibliography is provided at the end of the Chapter in accordance with the guidelines of the North-West University.

**Chapter 2:** Literature overview: Kinanthropometry in Youth Rugby. The bibliography is provided at the end of the Chapter in accordance with the guidelines of the North-West University.

**Chapter 3:** Article 1: Kinanthropometric profiles of elite u/18 Sevens Rugby players: A focus on positional status. This article will be presented for possible publication in the *Journal of Strength and Conditioning Research*. The bibliography is provided at the end of the article in accordance with the guidelines of the journal. Tables will

be included within the text, and although it is not in accordance with the guidelines of the journal it will make the article easier to read and understand.

**Chapter 4:** The comparison between successful and less successful u/18 Sevens Rugby players regarding their kinanthropometric characteristics. This article will be presented for possible publication in *The South African Journal of Sports Medicine*. Tables will be included within the text, and although it is not in accordance with the guidelines of the journal it will make the article easier to read and understand.

**Chapter 5:** Summary, conclusions, limitations and recommendations.

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# CHAPTER 2

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# 2

# LITERATURE OVERVIEW: KINANTHROPOMETRY IN YOUTH RUGBY

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## **2.1 INTRODUCTION:**

In this Chapter a literature overview will be conducted on existing research regarding the following topics: Firstly the importance of kinanthropometry in rugby, secondly a brief overview on the origin and development of Sevens Rugby, thirdly existing literature on adolescent Rugby (Union, League and Sevens) players with regards to kinanthropometric components will be presented and finally the effect of growth and maturation on the adolescent with regards to kinanthropometry will be discussed.

As was mentioned earlier in Chapter 1, past scientific research refers to anthropometry, to describe body measurements. However, in this study the research team refers to kinanthropometry. Kinanthropometry can be seen as controversial topic, as it is confused and mistaken with other terminology. It is, therefore, important to define and provide a short description of the latter to better comprehend, and to distinguish when compared to other terminology.

Kinanthropometry originated from the Greek words Kinéo (to move), Anthropos (human), and Metrein (to measure) (Ross, 1978:270). Firstly it is important to note that kinanthropometry arose from two terms, namely biometry and anthropometry (Beunen & Borms, 1990:2), and while both kinanthropometry and anthropometry focus on measuring of the human body, kinanthropometry also focuses on the measurement of the human body in motion (keeping in mind the factors that influence motion).

According to Stewart (2010:455), during the last two decades various other academic disciplines arose and were developed, leading to the possibility of overlapping in terminology. The latter defines kinanthropometry as “The academic discipline that involves the use of anthropometric measures in relation to other scientific parameters and/or thematic areas such as human movement, physiology or applied health sciences”. Anthropometry on the other hand is “The scientific procedures and processes of acquiring surface anatomical dimensional measurements such as lengths, breadths, girths, and skinfolds of the human body by means of specialist equipment” (Stewart, 2010:455). Thus, according to Stewart (2010:455), kinanthropometry can be classified as a scientific discipline and anthropometry is only the toolkit and skill set.

One can conclude that kinanthropometry is not only new terminology formed for already existing anthropometric knowledge, but rather a modern-day approach to the studying of the morphology of athletes, therefore a new approach to an old science (Buenaen & Borms, 1990:1).

## **2.2 THE IMPORTANCE OF KINANTHROPOMETRY IN SPORT AND RUGBY**

As indicated earlier, kinanthropometrical investigations' identity can be coupled to the fact that it is an investigation concerning the measurement of the morphological issues of the human body in movement. Whilst the morphological characteristics of athletes are important, it can be assumed that sportsmen and woman must have the appropriate physique for the sport they partake in to perform optimally (De Ridder, 2011:9).

According to Carter (1978:30), determining morphological profiles of sportsmen and women can be beneficial in two ways: Firstly, by knowing how their morphological profiles appear, sportsmen and women can be "formed" until they match the morphological profile of elite athletes by prescribing a physical training programme. Secondly, emerging athletes can be advised to take up a certain sport, based on their morphological profiles and the relevancy to elite athletes, taking part in a specific sport code.

It is, however, important to emphasize that a person's morphological characteristics are not the only factors leading to enhanced performance, but other factors evidently also play a role such as ball skills, decent hand-eye and foot co-ordination, physiology, psychology and biomechanics. Nevertheless, this morphological knowledge of sportsmen and women could still be immensely beneficial to coaches and sport scientists.

Decades ago Dr. James Tanner made the following statement: "Physique is a factor in the sort of success that may lead to inclusion in an Olympic team: or, more negatively, that lack of the proper physique may make it almost impossible for an athlete to reach that degree of success" (Tanner, 1964:14). Thus one thing we can still be sure of is that a "specific physique for a specific sport" is still as relevant today as it was decades ago.

Considering the importance of kinanthropometry with regards to Rugby, it is clear that specific characteristics are required of players due to the sport's physical demanding nature (Quarrie *et al.*, 1995:268). According to Rienzi *et al.* (1999:160), players are required to sustain and cope with the impact of physical contact and collisions within the game. This is especially evident when taking into consideration that all three variants (Rugby Union, Rugby League and Sevens Rugby) are contact orientated, each hosting their own respective world cup (Suarez-Arrones *et al.*, 2012:3155).

Kinanthropometry is also beneficial in rugby with regards to team performance and team selection. This is especially evident in Rugby Union where kinanthropometrical variables could have a significant implication in team selection (Nicholas, 1997:376). It is, therefore,

understandable that coaches and selectors place high priority on size and physique when choosing their players (Quarrie *et al.*, 1995:263). With regards to successful team performance, Olds (2001:260) determined that a large body size (indicated by height and weight (Rigg & Reilly, 1988:197) will be a substantial predictor for success in a Rugby Union match, this statement was supported by Duthie *et al.* (2003:976) and Sedeaud *et al.* (2012:583). The same was true for Rugby League where research indicated that body mass and stature both have a significant influence on success with regards to selection in either an elite or sub-elite team (Gabbett, 2002b:402; Gabbett & Hertzog, 2004:23; Gabbett *et al.*, 2009:221; Till *et al.*, 2013:441). According to Malousaris *et al.* (2008:338), certain playing positions within a team sport require specific physique characteristics depending on the physiological demands they have to endure during the game.

### **2.3 THE GAME OF SEVENS RUGBY**

During recent years, Sevens Rugby increased in popularity and is now played at domestic and international level around the globe (Higham *et al.*, 2012:277). Its popularity increased further since the launching of the Sevens Rugby World Cup (Rienzi *et al.*, 1999:161), IRB World Sevens Series and since Sevens Rugby was included to be part of the 2016 Olympic games taking place in Brazil, Rio de Janeiro making it one of the fastest growing sport codes in the world (Suarez-Arrones *et al.*, 2012:3155).

Tradition has it that in 1883, the Melrose football club in the Scottish Borders (RFU, 2014), was considering ideas to raise money in order to assist with the Club's finances. Ned Haig, a local butcher, (playing for the club since 1880) stepped in and made the suggestion that a football tournament should be held. In an article called "An old Melrose recollection", most probably written in 1907/1908 Haig stated the following: "Want of money made us rack our brains as to what was to be done to keep the Club from going to the wall, and the idea struck me that a football tournament might be attractive, but as it was hopeless to think of having several games in one afternoon with fifteen players on each side, the teams were reduced to seven men". The "seven men" consisted of a full back, two quarter-backs and four forwards, but as the passing game developed, the forward players were reduced to three with a consolation of an extra half-back. Each game was played under Rugby Union rules with each match lasting 15 minutes with seven players of each club competing (Melrose Sevens, 2014).

Since that first tournament in Melrose, Sevens Rugby grew in popularity and today the idea of the Melrose butcher and his apprentices to hold a sevens tournament, is not the only legacy left

behind but the rule that the first team to score in extra time is the winner of the game is still followed today in the World Sevens Series (SevensRugby.co.za., 2014)

Throughout the 1970's and 1980's the sevens tournament grew progressively with 7 players on a team playing two seven minute halves proceeding over a weekend of packed quality entertainment. More and more clubs and international teams started to take interest in the game as well as the number of spectators supporting the event (Australian Sevens Rugby, 2014).

One of the most popular tournaments in the sevens calendar known as the "Jewel in the Sevens Crown" is the Hong Kong tournament and by 1982 this particular tournament outgrew its original home at the Hong Kong Football Club and moved to the larger Hong Kong Stadium. In 1994 this stadium was rebuilt to a 40 000 seater due to the increasing ticket demands regularly outweighing its capacity (Australian Sevens Rugby, 2014). The Hong Kong turf played host to a number of rugby greats such as the Ella brothers in the 1980's and Jonah Lomu and George Gregan in die 90's (Australian Sevens Rugby, 2014).

In 1993 the first Sevens Rugby World Cup was held in Scotland and since then, took place every 4 years. Thus far it was hosted by Argentina, Dubai and Russia and twice by Hong Kong. Fiji and New Zealand have claimed the title twice while England and Wales have only been crowned champions once (Australian Sevens Rugby, 2014).

In 1998 Sevens Rugby was introduced to the commonwealth Games, a further boost to the value of the game. In the season of 1999 and 2000, the International Rugby Board (IRB) recognised the value and launched the first World Sevens Series (Australian Sevens Rugby, 2014), which consisted of 8 rounds taking place in Dubai, South Africa, New Zealand, United States, Hong Kong, Australia, England and Scotland (Meir, 2012:76). These tournaments consisted of group and knockout stages (Fuller *et al.*, 2010:179) and could be played over 2 or 3 day events (Higham *et al.*, 2012:277). International tournaments containing 16 teams and consisting out of matches are usually played over a period of 2 days and an international tournament containing 24 teams, consisting of 57 matches are usually played over a period of 3 days (Fuller *et al.*, 2010:179)

In 2011, Hongkong and Shanghai Banking Corporation (HSBC) became the naming-rights sponsor of the Sevens World Series, hosting 16 of the globe's top teams competing in tournaments across the world. The Sevens World Series has already been won eleven times by New Zealand with Fiji, South Africa and Samoa only crowned winners once each (Australian Sevens Rugby, 2014). One thing is for certain, Sevens Rugby will keep on moving forward especially now that the sport enjoys Olympic status.

Sevens Rugby is an abridged variant of Rugby Union (Higham *et al.*, 2012:277) and is played on the same size field as Rugby Union with similar rules and scoring guidelines (Del Coso *et al.*, 2013:1511; Ross *et al.*, 2013:357), with a few exceptions (Meir, 2012:76).

As previously mentioned each team can only field 7 players at any one time, 3 playing as forwards and 4 playing as backs, whereas in Rugby Union each team consists of 15 players (Delahunt *et al.*, 2013:3252; Duthie *et al.*, 2003:974) 7 playing in the back-line and 8 playing in the forwards (Nicholas, 1997:376; Van Gent & Spamer, 2005:51). In Sevens Rugby each half lasts 7 minutes with a 2 minute break at half-time (Meir, 2012:76), with an exception at cup finals, when the 2 halves are extended to 10 minutes (Suarez-Arrones *et al.*, 2012:1858). The shorter match durations allows for more games to be played on a single day, nonetheless some of the games can extend the specified time due to stoppages in play (Meir, 2012:76). Controversial to Rugby Union in which games are normally played every 5 to 7 days, Sevens Rugby is normally played in tournament format with teams playing 5 to 6 games during the course of 2 to 3 days (Ross *et al.*, 2013:357). Teams are allowed to have 12 players in their squad during each game, 7 on the pitch and 5 on the bench with only 3 changes allowed during the match (Meir, 2012:76).

Even though Sevens Rugby has grown dramatically, it's surprising how little research exist to provide a detailed outline of the requirements necessary to be a respectable Sevens Rugby player regarding their kinanthropometric components. However, an attempt will be made to give a short overview on the research available in Sevens Rugby.

In Sevens Rugby the roles between the forward and backline players are not yet outlined as clearly as in the Rugby Union format (Fuller *et al.*, 2010:179). In a study by Rienzi *et al.* (1999:163-164) in Sevens Rugby it was evident that the forwards had greater stature, body mass, as well as a greater muscle and adipose mass than the backs. With this in mind an argument can be made that a lighter body mass is more beneficial to backs for the simple reason that backs are required to sprint more during games and to accelerate past opponents (Rienzi *et al.*, 1999:163).

The above mentioned differences in the kinanthropometric components between the forward and the backline players support previous evidence (Rienzi *et al.*, 1999:163) that certain positional roles require a specific physique. This, required physique however, might be less prominent in Sevens Rugby compared to Rugby Union because of the sevens game being considered an "open style of play" and because of fewer scrums and lineouts occurring during game time.

The cause for players to be shorter and lighter than their peers in Rugby Union could be due to the physical attributes required for players to meet the higher demands for running with the ball and the lower demands for physical confrontation in Sevens Rugby (Fuller *et al.*, 2010:182).

## **2.4 TARGETED POPULATION**

The above literature led to the main emphasis of the literature Chapter, which is to focus on the scientific literature that has been published on Rugby Union, Rugby League and Sevens Rugby youth with regards to kinanthropometry. Although some studies include other components such as motor skills, and physical characteristics, the focus of the study will remain on kinanthropometry and how it differentiates between playing positions and level of participation. According to the literature (as discussed earlier), there are a few kinanthropometric characteristics important for success in rugby. These kinanthropometric characteristics that have been described in the literature include direct (stature, body mass, skinfold measurements, girth measurements as well as breadth measurements) and indirect measurements (Body Mass Index, sum of skinfolds, body fat, muscle mass, skeletal mass as well as somatotyping).

## **2.5 ADOLESCENT RUGBY PLAYERS**

The chosen population consisted of adolescent players with an age range of between 16 and 18 years. During adolescence elite athletes pass through a vulnerable stage of development (Schubring & Thiel, 2014:78) and although adolescence is a very sensitive time in a boy's life, especially because of so many physical changes occurring in the body, it's also the time where boys usually make a step-up with regards to their performance (Malina, 2014:160).

A detailed discussion will now follow of the different Rugby codes (Rugby Union, Rugby League and Sevens Rugby) with regards to the kinanthropometric literature available on each of them. The kinanthropometric characteristics will be summarized in Tabel format. However, it is important to keep in mind that studies published before the year 2000 were discarded in the following presentation due to relevancy, with the exception of one study in Sevens Rugby published in 1999.

### **2.5.1 Population of Rugby Union studies**

With regards to the study of Adendorff *et al.* (2004), 34 boys between the ages of 17-18 were selected, forming part of a longitudinal study with the first testing taking place in 1994 and the second in 2001. The goal of the study was to determine motor and physical abilities, rugby skills and kinanthropometrical components of 18 year old Rugby Union players, which showed the best rugby potential at age 10. The players were divided into three groups. The first being all the boys playing in their school's first team. They consisted of 18 players and were classified as the successful group (SG-1). The second group consisted of 16 players and were players competing in lower teams and those who did not participate in rugby anymore. They were classified as the less successful group (LSG-2). The third group also selected from the less successful group consisted of the same players as group 2 but excluded the players that did not participate in rugby anymore (n=5) thus leading to a group size of 11 players (LSG-3). Only the difference between Group 1 (SG-1) and Group 3 (LSG-3) will be discussed, because some players in LSG-2 did not participate in Rugby anymore.

In the study of Van Gent and Spamer in Rugby Union (2005) the population group consisted of different age levels namely, u/13 (n=22), u/16 (n=21), u/18 (n=18) and u/19 (n=19), all of them being Provincial North West rugby players. The population of each age group was small due to fact that all the players participated at elite level. The players of the different age groups were also divided into four positional groups namely: tight forwards (props, hooker and locks), loose forwards (flankers and eight man), halfbacks (scrum-halves and fly-halves) and backline players (centres, wings and full back). According to Van Gent and Spamer (2005:52), the previously mentioned groups are commonly used by all rugby coaches.

The study of Durandt *et al.* (2006) shows that elite junior South African rugby players (the Green Squad), selected in 2003 was chosen for this study. The u/16 players (N=92) were selected from the National Grant Komo tournament, while the u/18 players (N=82) were selected from the National Craven Week tournament.

Plotz and Spamer (2006) reported in their study that the players consisted of three elite u/18 groups (tested during the peak season of 2003), the first group being 22 players from the first team of the Ivybridge Sport School in South Western England, while the second and third group, both from South Africa consisted out of 20 players from the Blue Bulls Craven Week team and 22 players from the Leopards Craven Week team.

In the study by Spamer and De la Port (2006) 71 Green Squad (elite South African rugby players) players were selected from the u/16 Grant Khomo tournament, whereas 75 Green

Squad players were selected from the u/18 Craven week tournament. The test protocol (composed by the South African Rugby Union (SARU) was performed over two seasons (during the mid-season of 2003 and 2004) for each age group, and the same players tested during the 2003 season were tested again during the 2004 season. All the players followed a training programme constructed by SARU and consisted of weight training, cardiovascular training, running skills, plyometrics and handling skills. Players had the option to participate in swimming, spinning or treadmill running during weekends. The training programme was followed from August 2003 to February 2004. The same sample size used by Spamer and De la Port (2006) was also used by Durandt *et al.* (2006), with the exception of Durandt *et al.* (2006) only making use of the 2003 sample group.

According to the study by Spamer *et al.* (2009), two elite u/16 rugby teams from South Africa were compared to an elite u/16 team from New Zealand. The players were divided into 3 groups. The first group (tested in 2004 in New Zealand) consisted of 24 Provincial u/16 A players from Taranaki in New Zealand, the second group (tested in 1996) consisted of 43 elite u/16 high school rugby players situated in the North West Province in South Africa and the third group (tested in 2002) consisted of 21 elite U16 players (the same u/16 sample population used by Van Gent & Spamer, 2005) also from the North West Province competing in a national tournament. For the convenience of the discussion, group 1 will be referred to as NZ group, group 2 will be referred to as SA<sub>1</sub> and group 3 will be referred to as SA<sub>2</sub>.

Delahunt *et al.* (2013), investigated 136 Irish adolescent schools Rugby Union players between 16 and 18 years of age took part in their respective study. All the players competed for a team spot in one of five teams participating in the Leinster Schools Senior cup. The players were divided into backline and forward players and sub-divided into the following on-field positions namely props, hookers, second row, back row, scrum half, out half, centre and back three.

The above description of the populations on Rugby Union were all between the ages of 16 and 18 years and is summarized in Table 1A with an indication of the kinanthropometric variables that were measured in the studies involved.

**Table 1A: A comparison between different studies regarding adolescent Rugby Union players' kinanthropometric data.**

Authors	Age of interest	Population	Date	Kinanthropometric variables measured	Compared	Variables found to be significantly different
Adendorff <i>et al.</i>	u/18	34 boys between the ages of 17-18 were selected, and categorized as successful and less successful players.	2004	Stature (cm) Body mass (kg) BMI(kg/m <sup>2</sup> ) Body fat (%) Skeletal mass (%) Somatotyping	Successful players to less successful players.	Body mass (kg)* BMI(kg/m <sup>2</sup> )** Ectomorphic value**
Van Gent and Spamer	u/16 and u/18	The sample size contained u/16 (N=21) and u/18 (N=18) North West Provincial Rugby players.	2005	Stature (cm) Body mass (kg) Skinfold measurements (mm) Girth measurements (cm) Breadths measurements (cm) Σ7 skinfolds (mm) Body fat (%)	Playing positions of different age groups.	Stature (cm)** Body mass (kg)** Body fat (%) Skinfold measurements (mm)** Girths measurements (cm)** Breadth measurements (cm)** Σ7 skinfolds (mm)**
Durandt <i>et al.</i>	u/16 and u/18	Players competing in the u/16 National Grant Komo tournament and u/18 National Craven Week tournament were selected and consisted of 92 and 82 players respectively.	2006	Stature (cm) Body mass (kg) Σ7 skinfolds (mm) Body fat (%)	Playing positions between two age groups	Stature (cm) † Body mass (kg) † Σ7 skinfolds (mm) † Body fat (%) †

**Table 1A: A comparison between different studies regarding adolescent Rugby Union players' kinanthropometric data.**

Authors	Age of interest	Population	Date	Kinanthropometric variables measured	Compared	Variables found to be significantly different
Plotz and Spamer	u/18	Three elite u/18 groups were selected consisting of 22 players from the first team of the Ivybridge Sport School in South Western England, while the second and third group, both from South Africa consisted of the 20 players from the Blue Bulls and 22 players from the Leopards Craven Week teams.	2006	Stature (cm) Body mass (kg) Skinfold measurements (mm) Girth measurements (cm)	Three different sample groups	Stature (cm)* Skinfold measurements (mm)** Girth measurements (cm)**
Spamer and De la Port	u/16 and u/18	71 Green Squad players were selected from the u/16 Grant Khomo tournament, whereas 75 Green Squad players were selected from the u/18 Craven week tournament.	2006	Stature (cm) Body mass (kg) Σ7 skinfolds (mm) Body fat (%) Muscle mass (%) Somatotyping	Two age groups after consecutive seasons	NS
Spamer <i>et al.</i>	u/16	Two elite u/16 rugby teams from South Africa (SA <sub>1</sub> and SA <sub>2</sub> ) consisting of 43 and 21 players respectively, were compared to an elite u/16 team from New Zealand consisting of 24 players.	2009	Stature (cm) Body mass (kg) Skinfold measurements (mm) Girth measurements (cm) Body fat (%)	Three different sample groups	Body mass (kg)** Skinfold measurements (mm)** Girth measurements (cm)* Body fat (%)**

Note: NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; †statistical significant different ( $p < 0.05$ ).

**Table 1A: A comparison between different studies regarding adolescent Rugby Union players' kinanthropometric data.**

<b>Authors</b>	<b>Age of interest</b>	<b>Population</b>	<b>Date</b>	<b>Kinanthropometric variables measured</b>	<b>Compared</b>	<b>Variables found to be significantly different</b>
Delahunt <i>et al.</i>	u/16- u/18	A number of 136 Irish adolescent school Rugby Union players between the ages of 16 and 18 years were selected to take part in this study.	2013	Stature (m) Body mass (kg) Body fat (%) Body fat (kg) Lean mass (kg) Fat free mass (kg)	Players in forward and back units as well as players of individual playing positions	Stature (m) † Body mass (kg) † Body fat (%) † Body fat (kg) † Lean mass (kg) † Fat free mass (kg)†

Note: NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; †statistical significant different ( $p < 0.05$ ).

Significant conclusions can be drawn from the studies summarized in Tabel 1A. Most of the studies summarized produced practical as well as statistical significant differences with regards to different kinanthropometric measurements, indicating the huge benefit kinanthropometry poses for Rugby Union players.

## **2.5.2 Population of Rugby League studies**

Rugby League has similar rules and movement patterns to Rugby Union (Gabbett, 2005a:764), however, some differences do exist. Rugby League does not have a line-out, only involves 13 players per team (compared to 15 players of Rugby Union) and after each tackle, play is continued by an immediate play of the ball (Gabbett, 2005b:961). However, it is important to note that studies that used standardized kinanthropometric characterization are lacking in junior Rugby League players (Cheng *et al.*, 2014:547). Male junior Rugby League players are an inimitable population, undertaking maturation of important performance-related qualities.

All the players (N=159) participating in the study by Gabbett (2002a) were registered with the same sub-elite Rugby League club and competed in the Gold Coast Junior Rugby League competition consisting of u/16, u/15, u/14 and u/13 players or the Gold Coast Group 18 Senior Rugby League competition consisting of first grade (meaning the first team), second grade (meaning the second team) and u/19 players. Because of the specific age range used for this particular study only the u/16 sample size consisting of 21 players (12 forward and 9 backline players) will be taken into consideration for discussion.

With regards to the study of Gabbett (2005c), the players (N=240) participating in the study were between the ages of 16-18, all competing in a sub-elite competition known as the Gold Coast junior Rugby League competition. Participants were divided into forwards (N=115) and backs (N=125) and subdivided into the following positional groups: props, hookers and halves (hookers, halfbacks and five-eighths), backrowers (second-rowers and locks) and outside backs (centres, wingers and fullbacks).

In a study by Gabbett (2009:234) 88 players, participating for the same sub-elite junior Rugby League club were selected. The players were competing in the Gold Coast Junior competition at u/14 (53 players), u/16 (20 players) and u/18 (15 players) levels. Only the data of the players in the u/16 and u/18 categories were considered for the following discussion.

According to Gabbett *et al.* (2009), a total of 36 junior sub-elite and 28 junior elite Rugby League players participated in this study. The sub-elite players were all registered with the

same Rugby League club, while the elite players were all part of a National Rugby league club junior development programme. The junior elite and sub-elite players were divided into hit-up forwards (prop and second-row), adjustables (hooker, halfback, five-eight and lock) and outside backs (centre, wing and fulback).

In the study of Cheng *et al.* (2014), a total of 446 players from all 18 clubs selected to play in the Australian state-level junior u/18 elite Rugby League competition were invited to participate in this study. Players were divided into forward and backline players as well as into positional subgroups namely: hit-up forwards (props), wide-running forwards (second rowers and locks), adjustables (fullbacks, five-eight, halfback and hookers) and lastly outside backs (wingers and centres).

Positional group classification can differ greatly in Rugby League as noted in the population discussion of the different studies. Therefore, it is important to note that authors sometimes make different group classifications which usually consist of different individual positions for example, hit-up forwards, according to Gabbett *et al.* (2009), consist of the props and the second row, while Cheng *et al.* (2014) are of the opinion that they consist of only the props.

**Table 1B: A comparison between different studies regarding adolescent Rugby League players' kinanthropometric data.**

Authors	Age of interest	Population	Date	Kinanthropometric variables measured	Compared	Variables found to be significantly different
Gabbett	u/16	The particular age group used participating in this study consisted of 12 forward and 9 back line players	2002a	Body mass (kg)	Forwards with backs	NS
Gabbett	u/16-u/18	The players (N=240) participating in this study were between the ages of 16-18, all competing in a sub-elite competition.	2005c	Stature (cm) Body mass (kg) Σ4 skinfolds (mm)	Specific playing positions and positional playing groups	Stature (cm)† Body mass (kg) † Σ4 skinfolds (mm)†
Gabbett	u/16 and u/18	A total of 20 u/16 and 15 u/18 players of the same sub-elite junior Rugby League club participated in this study.	2009	Stature (cm) Body mass (kg) Σ4 skinfolds (mm)	Different age groups as well as starters with non-starters	NS
Gabbett <i>et al.</i>	u/16	A total of 36 junior sub-elite and 28 junior elite Rugby League players participated in this study.	2009	Stature (cm) Body mass (kg) Σ7 skinfolds (mm)	Playing levels, starters and non-starters and different positional playing groups	Stature (cm)*† Body mass (kg) † Σ7 skinfolds (mm)
Cheng <i>et al.</i>	u/18	A total of 446 players from all 18 clubs selected to play in the Australian state-level junior u/18 elite Rugby League competition were invited to participate in this study	2014	Stature (cm) Body mass (kg) Girth measurements (cm) Breadth measurements (cm) BMI (kg/m <sup>2</sup> ) Σ7 skinfolds (mm) Body fat (%) Somatotyping	Forwards with backs and positional playing groups	Body mass (kg) † Girth measurements (cm) † Breadth measurements (cm)† BMI (kg/m <sup>2</sup> ) † Σ7 skinfolds (mm)† Body fat (%) † Somatotyping†

Note: NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; †statistical significant different ( $p < 0.05$ ).

Significant conclusions can be drawn from the studies summarized in Tabel 1B . Most of the studies summarized produced practical as well as statistical significant differences with regards to different kinanthropometric measurements, indicating the huge benefit kinanthropometry poses for Rugby League players.

### **2.5.3 Population of Sevens Rugby studies**

No research to date has been published on adolescent Sevens Rugby players, however, for the relevancy of this Chapter, the literature published on players from all Sevens Rugby age groups, will be discussed. Although not the main focus, kinanthropometric characteristics of Sevens Rugby players have been reported in studies referring to player profiling, time-motion analysis, load monitoring, and injury epidemiology. Studies will not be explained in depth as most of them did not focus primarily on kinanthropometry.

In the study by Rienzi *et al.* (1999), kinanthropometric data were obtained from 27 players from 14 different teams participating in an international Sevens Rugby tournament held in Uruguay in 1996. The study by Takahashi *et al.* (2007) collected data from the Japanese Sevens Rugby squad (N=7) participating in the Japan Sevens Tournament held in 2003. In the investigation by Fuller *et al.* (2010), kinanthropometric data were gathered on 264 Sevens Rugby players (162 backline players and 88 forward players) representing the 12 countries that participated in all 8 tournaments of the 2008/2009 IRB Sevens World Series and the IRB Sevens Rugby World Cup in 2009.

The study by Elloumi *et al.* (2012) compared kinanthropometric data of 16 players from the Tunisian national Sevens Rugby team between December 2008 and March 2009. Players were measured three times during the training period, however, only the first measurement data were used for the comparison of the all the Sevens Rugby players later in this study. Regarding the study of Higham *et al.* (2012), 19 international Sevens Rugby players competing in 16 matches over three domestic tournaments and 11 matches played during two international tournaments were assessed during this particular study. In the study of Suarez-Arrones *et al.* (2012), seven highly trained players from the same team were investigated through 5 competitive club level matches. The study by Higham *et al.* (2013) examined 18 national Sevens Rugby players from the same team.

In the investigation by Granatelli *et al.* (2014), nine Italian Sevens Rugby players competing at a professional level of which five also competing at international level were evaluated. The study by West *et al.* (2014) investigated 10 elite international Sevens Rugby players.

**Table 1C: A comparison between different studies regarding Sevens Rugby players' kinanthropometric data.**

Authors	Average age	Population	Date	Kinanthropometric variables measured	Study sample	Variables found to be significantly different
Rienzi <i>et al.</i>	Not mentioned	International (N=27)	1999	Stature (cm) Body mass (kg) Body fat (%) Body fat (kg) Muscle mass (%) Muscle mass (kg) Somatotyping	Selected forward and backline players from an international Sevens Rugby tournament.	Stature (cm) † Body mass (kg) † Muscle mass (kg) †
Takahashi <i>et al.</i>	20.7 years	International (N=7)	2007	Stature (cm) Body mass (kg)	Players from the Japan Sevens Rugby squad (variable was only mentioned and not discussed)	N/A
Fuller <i>et al.</i>	23.1 years	International (N=267)	2010	Stature (cm) Body mass (kg)	Forward and backline players	Stature (cm) † Body mass (kg) †
Elloumi <i>et al.</i>	23.8 years	International (N=16)	2012	Stature (cm) Body mass (kg) BMI(kg/m <sup>2</sup> ) Body fat (%)	Players from the Tunisian national Sevens Rugby team (data set of players before they started with their training programme-see article for more information)	N/A
Higham <i>et al.</i>	21.2 years	International (N=19)	2012	Stature (cm) Body mass (kg)	International Sevens Rugby players (variable was only mentioned and not discussed)	N/A

Note: NS, non-significant; N/A, not applicable; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^{*}$ ; †statistical significant different ( $p < 0.05$ ).

**Table 1C: A comparison between different studies regarding Sevens Rugby players' kinanthropometric data.**

Authors	Average age	Population	Date	Kinanthropometric variables measured	Study sample	Variables found to be significantly different
Higham <i>et al.</i>	21.9 years	International (N=18)	2013	Stature (cm) Body mass (kg) Σ7 skinfolds (mm)	A national Sevens Rugby squad	N/A
Granatelli <i>et al.</i>	25.1 years	National and international (N=9)	2014	Stature (cm) Body mass (kg) BMI(kg/m <sup>2</sup> )	Sevens Rugby players (variable was only mentioned and not discussed)	N/A
Suarez-Arrones <i>et al.</i>	27.4 years	Domestic (N=10)	2014	Stature (cm) Body mass (kg) Σ6 skinfolds (mm)	Highly trained Sevens Rugby players (variable was only mentioned and not discussed)	N/A
West <i>et al.</i>	25.5 years	International (n=10)	2014	Stature (cm) Body mass (kg)	International Sevens Rugby players (variable was only mentioned and not discussed)	N/A

Note: NS, non-significant; N/A, not applicable; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^{*}$ ; †statistical significant different ( $p < 0.05$ ).

It is clear in Table 1C that not a great deal of significant differences have been detected in Sevens Rugby regarding players' kinanthropometric characteristics. A shortage in literature exist with regards to a detailed outlining of Sevens Rugby players' kinanthropometric characteristics.

## **2.6 STATURE AND BODY MASS**

Research suggests that two major physical characteristics which play a definite role in the selection process are body mass and stature (Norton & Olds, 2001:764). A high body mass is considered highly beneficial, with lightweight players simply being outplayed or not seen as robust enough. Thus one can expect body mass to be a highly selective feature in international Rugby (Norton *et al.*, 1996:291).

### **2.6.1 Stature and body mass in Rugby Union**

Teams consisting of taller and heavier players perform better in Rugby Union (Duthie *et al.*, 2003:976; Olds 2001:257), stating a strong relationship exists between body size (indicated by height and weight (Rigg & Reilly, 1988:197) and success for teams and individuals. A discussion will now follow on previous literature done on adolescent Rugby Union players regarding stature and body mass to gain a better understanding of the influence these direct measurements have, if any at all, on the performance of the players. A summary of the descriptive statistics of different studies will be given in Table format followed by a brief discussion of the mentioned results.

**Table 2A: Comparison of stature (cm) in elite adolescent Rugby Union players as reported by different authors.**

Authors	Study group	N	$\bar{X}$		SD	p-value	d-value
			u/16	u/18			
Adendorff <i>et al.</i> (2004:449)	Successful group	18	-	181.9	8.9	-	0.05
	Less successful group	11	-	181.4	6.5	-	
Durandt <i>et al.</i> (2006:40)	U16 Green Squad	92	175.6	-	5.7	<0.001	-
	U18 Green Squad	82	-	179.2	6.7		-
Plotz and Spamer (2006:103)	Blue Bulls players (BB)	18	-	185.6	6.6	-	0.50* (BB vs. IV)
	Ivybridge players (IV)	21	-	181.9	7.4	-	0.29 (IV vs. LP)
	Leopards players (LP)	21	-	179.5	8.1	-	0.75* (LP vs. BB)
Spamer and De la Port (2006:178)	U16 Green Squad-2003 season	71	175.4	-	8.1	-	0.34
	U16 Green Squad-2004 season	69	178.2	-	7.6	-	
	U18 Green Squad -2003 season	75	-	180.3	9.2	-	0.02
	U18 Green Squad -2004 season	71	-	180.4	9.0	-	
Spamer <i>et al.</i> (2009:54)	New Zealand group (NZ)	24	179.7	-	5.8	-	-
	South Africa group 1 (SA <sub>1</sub> )	43	177.6	-	5.6	-	0.4 (NZ vs. SA <sub>1</sub> )
	South Africa group 2 (SA <sub>2</sub> )	22	180.9	-	8.2	-	0.1 (NZ vs. SA <sub>2</sub> )

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; significant difference ( $p < 0.05$ ).

From table 2A it is clear that in the investigation of Durandt *et al.* (2006), u/16 players were on average significantly shorter ( $p < 0.001$ ) than u/18 players. One could argue that the reason for the latter occurring might be because of the age difference; or the possibility of growth and maturation playing a role. The latter is supported by Cumming *et al.* (2009:678) who state that males who are advanced in maturation tend to have greater gains in height. In the study by Plotz and Spamer (2006), only medium practical significant differences were found when the Blue Bulls (BB) players were compared to the Ivybridge (IV) ( $d=0.5$ ) players, with high practical significance attained for almost all the characteristics when compared to the Leopards (LP) ( $d=0.75$ ) players. Small practical differences were found when comparing the IV players to the LP players. No practical significant differences whatsoever were found with regards to height in the remainder of the studies by Adendorf *et al.* (2004), Spamer and De la Port (2006) and Spamer *et al.* (2009).

When comparing the studies regarding the u/16 age group it was evident that the NZ (New Zealand) group and SA<sub>2</sub> (South African) group in the study of Spamer *et al.* (2009) were reasonably superior in stature with 179.7 cm and 180.9 cm respectively compared to the 175.6 cm and 175.4 cm of the u/16 Green Squad of Durandt *et al.* (2006) and Spamer and De la Port (2006) (2003 season). Although of the same chronological age it could be seen that the players differed with regards to their biological maturity. According to Malina (2002:263) and Malina *et al.* (2004:340), size differences in children with contrasting maturity status are most obvious during adolescence at 11 to 16 years of age in boys. Another reason for the difference occurring could be the small sample sizes of the NZ (N=24) and SA<sub>2</sub> (N=22) groups.

In the u/18 age groups no large practical significant differences existed except for the BB players ( $\bar{X}=185.6\text{cm}$ ) of Plotz and Spamer (2006) who were found to have greater stature values compared to the other groups. Although the BB players is not as elite as the Greens Squad or NZ group the BB players, however, were the winners of the 2003 Craven Week tournament (Plotz & Spamer, 2006:106). Literature found that a large body size, indicated by height and weight (Rigg & Reilly, 1988:197), was a considerable predictor of success in Rugby Union (Duthie *et al.*, 2003:976; Olds, 2001:260; Sedeaud *et al.*, 2012:583).

**Table 2B: Comparison of body mass (kg) in elite adolescent Rugby Union players as reported by different authors.**

Authors	Study group	N	$\bar{X}$		SD	p-value	d-value
			u/16	u/18			
Adendorff <i>et al.</i> (2004:449)	Successful group	18	-	83.1	11.6	-	0.62*
	Less successful group	11	-	75.9	8.4	-	
Durandt <i>et al.</i> (2006:41)	U16 Green Squad	92	76.5	-	8.2	<0.0001	-
	U18 Green Squad	82	-	84.9	8.3		-
Plotz and Spamer (2006:103)	Blue Bulls players (BB)	18	-	87.4	14.3	-	0.03 (BB vs. IV)
	Ivybridge players (IV)	21	-	87.8	11.5	-	0.25 (IV vs. LP)
	Leopards players (LP)	21	-	84.9	11.8	-	0.17 (LP vs. BB)
Spamer and De la Port (2006:178)	U16 Green Squad-2003 season	71	76.2	-	11.7	-	0.24
	U16 Green Squad -2004 season	69	79.5	-	13.6	-	
	U18 Green Squad -2003 season	75	-	85.1	12.5	-	0.13
	U18 Green Squad -2004 season	71	-	86.8	13.9	-	
Spamer <i>et al.</i> (2009:54)	New Zealand group (NZ)	24	81.3	-	8.3	-	-
	South Africa group 1 (SA <sub>1</sub> )	43	72.8	-	9.6	-	0.9 (NZ vs. SA <sub>1</sub> )
	South Africa group 2 (SA <sub>2</sub> )	22	76.6	-	11.4	-	0.1 (NZ vs. SA <sub>2</sub> )

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; significant difference ( $p < 0.05$ ).

From table 2B the study of Adendorff *et al.* (2004) showed a moderate meaningful difference with respect to body mass ( $d=0.62$ ) when the successful group was compared to the less successful group. The results of Durant *et al.* (2006) showed that the u/16 Green Squad ( $\bar{X}=76.5$  kg) weighed significantly less than the u/18 Green Squad ( $\bar{X}=84.9$  kg). Again the latter might be linked to growth and maturity differences. Large practical significant difference ( $d=0.9$ ) was evident in the study of Spamer *et al.* (2009) between the NZ and SA<sub>1</sub> group. No meaningful differences for the weight variable were found in the studies by Plotz and Spamer (2006) and Spamer and De la Port (2006).

In the u/16 age group no large practical significant differences occurred except for the NZ group ( $\bar{X}=81.2$  kg) in the study of Spamer *et al.* (2009) and the Green Squad ( $\bar{X}=79.5$  kg-2004 season) in the study of Spamer and De la Port (2006) being considerably heavier than the SA<sub>1</sub> group ( $\bar{X}=72.8$  kg) of Spamer *et al.* (2009). It is important to note that although all the players were elite, the SA<sub>1</sub> group consisted only of players playing for their school's first team whereas the players of both the NZ group and Green Squad were selected to represent their country at international level. A possible reason for the NZ group and Green Squad players being heavier might be due to the fact that they were elite, and classified as being the best regarding their age group and according to literature (Olds, 2001:260; Quarrie *et al.*, 1995:263) body size (indicated by height and weight, Rigg & Reilly, 1988:197) and physique plays a major role in team selection and successful performance. Another reason could be the lapsed time between the date of testing with the Green Squad being tested during 2003, the NZ group in 2004 and SA<sub>1</sub> group way back in 1996.

With regards to the u/18 age group, all of the involved groups were heavier than the less successful group of Adendorff *et al.* (2004), which supports the literature stating that coaches and selectors place high emphasis on size and physique when choosing their players (Adendorff *et al.*, 2004:454; Quarrie *et al.*, 1995:263). Quarrie *et al.* (1995:267) also documented that body mass differs between different levels of competition.

Certain playing positions within a team sport require specific physique characteristics dependent on the physiological demands they have to endure during the game (Malousaris *et al.*, 2008:338). According to the research, the most visible kinanthropometric differences existing between forward players and backline players are stature and body mass (Quarrie *et al.*, 1995:268; Quarrie *et al.*, 1996:56). Research further indicates that stature and body mass differs between different playing positions (Holway & Garavaglia, 2009:1217; Quarrie *et al.*, 1996:56).

A discussion follows with regards to previous literature pertaining to adolescent Rugby Union players' stature and body mass in different playing positions. A summary of the descriptive statistics of different studies will be given in table format followed by a brief discussion of the results mentioned, firstly stature followed by body mass.

**Table 2C: Comparison of stature (cm) in elite and non-elite adolescent Rugby Union players regarding positional classification as reported by different authors.**

Authors	Positional group/units	N		$\bar{X}$						d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18	SD	
Van Gent and Spamer (2005:54,56)	Tight forwards (TF) (props, hookers and locks)	21	18	183.9	-	187.9	-	-	-	u/16=0.02 u/18=0.02 (TF vs.LF)
	Loose forwards (LF) (flankers and eight man)			183.8	-	188.0	-	-		
	Halves (H) (scrumhalf and fly-half)			172.5	-	172.0	-	-	u/16=0.81** u/18=1.45** (H vs. BL)	
	Back-line (BL) (centers, wings and fullback)			178.5	-	182.8	-	-		
Durandt <i>et al.</i> (2006:40)	<b>Individual positions</b>									
	Prop	10	13	177.5	6.0	180.3	3.8	-	-	-
	Hooker	7	5	173.4	3.1	178.8	6.3	-	-	-
	Lock	10	11	187.2	5.5	194.2	5.2	-	-	-
	Loose forwards	16	15	180.8	4.3	181.3	6.3	-	-	-
	Scrumhalf	6	8	165.9	10.3	167.8	5.6	-	-	-
	Fly-half	8	7	173.0	5.3	177.6	7.6	-	-	-
	Wing	15	9	171.7	5.2	176.4	8.2	-	-	-
	Centre	12	11	173.4	6.5	179.1	8.5	-	-	-
Fullback	8	3	178.1	5.5	177.6	9.0	-	-	-	

Authors	Positional group/units	N		$\bar{X}$						d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18	SD		
Delahunt <i>et al.</i> (2013: 3254-3255)	Prop <sup>c</sup>	16	-	-	-	-	-	181.0	-	-	
	Hooker <sup>c</sup>	13	-	-	-	-	-	176.0	-	-	
	Second row (lock) <sup>a,b,d,e,f,g,h</sup>	19	-	-	-	-	-	189.0	-	-	
	Back row (loose forwards) <sup>c</sup>	24	-	-	-	-	-	179.0	-	-	
	Scrumhalf <sup>c</sup>	14	-	-	-	-	-	175.0	-	-	
	Out half (fly-half) <sup>c</sup>	9	-	-	-	-	-	179.0	-	-	
	Centre <sup>c</sup>	16	-	-	-	-	-	181.0	-	-	
	Back three (wings and fullback) <sup>c</sup>	25	-	-	-	-	-	178.0	-	-	
	<b>Forward and back units</b>										
	Forward players	72	-		--	-	-	182.0	7.1	0.07	
Backline players	64	-	-	-	-	-	178.0	5.6			

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Durant *et al.* (2006):

- Props vs. Scrumhalf  $p < 0.00002$
- Props vs. Wings  $p < 0.05$
- Hookers vs. Scrumhalf  $p < 0.015$
- Locks vs. All positions  $p < 0.00004$
- Loose forward vs. Scrumhalf  $p < 0.00001$
- Loos forwards vs. Wing  $p < 0.0007$
- Scrumhalf vs. Fly-half  $p < 0.013$
- Scrumhalf vs. Centre  $p < 0.003$

- Scrumhalf vs. Fullback  $p < 0.0009$

Delahunt *et al.* (2013):

- <sup>a</sup> Significantly different from prop
- <sup>b</sup> Significantly different from hooker
- <sup>c</sup> Significantly different from second row
- <sup>d</sup> Significantly different from back row
- <sup>e</sup> Significantly different from scrum half
- <sup>f</sup> Significantly different from out half
- <sup>g</sup> Significantly different from centre
- <sup>h</sup> Significantly different from back three

When player positional differences amongst Rugby Union players for stature were compared Van Gent and Spamer (2005) yielded a large practical significant difference in stature ( $d=0.81$ ) between the back-line and half-back rugby players in the u/16 age group. Although Sedeaud *et al.* (2013:190) state that a large body size (indicated by height and weight, Rigg & Reilly, 1988:197) already occurs amongst young players even as early as 15 years, Van Gent and Spamer (2005:59) are of the opinion that many of the players at this age are relatively similar in spite of their position, giving the coaches the freedom to still change a forward player to a backline player and *vice versa*. The u/18 age group experienced the same occurrence with the back-line players being significantly taller than the half-backs ( $d=1.45$ ). This difference in stature could be due to the smaller size of scrum halves in order for them to be more agile or because of the minimal requirements for contact expected by this position which serves players who have a smaller size (Holway & Garavaglia, 2009:1217). Meaningful differences also occurred in the investigation by Durandt *et al.* (2006), with respect to stature, between the different playing positions with the locks being the tallest in both age groups ( $\bar{X}=187.2$  cm and  $\bar{X}=194.2$ cm). However, this comes as no surprise, as it is mandatory for locks to have greater stature as it is an important requisite for success in line-outs (Duthie *et al.*, 2003:977; Holway & Garavaglia, 2009:1217) and restarts to win possession of the ball (Delahunt *et al.*, 2013:3256). When evaluating the results of Delahunt *et al.* (2013), it is clear that the second row players (locks) were significantly taller than all the other positions.

When comparing the u/18 loose forwards of all three (Delahunt *et al.*, 2013; Durandt *et al.*, 2006; Van Gent & Spamer, 2005) studies it is clear that the average stature of the loose forwards of Van Gent and Spamer (2005) were greater ( $\bar{X}=188.0$  cm) compared to the loose forward players in the studies of Durandt *et al.* (2006) and Delahunt *et al.* (2013) ( $\bar{X}=181.3$  cm and  $\bar{X}=179.0$  cm). This could be due to a small sample size of Van Gent and Spamer (2005) who's u/18 group consisted of only 18 players, whereas the sample size of Durandt *et al.* (2006) consisted of 82 players of which 15 were loose forwards. The players taking part in the study of Delahunt *et al.* (2013) on the other hand were between the ages of 16-18 years with an average age of 16.93 with no distinction made between the age groups. The average stature of the locks in the study of Durandt *et al.* (2006) were relatively taller compared to the second row (locks) players ( $\bar{X}=194.2$  cm vs.  $\bar{X}=189.0$  cm) of Delahunt *et al.* (2013). According to Delahunt *et al.* (2013), the group of players in his study was a mixed sample whereas the players of Durandt *et al.* (2006) were elite, which according to Olds (2001:257) and Duthie *et al.* (2003:976) is evident when comparing players of different competitive standards. Regarding the scrum halves of Delahunt *et al.* (2013) and Durandt *et al.* (2006) it is clear that the scrum halves of Delahunt *et al.* (2013) had greater stature values.

The forward players ( $\bar{X}$  = 1.82cm) were considerably taller than the back-line players ( $\bar{X}$  = 1.78cm) which are greatly supported by the literature with regards to senior Rugby Union players (Duthie *et al.*, 2003:987; Nicholas & Baker, 1995:15; Quarrie *et al.*, 1995:268; Sedeaud *et al.*, 2012:581).

**Table 2D: Comparison of body mass (kg) in elite adolescent Rugby Union players regarding positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$						d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18	SD	
Van Gent and Spamer (2005:54,56)	Tight forwards (TF) (props, hookers and locks)	21	18	82.8	-	96.6	-	-	-	u/16=0.67* u/18=1.67** (TF vs.LF)
	Loose forwards (LF) (flankers and eight man)			77.5	-	83.5	-	-		
	Halves (H) (scrumhalf and fly-half)			68.0	-	68.7	-	-	u/16=0.54* u/18=1.13** (H vs. BL)	
	Back-line (BL) (centers, wings and fullback)			72.3	-	77.5	-	-		
Durandt <i>et al.</i> (2006:40)	<b>Individual positions</b>									
	Prop	10	13	95.5	14.1	100.8	13.1	-	-	-
	Hooker	7	5	79.5	6.4	93.1	5.7	-	-	-
	Lock	10	11	87.1	8.8	95.2	8.4	-	-	-
	Loose forwards	16	15	80.5	7.3	88.2	5.5	-	-	-
	Scrumhalf	6	8	60.8	8.9	70.3	4.9	-	-	-
	Fly-half	8	7	69.6	5.3	75.0	8.2	-	-	-
	Wing	15	9	68.4	6.7	77.7	12.2	-	-	-
	Centre	12	11	71.9	9.1	85.1	9.9	-	-	-
Fullback	8	3	75.2	6.8	78.8	6.6	-	-	-	
Delahunt <i>et al.</i> (2013:3254-3255)	Props <sup>b,d,e,f,g,h</sup>	-	16	-	-	-	-	92.5	-	-

Authors	Positional group	N		$\bar{X}$					d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18		SD
	Hooker <sup>a,e,h</sup>	-	13	-	-	-	-	81.2	-	-
	Second row (lock) <sup>e,h</sup>	-	19	-	-	-	-	84.9	-	-
	Back row (loose forwards) <sup>a,e</sup>	-	24	-	-	-	-	78.1	-	-
	Scrum half <sup>a,b,c,d</sup>	-	14	-	-	-	-	69.4	-	-
	Out half (fly-half) <sup>a</sup>	-	9	-	-	-	-	75.5	-	-
	Centre <sup>a</sup>	-	16	-	-	-	-	78.2	-	-
	Back three (wings and fullback) <sup>a,b,c</sup>	-	25	-	-	-	-	72.5	-	-
<b>Forward and back units</b>										
	Forward players		72	-	-	-	-	83.6	10.5	0.23
	Backline players		64	-	-	-	-	73.7	6.6	

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Durant *et al.* (2006:40):

- Prop vs. Hooker  $p < 0.00660$
- Prop vs. Loose forward  $p < 0.00001$
- Props vs. Scrumhalf  $p < 0.00001$
- Prop vs. Fly-half  $p < 0.00001$
- Props vs. Wing  $p < 0.00001$
- Prop vs. Centre  $p < 0.00001$
- Prop vs. Fullback  $p < 0.00001$
- Hookers vs. Scrumhalf  $p < 0.00001$
- Hooker vs. Fly-half  $p < 0.00889$
- Hooker vs. Wing  $p < 0.00715$
- Lock vs. Scrumhalf  $p < 0.00001$

- Lock vs. Fly-half  $p < 0.00001$
- Lock vs. Wing  $p < 0.00001$
- Lock vs. Centre  $p < 0.00006$
- Lock vs. Fullback  $p < 0.00180$
- Loose forward vs. Scrumhalf  $p < 0.00001$
- Loos forwards vs. Fly-half  $p < 0.00521$
- Loose forward vs. Wing  $p < 0.00005$
- Centre vs. Scrumhalf  $p < 0.00975$

Delahunt *et al.* (2013):

- <sup>a</sup>Significantly different from prop
- <sup>b</sup>Significantly different from hooker
- <sup>c</sup>Significantly different from second row
- <sup>d</sup>Significantly different from back row
- <sup>e</sup>Significantly different from scrum half
- <sup>f</sup>Significantly different from out half
- <sup>g</sup>Significantly different from centre
- <sup>h</sup>Significantly different from back three

When player positional differences amongst Rugby Union players for body mass were compared, Van Gent and Spamer (2005:52-58) yielded moderate significant difference in the u/16 players between the tight forwards and loose forwards ( $d=0.67$ ) as well as between the back-line and half-back players ( $d=0.54$ ). In the results of the u/18 players it was clear that there was a large practical significant difference in body mass ( $d=1.67$ ) between the tight and loose forwards. When evaluating the tight forwards, Quarrie *et al.* (1996:55-56) is of the opinion that the physique of props display the demands placed upon them during scrums, rucks and mauls. It is evident when looking at the findings of Maud and Schultz (1984:87) that a large body mass is very beneficial towards previously mentioned set pieces. According to Deutsch *et al.* (2007:462,466), front row forwards (prop and lock) are more involved in rucks and mauls than players in other positional sub groups. Hookers resemble similar to props but weigh slightly less (Quarrie *et al.*, 1996:56). Locks (also forming part of the tight forwards) require significant stature for line outs (Holway & Garavaglia, 2009:1217), and an increase in stature is associated with an increase in weight.

When observing the loose forwards one expect tight forwards to have greater body mass, which according to Deutsch *et al.* (2007:468), allows loose forwards to have a smaller size enabling them to be more mobile on the field. The same phenomenon occurring between the tight and loose forwards occurred between the back-line and half-backs with the back-line players having a higher practical significant different body mass ( $d=1.13$ ) compared to the half-backs. As mentioned previously during the discussion of the stature variable it was explained that the scrum halves were smaller in size. Centres (forming part of the backline) are involved with most physical contact against the opposition compared to other backline players with Quarrie *et al.* (1996:56) stating that this position is the strongest of all the backline categories with the highest endomorphy and mesomorphy (focused on later in this Chapter) values. One can, therefore, assume centres to have the greatest body mass values. The previous statement is supported by Olds (2001:259) stating that body mass is beneficial in contact orientated sport. In the investigation of Durandt *et al.* (2006), when comparing body mass between player positions, props were the heaviest compared to all other positions with the scrum halves weighing the least in both the age groups. When looking at the comparison between the playing positions in the study by Delahunt *et al.* (2013) it was found that the body mass of the props were notable greater with respect to the hookers and back row players (also referred to as loose forwards according to Duthie *et al.* (2003:975). Props are normally the heaviest players because they serve as the driving force in scrums and are regularly involved in rucks, mauls and tackles (Delahunt *et al.*, 2013:3256). Back row players frequently compete for the ball and are involved in tackling, rucking and numerous ball carries, indicating the reason for their smaller body mass compared to the props (Delahunt *et al.*, 2013:3256).

The loose forwards of Durant *et al.* (2006) were substantially heavier ( $\bar{X}$  =88.2 kg) compared to the back row players ( $\bar{X}$  =78.1 kg) of Delahunt *et al.* (2013). The same occurrence is visible with regards to the props ( $\bar{X}$  =100.8 kg compared to  $\bar{X}$  =92.5 kg), hookers ( $\bar{X}$  =93.1 kg compared to  $\bar{X}$  =81.2 kg) and locks ( $\bar{X}$  =95.2 kg compared to  $\bar{X}$  =84.9 kg), with the players of Durandt *et al.* (2006) being heavier in all the mentioned positions. The latter agrees with the conclusion made during the discussion of the stature variable, where it was mentioned that the players in the study of Durandt *et al.* (2006) were elite, whereas the players in the study of Delahunt *et al.* (2013) were not. According to Olds (2001:257), an increase in professionalism could be due to an increase in rugby players' body mass, with a greater increase amongst forward players. Another reason could be that the players in the study of Durandt *et al.* (2006) may have been exposed to a higher frequency, volume and intensity of training compared to the mixed sample in the study of Delahunt *et al.* (2013). Such differences have been observed in senior Rugby Union players where it was discovered that New Zealand senior A players were characterized with a more advantageous kinanthropometric profile when compared with senior B players (Quarrie *et al.*, 1995:269). The forward players had significantly more body mass than players in the back unit. This is not an unexpected observation as the latter is supported by the literature in adolescent (De Ridder, 1993:162) and senior Rugby Union players (Nicholas & Baker, 1995:15; Quarrie *et al.*, 1995:268). Forward and backline players have different tasks during specific phases of the game with different kinanthropometric characteristics necessary to carry out these different tasks (Nicholas, 1997:377). According to Delahunt *et al.* (2013:3252) and Deutsch *et al.* (2007:467), forwards are much more involved in rucking, mauling and scrumming and as mentioned earlier, a large body mass is very valuable when involved in these phases of play (Maud & Schultz, 1984:87).

## **2.6.2 Stature and body mass in Rugby League**

Stature and body mass are physically qualities that may influence selection into an elite and sub-elite junior Rugby League team (Gabbett *et al.*, 2009:221). Body mass seems to exert a greater influence than stature on performance in Rugby league (Gabbett & Hertzog, 2004:23).

Literature referring to adolescent Rugby League will now be discussed to discover if stature and body mass have an influence on players with regards to performance. A summary of the descriptive statistics of different studies regarding performance will be provided in table 3A followed by a brief discussion of the results mentioned, firstly stature will be discussed followed by body mass.

**Table 3A: Comparison of stature (cm) in junior elite and sub-elite Rugby League players as reported by different authors.**

Authors	Age group	N	Elite		Sub-elite				d-value
			$\bar{X}$	SD	u/16		u/18		
					$\bar{X}$	SD	$\bar{X}$	SD	
Gabbett (2009:236)	u/16	20	-	-	171.6	6.6	-	-	NS
	u/18	15	-	-	-	-	177.7	6.2	
Gabbett <i>et al.</i> (2009:218)	u/16-Elite	28							0.34
	u/16-Sub-elite	36	178.0	5.9	176.0	6.0	-	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

In the results of Gabbett (2009) it was clear that the u/16 players ( $\bar{X} = 171.6$  cm) were remarkably shorter than the u/18 players ( $\bar{X} = 177.7$  cm). The latter could be attributed to the fact that boys who are advanced in their maturity status tend to be taller (Malina, 2002:263). However, the u/16 group of Gabbett *et al.* (2009) showed no difference when comparing the elite players to the sub-elite players. Although no differences were found between the elite and sub-elite players regarding the stature variable, research has identified improvement of kinanthropometric qualities between selection and playing level (Gabbett, 2000:307; Gabbett *et al.*, 2009:221; Gabbett *et al.*, 2011:1458; Till *et al.*, 2011:266).

Both the elite and sub-elite groups of Gabbett *et al.* (2009) were taller than the sub-elite group of Gabbett (2009) regarding the 16 year olds. A possible explanation for the elite players being taller than the sub-elite players might be due to stature playing an influential role of either being selected for playing in an elite or sub-elite team (Gabbett *et al.*, 2009:221). A possible explanation for the sub-elite group of Gabbett *et al.* (2009) being taller than the sub-elite group of Gabbett (2009) could be due to a varying maturity status.

**Table 3B: Comparison of stature (cm) in junior elite and sub-elite Rugby League players regarding starters and non-starters as reported by different authors.**

Authors	Age group	N	Elite					Sub-elite								
			Starters		Non-starters		d-value	u/16		u/18		u/16		u/18		d-value
								Starters		Starters		Non-starters		Non-starters		
			$\bar{X}$	SD	$\bar{X}$	SD		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Gabbett (2009:237)	u/16	20	-	-	-	-	-	172.7	4.9	-	-	169.9	8.7	-	-	0.40
	u/18	15	-	-	-	-	-	-	-	178.0	4.8	-	-	177.5	7.8	0.08
Gabbett <i>et al.</i> (2009:219)	u/16-Elite	28														
	u/16-Sub-elite	36	179.3	6.2	175.1	4.2	0.79*	177.8	4.5	-	-	174.2	8.1	-	-	0.55*

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Evaluating stature amongst the adolescent Rugby League, Gabbett (2009) demonstrated that the starters were taller than the non-starters in both age groups. However, it was not of practical significance. When comparing the elite players and sub-elite players of Gabbett *et al.* (2009) it was found that the starters had a greater stature compared to the non-starters, displaying moderate practical significance ( $d=0.79$  and  $d=0.55$ ) between the groups.

Comparing the u/16 sub-elite players of both Gabbett (2009) and Gabbett *et al.* (2009) the results revealed that both the starters and the non-starters of Gabbett *et al.* (2009) had greater stature. Although of the same playing level (sub-elite), it could be that the shortage of stature in the players of Gabbett (2009) can likely be a result of incomplete pubertal development which is supported by research claiming that males who are advanced in maturation have a tendency to be taller than their later maturing peers (Cumming *et al.*, 2009:678). Another explanation could be due to the different sample sizes of the studies.

**Table 3C: Comparison of body mass (kg) in junior elite and sub-elite Rugby League players as reported by different authors.**

Authors	Age group	N	Elite		Sub-elite				d-value
			$\bar{X}$	SD	u/16		u/18		
					$\bar{X}$	SD	$\bar{X}$	SD	
Gabbett (2009:236)	u/16	20	-	-	67.0	17.7	-	-	NS
	u/18	15	-	-	-	-	78.5	13.6	
Gabbett <i>et al.</i> (2009:218)	u/16-Elite	28							0.27
	u/16-Sub-elite	36	77.5	10.0	74.3	13.4	-	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

**Table 3D: Comparison body mass (kg) in junior elite and sub-elite Rugby League players regarding starters and non-starters as reported by different authors.**

Authors	Age group	N	Elite					Sub-elite								
			Starters		Non-starters		d-value	u/16		u/18		u/16		u/18		d-value
			$\bar{X}$	SD	$\bar{X}$	SD		Starters	Starters	Non-starters	Non-starters	Non-starters	Non-starters			
			$\bar{X}$	SD	$\bar{X}$	SD		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD			
Gabbett (2009:237)	u/16	20	-	-	-	-	-	65.2	9.6	-	-	69.8	26.3	-	-	0.23
	u/18	15	-	-	-	-	-	-	-	75.6	14.4	-	-	81.4	0.42	0.42
Gabbett et al. (2009:219)	u/16-Elite	28														
	u/16-Sub-elite	36	80.3	10.4	71.8	6.2	0.99**	74.9	11.2	-	-	77.6	15.0	-	-	0.20

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

The results in table 3D of Gabbett (2009) indicated a remarkable difference in body mass when comparing the u/16 ( $\bar{X}$  =67 kg) and u/18 ( $\bar{X}$  =78.5) players with each other. However, it is not surprising as boys advanced in maturity status tend to be heavier (Malina, 2002:263). The investigation of Gabbett *et al.* (2009) on the other hand yielded no meaningful differences when the elite players were compared to the sub-elite players. While comparing kinanthropometrical variables of the two studies with each other it was evident in the u/16 category that both the elite ( $\bar{X}$  =77.5 kg) and sub-elite players ( $\bar{X}$  =74.3 kg) in the study of Gabbett *et al.* (2009) were remarkably heavier than the sub-elite players ( $\bar{X}$  =67.0 kg) of Gabbett (2009). Gabbett and Hertzog (2004:23) are of the opinion that body mass can discriminate between elite and sub-elite players. Gabbett (2002b:402) and Till *et al.* (2013:441) are in accordance with the latter stating that size (indicated by height and weight) plays an important role regarding selection especially in junior representative levels. According to Cheng *et al.* (2014:550), anthropometric limitations could appear due to incomplete pubertal development which might be the case for the u/16 sub-elite players in the study of Gabbett (2009).

The results of Gabbett (2009) demonstrated no meaningful differences between the kinanthropometrical variables of the u/16 starters and non-starters. The same occurrence was visible between the u/18 starters and non-starters. In the study of Gabbett *et al.* (2009), elite starters had a greater body mass ( $d=0.99$ ) compared to non-starters. This result could be supported by the findings of Gabbett (2002b:402) who claims that body mass might be one of the factors playing a part in the selection process. Both the sub-elite starters ( $\bar{X}$  =74.9 kg) and non-starters ( $\bar{X}$  =77.6 kg) in the study of Gabbett *et al.* (2009) had greater weight values compared to the sub-elite starters ( $\bar{X}$  =65.2 kg) and non-starters ( $\bar{X}$  =69.8 kg) in the study of Gabbett (2009) with regards to the u/16 age group. a similar phenomenon was observed when comparing stature as previously mentioned which strengthens our viewpoint even more when stating that pubertal development may play a role. According to Malina *et al.* (2004:10,225), when comparing a group of boys of similar age, the boys with the earlier biological maturity usually have the tendency to be taller, heavier and stronger. The difference in sample sizes of the studies could also be a determining factor.

In Rugby League team positions can be generally classified (Gabbett, 2005c:675) as forward (the players involved in the scrum) or backline (the players not involved in the scrums) players which is in resemblance with Rugby Union. According to the literature in Rugby League, body mass is the only kinanthropometric characteristic that can successfully predict selection as a forward or a backline player (Gabbett, 2002a:338), however a variety of research has discovered stature to be different with regards to positional groups and individual positions

(Gabbett, 2006:1276; O'Connor, 1996:24). A summary of the descriptive statistics of different studies regarding playing positions will be given in table format followed by a brief discussion of the results mentioned.

**Table 3E: Comparison of stature (cm) in junior elite and sub-elite Rugby League players with regards to positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$				p-value	d-value	
		u/16	u/18	u/16	SD	u/18	SD			u/16-u/18
Gabbett (2005c:678)	Props	37	-	-	-	-	-	183.9	<0.05†	-
	Hookers and halves (hookers, halfbacks and five-eighths)	69	-	-	-	-	-	172.2	<0.05†	-
	Back rowers (second-rowers and locks)	47	-	-	-	-	-	176.8	NS	-
	Outside backs (centers, wingers and fullbacks)	87	-	-	-	-	-	176.6	NS	-
	<b>Individual positions</b>									
	Prop	37	-	-	-	-	-	183.9	<0.05#	-
	Hooker	31	-	-	-	-	-	171.9	NS	-
	Second row	36	-	-	-	-	-	176.8	NS	-
	Lock	11	-	-	-	-	-	176.7	NS	-
	Halfback	27	-	-	-	-	-	170.6	<0.05‡	-
	Five-eight	11	-	-	-	-	-	176.3	NS	-
	Centre	27	-	-	-	-	-	176.7	NS	-
Wing	39	-	-	-	-	-	176.4	NS	-	
Fullback	21	-	-	-	-	-	177.1	NS	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from second row

**Table 3E: Comparison of stature (cm) in junior elite and sub-elite Rugby League players with regards to positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$					p-value	d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18		
Gabbett <i>et al.</i> (2009:220)	<b>Elite</b>									
	Hit-up forwards (prop and second-row)	28	-	180.9	6.7	-	-	-	NS	0.92**
	Adjustables (hooker, halfback, five-eight and lock)			175.5	4.9	-	-	-	NS	
	Outside backs (centers, wing and fullback)			178.8	5.5	-	-	-	NS	
	<b>Sub-elite</b>									
	Hit-up forwards (prop and second-row)	36	-	176.7	5.3	-	-	-	NS	0.50*
Adjustables (hooker, halfback, five-eight and lock)	174.5			3.3	-	-	-	NS		
Outside backs (centers, wing and fullback)	176.4			7.4	-	-	-	NS		
Cheng <i>et al.</i> (2014:549)	Hit-up forwards (props)	-	15	-	-	179.6	6.1	-	NS	-
	Wide-running forwards (second rowers and locks)	-	28	-	-	183.1	4.8	-	NS	-
	Adjustables (fullbacks, five-eights, halfbacks and hookers)	-	39	-	-	175.1	5.4	-	<0.001†	-
	Outside backs (wingers and centers)	-	26	-	-	180.6	5.2	-	NS	-
	<b>Forward and back units</b>									
	Forward players	-	60	-	-	180.6	6.6	-	0.13	-
	Backline players	-	56	-	-	178.6	5.5	-		-

Note:  $\bar{X}$  , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from second row.

When player positional differences amongst Rugby League players for stature were compared, Gabbett (2005c) found that the props had greater stature compared to the rest of the subgroups. This is consistent with previous studies done on senior Rugby League regarding sub-elite players (Gabbett, 2006:1276) and elite players (O'Connor, 1996:24). Hookers and halves were significantly ( $p < 0.05$ ) shorter than the rest of the subgroups. According to Gabbett *et al.* (2009) studying elite players it was evident that the hit-up forwards were notably taller than the adjustables with an effect size of 0.92. The sub-elite players of Gabbett *et al.* (2009:220) only showed moderate practical significant difference while comparing the hit-up forwards to the adjustables. When comparing the elite players to the sub-elite players it was clear that the elite hit-up forwards ( $\bar{X} = 180.9$  cm) were relatively taller than the sub-elite hit-up forwards ( $\bar{X} = 176.7$  cm). The adjustables of Cheng *et al.* (2014) had the smallest stature ( $p < 0.001$ ) compared to the rest of the positional groups.

The props positional group ( $\bar{X} = 183.9$  cm) of Gabbett (2005c) were reasonably taller than the hit-up forwards (consisting out of props) positional group ( $\bar{X} = 179.6$  cm) of Cheng *et al.* (2014), this may be due to the difference in sample size. The props positional group of Gabbett (2005c) consisted of 37 players, whereas the hit-up forwards positional group of Cheng *et al.* (2014) only consisted of 15 props. The wide-running forwards (consisting of second-rowers and locks) positional group ( $\bar{X} = 183.1$  cm) of Cheng *et al.* (2014) were found to be taller than the back rowers (consisting of second-rowers and locks) positional group ( $\bar{X} = 176.8$  cm) of Gabbett (2005c). Previous research has shown stature to play an important role to either being selected for an elite or sub-elite team (Gabbett *et al.*, 2009:221) as the players of Cheng *et al.* (2014) were classified as elite and the players of Gabbett (2005c) as sub-elite.

The results of Gabbett (2005c:677) indicated props to be statistically significant ( $p < 0.05$ ) taller compared to all the individual positions, which is consistent with research done on senior Rugby League players (O'Connor, 1996:24). However in a study by Gabbett (2006:1276) done on senior Rugby League players, props were significantly taller than all positions except lock and fullback. In addition, the halfbacks were notable ( $p < 0.05$ ) shorter than the second row players.

No significant differences in stature came to the fore while comparing the forward players to the backline players.

**Table 3F: Comparison of body mass (kg) in junior elite and sub-elite Rugby League players with regards to positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$						p-value	d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16- u/18	SD			
Gabbett (2005c:678)	Props	37	-	-	-	-	-	101.1	-	<0.05†	-	
	Hookers and halves (hookers, halfbacks and five-eighths)	69	-	-	-	-	-	69.9	-	<0.05†	-	
	Back rowers (second-rowers and locks)	47	-	-	-	-	-	81.5	-	NS	-	
	Outside backs (centers, wingers and fullbacks)	87	-	-	-	-	-	76.4	-	NS	-	
	<b>Individual positions</b>											
	Prop	37	-	-	-	-	-	101.1		<0.05#	-	
	Hooker	31	-	-	-	-	-	69.9		<0.05§	-	
	Second row	36	-	-	-	-	-	83.6		NS	-	
	Lock	11	-	-	-	-	-	74.8		NS	-	
	Halfback	27	-	-	-	-	-	69.1		<0.05§	-	
	Five-eight	11	-	-	-	-	-	72.0		NS	-	
	Centre	27	-	-	-	-	-	79.6		NS	-	
	Wing	39	-	-	-	-	-	72.9		<0.05§	-	
Fullback	21	-	-	-	-	-	78.8		NS	-		

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group; §significantly different ( $p < 0.05$ ) from second rowers.

**Table 3F: Comparison of body mass (kg) in junior elite and sub-elite Rugby League players with regards to positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$						p-value	d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16- u/18	SD		
Gabbett <i>et al.</i> (2009:220)	<b>Elite</b>										
	Hit-up forwards (prop and second-row)	28	-	87.0	11.1	-	-	-	-	NS	1.56**
	Adjustables (hooker, halfback, five-eight and lock)			73.0	6.2	-	-	-	-	<0.05‡	
	Outside backs (centers, wing and fullback)			74.9	7.6	-	-	-	-	<0.05‡	
	<b>Sub-elite</b>										
	Hit-up forwards (prop and second-row)	36	-	88.9	7.2	-	-	-	-	NS	2.71**
	Adjustables (hooker, halfback, five-eight and lock)			68.0	8.2	-	-	-	-	<0.05‡	
Outside backs (centers, wing and fullback)	69.2			12.2	-	-	-	-	<0.05‡		
Cheng <i>et al.</i> (2014: 549)	Hit-up forwards (props)	-	15	-	-	101.6	8.8	-	-	<0.05†	-
	Wide-running forwards (second rowers and locks)	-	28	-	-	93.9	9.8	-	-	<0.05†	-
	Adjustables (fullbacks, five-eights, halfbacks and hookers)	-	39	-	-	77.7	4.8	-	-	NS	-
	Outside backs (wingers and centers)	-	26	-	-	82.6	7.3	-	-	NS	-

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^{*}$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group; §significantly different ( $p < 0.05$ ) from second rowers.

**Table 3F: Comparison of body mass (kg) in junior elite and sub-elite Rugby League players with regards to positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$						p-value	d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16- u/18	SD			
<b>Forward and back units</b>												
Gabbett (2002a:336)	Forward players	12	-	75.5	-	-	-	-	-	-	NS	-
	Backline players	9	-	64.8	-	-	-	-	-	-		-
Cheng <i>et al.</i> (2014: 549)	Forward players	-	60	-	-	92.6	12.2	-	-	<0.001	-	
	Backline players	-	56	-	-	80.9	7.1	-	-		-	

**Note:**  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group; §significantly different ( $p < 0.05$ ) from second rowers.

Similar to the stature variable the props positional group of Gabbett (2005c) had considerably ( $p < 0.05$ ) greater body mass compared to all the positional groups, with the hookers and halves being significantly ( $p < 0.05$ ) lighter compared to all the positional groups. The investigation of Cheng *et al.* (2014) demonstrated that the hit-up forwards were considerably heavier ( $p = < 0.001$ ) compared to the rest of the positional groups. The wide-running forwards on the other hand weighed remarkably more ( $p < 0.001$ ) than the adjustables and outside backs. Consistent with all of these findings regarding the props positional group (also classified as hit-up forwards in the study of Cheng *et al.*, 2014) being heavier compared to all the other positional groups were studies of Till *et al.* (2013:440) on junior Rugby League players and Gabbett (2006:1276) on senior Rugby League players. Observing the results of Gabbett *et al.* (2009), it was discovered that the body mass ( $d = 1.56$ ) of the elite hit-up forwards (consisting of the prop and second row in the study of Gabbett *et al.*, 2009) was significantly greater than the adjustables and outside backs while comparing the positional groups. The same occurrence was visible for the sub-elite players with the hit-up forwards also being significantly heavier ( $d = 2.71$ ) than the adjustables and outside backs.

A previous study on senior Rugby League players yielded similar results (Meir *et al.*, 2001:454). A possible explanation for the props positional group or any of the groups containing props, being heavier than the rest of the positional groups may be attributed to the amount of physical collisions they have to endure such as rucking and tackling (Gabbett, 2002a:338; Gabbett, 2002b:403; Gabbett, 2005c:678; Gabbett, 2006:1278; Meir *et al.*, 2001:456). The higher body mass also contributes to an increase in momentum (Gabbett, 2005c:678; Gabbett, 2006:1278; Gabbett *et al.*, 2009:221), making it difficult for the opposition to tackle these players effectively (O'Connor, 1996:22). According to Meir *et al.* (2001:456), speed is an important requisite for Rugby League players, even more so for wingers, centres and fullbacks. It is, therefore, understandable to find the back-line positional groups or any of the groups containing back-line players to weigh considerably less than the groups containing props, due to the greater absolute body weight and fat mass (Meir *et al.*, 2001:456) of players in this position.

When comparing the back rowers positional group of Gabbett (2005c) and the wide-running forwards positional group of Cheng *et al.* (2014), the positional group of Cheng *et al.* (2014) weighed considerable more ( $\bar{X} = 93.9$  kg compared to  $\bar{X} = 81.5$  kg) than the group of Gabbett (2005c). Research by Till *et al.* (2013:441) explains that this phenomenon could be attributed to a difference in playing level. The players of Cheng *et al.* (2014) being elite compared to the sub-elite players of Gabbett (2005c). In the results of Gabbett (2005c) it's clear that significant differences ( $p < 0.05$ ) in body mass occurred amongst the different individual positions. The props were remarkably heavier than all the other positions, with the hookers and halfbacks

weighing considerably less when compared to the second row players. Previous research done on senior Rugby League also discovered props to be significantly heavier compared to all other positions on the team (Gabbett, 2006:1276; Meir *et al.*, 2001:454). In partial agreement with the findings of Gabbett (2005c), Meir *et al.* (2001:454) also discovered the second rowers' body mass to be significantly greater than the hookers, halfbacks and wingers. However, this was also true when the second rowers body mass was compared to the rest of the positions (e.g. locks, five-eighths, centers and fullbacks) excluding props. Props use their momentum to break through the advantage line of the opposing team (Meir *et al.*, 2001:455), which might explain their superiority in body mass. It is also evident from the literature that hookers and halfbacks cover more distance on average compared to any other position, which might explain their relative small values of body mass, since mass together with excess body fat have been shown to have a negative influence on aerobic performance (Meir *et al.*, 2001:456).

In the results of Cheng *et al.* (2014) illustrated in Table 3F, while comparing the forward players to the backline players, the forward players' body mass was significantly higher ( $p < 0.001$ ) than the backline players. This is consistent with previous research done on senior professional (Meir, 1993:28; Meir *et al.*, 2001:454) and semi-professional (Gabbett, 2002b:401) Rugby League players who also found forwards to be heavier than backs. Forward players undergo considerably more physical collision (Stephenson *et al.*, 1996:334) and are much more involved in tackles (Meir, 1993:26) compared to backline players, thus making it more likely that a greater body mass will assist the forwards in developing greater impact forces related to these events (Gabbett, 2005b:962). Although the forwards' body mass was greater compared to the backs in the study of Gabbett (2002a), it was not statistically significant different with regards to the u/16 group. However, the study still concluded that body mass was a significant predictor to classify players correctly as either a forward or a back (Gabbett, 2002a:338).

### **2.6.3 Stature and body mass in Sevens Rugby**

Due to the limited comprehensive studies available on Sevens Rugby regarding kinanthropometry, no conclusion could be made on the effect of stature and body mass on performance in Sevens Rugby. However a study by Rienzi *et al.* (1999:162) found that no kinanthropometric components differentiate between winners and losers. Previous literature on Sevens Rugby players regarding stature and body mass will now be discussed, with the descriptive statistics of the different studies being summarized in table format. Firstly a look at stature, followed by body mass. One should note that all the Sevens Rugby literature that will be

observed now is all on senior Sevens Rugby players and not on adolescent players, thus meaning due to the age difference it is probably that the mentioned results will differ from that of adolescent Sevens Rugby players due to fact that the adolescent players are still growing and maturing.

**Table 4A: Comparison of stature (cm and m) in Sevens Rugby players as reported by different authors.**

Authors	$\bar{X}$ age (years)	N	$\bar{X}$	SD
Rienzi <i>et al.</i> (1999:162)	Not mentioned	27	179.3	6.6
Takahashi <i>et al.</i> (2007:13)	20.7	7	179.3	8.2
Fuller <i>et al.</i> (2010:181)	23.1	264	182.5	7.1
Elloumi <i>et al.</i> (2012:179)	23.8	16	183.1	3.1
Higham <i>et al.</i> (2012:278)	21.2	19	1.81 (meters)	0.05
Suarez-Arrones <i>et al.</i> (2012:3156)	27.4	7	180.4	7.8
Higham <i>et al.</i> (2013:21)	21.9	18	1.83 (meters)	0.06
Granatelli <i>et al.</i> (2014:729)	25.1	9	180.5	3.5
Suarez-Arrones <i>et al.</i> (2014:316)	27.4	10	180.4	7.8
West <i>et al.</i> (2014:689)	25.5	10	1.83	0.08

Note:  $\bar{X}$ , mean; SD, standard deviation.

From the above mentioned results it is clear that the Sevens Rugby players of Elloumi *et al.* (2012), Higham *et al.* (2013) and West *et al.* (2014) were superior in stature especially compared to the studies of Rienzi *et al.* (1999) and Takahashi *et al.* (2007). This might be an indication of the changing demands in Sevens Rugby over the years (Fuller *et al.*, 2010:182) as the data of the studies concerned were collected in 1999 and 2003.

**Table 4B: Comparison of body mass (kg) in Sevens Rugby players as reported by different authors.**

Authors	$\bar{X}$ age (years)	N	$\bar{X}$	SD
Rienzi <i>et al.</i> (1999:162)	Not mentioned	27	84.7	10.4
Takahashi <i>et al.</i> (2007:13)	20.7	7	86.4	8.4
Fuller <i>et al.</i> (2010:181)	23.1	264	90.1	9.5
Elloumi <i>et al.</i> (2012:179)	23.8	16	87.3	7.4
Higham <i>et al.</i> (2012:278)	21.2	19	89.7	7.3
Suarez-Arrones <i>et al.</i> (2012:3156)	27.4	7	87.9	11.0
Higham <i>et al.</i> (2013:21)	21.9	18	89.7	7.6
Granatelli <i>et al.</i> (2014:729)	25.1	9	86.0	9.4
Suarez-Arrones <i>et al.</i> (2014:316)	27.4	10	87.9	11.0
West <i>et al.</i> (2014:689)	25.5	10	86.1	10.0

Note:  $\bar{X}$ , mean; SD, standard deviation.

While comparing the differences in body mass amongst the Sevens Rugby players, the study of Fuller *et al.* (2010) displayed greater body mass when compared to the studies of Granatelli *et al.* (2014), Rienzi *et al.* (1999), Takahashi *et al.* (2007) and West *et al.* (2014). The increase in body mass compared to the study of Rienzi *et al.* (1999) and Takahashi *et al.* (2007) might be due to the changing in demands of Sevens Rugby over the years. The reasonably low body mass values in the studies of Granatelli *et al.* (2014) and West *et al.* (2014) might be due to the large difference in study sample size. Fuller *et al.* (2010) made use of a study population of 264 players compared to the 9 players of Granatelli *et al.* (2014) and the 10 players of West *et al.* (2014).

Most studies of Sevens Rugby have combined the data of the forward and backline players (Ross *et al.*, 2013:361) except those of Fuller *et al.* (2010:181) and Rienzi *et al.* (1999:162). Consistent with Rugby Union, forward and backline players in Sevens Rugby also differ in terms of stature and body mass with forward players having greater values in stature and body mass compared to backline players (Fuller *et al.*, 2010:182; Rienzi *et al.*, 1999:163). However, these differences may be less prominent than in Rugby Union because of fewer scrums and line-outs taking place in Sevens Rugby (Rienzi *et al.*, 1999:163).

**Table 4C: Comparison of stature (cm) in Sevens Rugby players with regards to forward and backline players.**

Authors	Positional group	$\bar{X}$ age (years)	N	$\bar{X}$	SD	p-value
Rienzi <i>et al.</i> (1999:162)	Forward players	Not mentioned	17	184.6	4.6	<0.01
	Backline players		13	175.6	5.1	
Fuller <i>et al.</i> (2010:181)	Forward players	23.1	88	187.5	5.8	<0.001
	Backline players		162	180.1	6.4	

Note:  $\bar{X}$ , mean; SD, standard deviation; statistical significant different (p<0.05).

When comparing Sevens Rugby forward with backline players Rienzi *et al.* (1999) found that forward players were statistical significant (p<0.01) taller compared to backline players. In the study by Fuller *et al.* (2010), similar results were found. The difference in stature between the forward and backline players in the above mentioned results is less than usually observed in Rugby Union which may indicate that forward players in Sevens Rugby need to be more mobile compared to Rugby Union (Rienzi *et al.*, 1999:163).

The stature of the forward and backline players in the study of Fuller *et al.* (2010) were greater than those of Rienzi *et al.* (1999). These increases in stature of the players in the study by Fuller *et al.* (2010) may be explained due to an elapsed time frame of 13 years between the 2 studies involved here. The Sevens Rugby players in the study of Rienzi *et al.* (1999) were measured way back in 1996 while the players in the study of Fuller *et al.* (2010) were measured between the season of 2008 and 2009, which may reveal changing demands in Sevens Rugby occurring (Fuller *et al.*, 2010:182). Another reason could be the difference in sample size as the forward (N=88) and backline players (N=162) in the study of Fuller *et al.* (2010) are greater than the forward (N=17) and backline players (N=13) in the study of Rienzi *et al.* (1999).

**Table 4D: Comparison of body mass (kg) in Sevens Rugby players with regards to forward and backline players.**

Authors	Positional group	$\bar{X}$ age (years)	N	$\bar{X}$	SD	p-value
Rienzi <i>et al.</i> (1999:162)	Forward players	Not mentioned	17	93.5	7.8	<0.01
	Backline players		13	78.6	7.1	
Fuller <i>et al.</i> (2010:181)	Forward players	23.1	88	97.7	7.2	<0.001
	Backline players		162	86.0	7.8	

Note:  $\bar{X}$ , mean; SD, standard deviation; statistical significant different (p<0.05).

Positional differences regarding body mass were visible in both the studies of Fuller *et al.* (2010) and Rienzi *et al.* (1999), with the forward players having statistical significant larger body mass compared to the backline players in both instances ( $p < 0.001$  and  $p < 0.01$ ). Forward players have an advantage in being heavier as it benefits them in gaining position of the ball during scrums or phases of play where forward players are more involved in than backline players (Rienzi *et al.*, 1999:163). A lighter body mass is considered advantageous to backline players as it is their responsibility to accelerate or sprint past their opponents (Rienzi *et al.*, 1999:163).

The forward and backline players in the study of Fuller *et al.* (2010:181) were heavier compared to the forward and backline players of Rienzi *et al.* (1999). Once again the elapsed time frame could be the reason or the large difference in the study sample size of both studies.

It is clear in all three Rugby codes that size (stature and body mass) differs between playing positions which is in accordance with literature indicating that positional roles are associated with a specific physique (Rienzi *et al.*, 1999:162). It is also thought that performance may be dependable on the morphological make-up of the players (Rienzi *et al.*, 1999:162). The latter is strongly supported by the literature in Rugby Union declaring stature and body mass to be a significant predictor of success, whereas research in Rugby league only discovered body mass to determine whether a player is going to be successful or not. These findings have yet to be confirmed in Sevens Rugby.

## **2.7 SKINFOLD MEASUREMENTS**

Skinfold measurement is normally used to estimate fatness or adiposity. The monitoring of body fat is especially important for athletes immersed in weight loss or weight gain programmes in order to assess specific tissue masses (Norton *et al.*, 1996:325-326). Greater skinfold measurements are an indication of increased subcutaneous fat (Wilders & De Ridder, 2001:98).

### **2.7.1 Skinfold measurements in Rugby Union**

Rugby Union is contact orientated and as such players have to endure numerous physical collisions. As mentioned earlier skinfold measurements are used to estimate fatness (Norton *et al.*, 1996:325-326), and as such body fat (subcutaneous fat) could serve as a protective buffer during contact situations (Bell, 1973:7).

When taking performance into consideration skinfold thickness could distinguish whether a player is selected or not selected to play (Gabbett *et al.*, 2011:1460).

Although no literature exist on adolescent Rugby League players regarding skinfold measurements it is certainly important, due to research claiming that skinfold thickness could distinguish between 'n Rugby League player being selected to play or not to play (Gabbett *et al.*, 2011:1460).

Although no literature have been published on individual skinfold measurements in adolescent Sevens Rugby players, research is available on the sum of skinfolds, and will be discussed later in this Chapter.

**Table 5A: Comparison of skinfold measurements in elite adolescent Rugby Union players as reported by different authors.**

Skinfolds (mm)	Blue Bulls players (BB) N=18		Ivybridge players (IV) N=21		Leopards players (LP) N=21		BB vs. IV	IV vs. LP	LP vs. BB
	Mean	SD	$\bar{X}$	SD	$\bar{X}$	SD	d-value	d-value	d-value
Plotz and Spamer (2006:103)									
Triceps	10.3	4.2	13.5	4.8	14.9	5.4	0.65*	0.10	0.30
Sub-scapular	12.7	5.5	15.7	7.1	12.8	5.1	0.42	0.41	0.01
Mid-axilla	10.7	6.4	13.1	8.3	9.0	5.6	0.29	0.49	0.26
Supra-spinal	14.3	11.1	13.4	4.6	10.9	5.9	0.08	0.44	0.31
Pectoral	8.3	4.5	13.1	5.9	7.7	3.6	0.81**	0.91**	0.12
Abdominal	17.0	11.0	19.5	8.5	14.9	8.9	0.23	0.52*	0.19
Thigh	14.6	6.2	17.3	7.0	13.8	5.1	0.38	0.49	0.12
Calf	9.8	5.3	15.3	5.2	8.7	4.4	1.05**	1.27**	0.20
Skinfolds (mm)	New Zealand group (NZ) N=24		South Africa group 1 (SA <sub>1</sub> ) N=43		South Africa group 2 (SA <sub>2</sub> ) N=22		NZ vs. SA <sub>1</sub>	NZ vs. SA <sub>2</sub>	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	d-value	d-value	
Spamer et al. (2009:54)									
Triceps	13.0	4.5	12.7	5.6	8.0	2.8	0.1	1.1**	
Sub-scapular	14.5	7.1	11.0	4.4	10.3	2.8	0.5*	0.6*	
Mid-axilla	13.3	7.6	9.6	4.5	-	-	0.5*	-	
Supra-spinal	20.7	9.3	11.9	5.5	-	-	0.9**	-	
Pectoral	9.7	3.4	6.8	2.8	5.7	2.3	0.9**	1.2**	
Abdominal	20.7	9.9	15.6	8.9	12.6	6.5	0.5*	0.8**	
Thigh	17.2	5.2	15.5	5.2	10.8	4.0	0.3	1.2**	
Calf	11.8	4.6	11.0	4.4	7.1	2.8	0.2	1.0**	

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

From Table 5A practical significant differences with regards to pectoral ( $d=0.81$ ) and calf skinfold ( $d=1.05$ ) measurements occurred between the BB and IV team (Plotz & Spamer, 2006). The IV team compared to the LP team also showed notable differences in the pectoral ( $d=0.91$ ) and calf skinfold ( $d=1.27$ ) measurements. When comparing the NZ group to the SA<sub>1</sub> group large practical significant differences were found for the supra-spinal ( $d=0.9$ ) and pectoral ( $d=0.9$ ) skinfolds, and with regards to the NZ group compared to the SA<sub>2</sub> group large practical significant differences were found for the tricep ( $d=1.1$ ), pectoral ( $d=1.2$ ), abdominal ( $d=0.8$ ), thigh ( $d=1.2$ ) and calf ( $d=1.0$ ) skinfold measurements. As mentioned previously skinfold measurements are used to estimate fatness and while Malina *et al.* (2004:114-115) are of the opinion that percent body fat reaches its lowermost point at 16 to 17 years of age and then gradually starts to increase into young adulthood, it could explain the NZ groups' greater skinfolds measurements compared to the SA groups. According to research, Maori, Tongan and Samoan rugby players develop earlier than their SA counterparts (Du Plessis, 2007:101). Thus stating that the NZ group could be considered early developers, it might be possible that they already experienced an increase in body fat percentage. As mentioned previously Malina *et al.* (2004:114-115) stated that percentage body fat reaches its lowermost point at 16-17 years and then steadily increases into young adulthood (Malina *et al.*, 2004:114-115).

Research found that props have a high degree of body fat in order to protect them during tackles and collisions (Durandt *et al.*, 2006:44). Controversial to the latter, fullbacks and wings have lower fat percentages than other positions as it is important for them to perform high-intensity activities like sprinting (Deutsch *et al.*, 1998:567).

**Table 5B: Comparison of skinfold measurements in elite u/16 and u/18 Rugby Union players regarding positional classification**

Study by: Van Gent and Spamer (2005:54,56)												
Skinfolds (mm)	u/16 (N=21)				u/18 (N=18)							
	Tight forwards (TF)		Loose forwards (LF)		Halves (H)		Back-line (BL)		TF vs. LF		H vs. BL	
	$\bar{X}$		$\bar{X}$		$\bar{X}$		$\bar{X}$		d-value		d-value	
	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18
Triceps	9.2	12.7	9.0	8.3	6.0	8.0	6.9	7.6	0.07	1.72**	0.34	0.14
Supra-spinal	10.8	13.5	9.3	11.0	5.5	7.3	7.5	8.0	0.37	0.62*	0.49	0.16
Sub-scapular	12.3	15.4	10.3	11.0	7.5	9.5	9.1	8.3	0.75*	1.61**	0.61*	0.47
Pectoral	6.3	7.2	5.5	5.5	4.0	3.7	5.7	5.3	0.28	0.60*	0.59*	0.55*
Abdominal	16.8	19.9	11.8	16.0	8.0	8.8	10.1	10.0	0.74*	0.58*	0.32	0.17
Thigh	12.6	11.7	10.8	11.3	7.0	7.3	9.9	9.7	0.52*	0.13	0.80**	0.66*
Calf	8.2	8.9	7.8	8.0	4.5	5.0	6.4	7.3	0.13	0.26	0.57*	0.69*

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$

In the u/16 category (Table 5B) moderate practical significant differences were attained comparing the TF with the LF for the sub-scapular ( $d=0.75$ ) and abdominal ( $d=0.74$ ) skinfold measurements almost reaching large practical significant status. When H compared to the BL, is investigated a large practical significant differences occurred for the thigh ( $d=0.80$ ) skinfold. In the u/18 category large practical significant differences between the TF and LF were attained for both the tricep ( $d=1.72$ ) and sub-scapular ( $d=1.61$ ) skinfold measurements.

While comparing the u/16 age group to the u/18 age group it is evident that the different positional groups of the u/18 age players were nearly greater in all the skinfold measurements, which is an indication that the more maturing players possess more subcutaneous fat. The latter is consistent with the literature claiming that as age increases subcutaneous fat also increases (Wilders & De Ridder, 2001:99).

It is evident that skinfold measurements in Rugby Union differed between positional groups and that the positional groups with the greatest skinfold measurements were usually those subjected to the most physical contact during the game.

## **2.8 GIRTH MEASUREMENTS**

Circumferences (girth measurements) are affected by fat mass, muscle mass and skeletal size; therefore, these measures are related to fat mass (Heyward & Stolarczyk, 1996:67; Wilders & De Ridder, 2001:97).

### **2.8.1 Girth measurements in Rugby Union**

Rugby players usually have greater girth measurements compared to the average man which could be attributed to the fact that Rugby is contact orientated which places high physical demands on the players. Consequently it means that Rugby players muscle mass and skeletal mass is better developed (Wilders & De Ridder, 2001:97) as girth measurements are also an indication of muscle mass, due to the fact that it is used in calculations of muscle mass (Martin *et al.* 1990:731).

**Table 6A: Comparison of girth measurements (cm) in elite adolescent Rugby Union players as reported by different authors.**

Study by: Plotz and Spamer (2006:103)									
Girths (cm) Plotz & Spamer (2006:103)	Blue Bulls players (BB) N=18		Ivybridge players (IV) N=21		Leopards players (LP) N=21		BB vs. IV	IV vs. LP	LP vs. BB
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	d-value	d-value	d-value
Forearm	28.8	3.0	28.8	1.3	28.8	1.6	0.01	0.02	0.02
Ankle	23.8	2.3	27.2	1.3	25.0	1.5	1.48**	1.45**	0.51*
Calf	38.2	3.1	40.1	3.1	36.9	3.4	0.60*	0.95**	0.39
Girths (cm) Spamer <i>et al.</i> (2009:54)	New Zealand group (NZ) N=24		South Africa group 1 (SA <sub>1</sub> ) N=43		South Africa group 2 (SA <sub>2</sub> ) N=22		NZ vs. SA <sub>1</sub>	NZ vs. SA <sub>2</sub>	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	d-value	d-value	
Flexed upper arm	33.7	2.9	32.1	2.3	32.6	2.8	0.6*	0.4	
Forearm	28.4	1.6	27.5	1.7	27.9	1.9	0.6*	0.3	
Ankle	24.8	1.2	23.9	1.7	24.1	3.2	0.5*	0.2	
Calf	38.1	2.7	37.0	3.7	36.8	4.2	0.3	0.3	
Upper leg	57.0	3.5	56.0	4.4	-	-	0.2	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

A large practical significant difference regarding the girth measurements present in Table 6A between the BB and IV players were found in ankle girth ( $d=1.48$ ). Whereas comparing the LP team to the IV team large practical significant differences were found for both the ankle ( $d=1.45$ ) and calf girths ( $d=0.95$ ). No practical significant differences were found between the BB and LP players. When comparing the NZ group to the SA groups only moderate practical significant differences were found between the NZ and SA<sub>1</sub> group regarding the flexed upper arm ( $d=0.6$ ), forearm ( $d=0.6$ ) and ankle ( $d=0.5$ ) girth measurements.

When comparing the studies of Plotz and Spamer (2006) and Spamer *et al.* (2009) it is clear that the ankle girth ( $\bar{X}=27.2$  cm) of the IV team was greater than all groups of Spamer *et al.* (2009). Also evident is the calf girth of both the SA<sub>1</sub> ( $\bar{X}=37.0$  cm) and SA<sub>2</sub> ( $\bar{X}=36.8$  cm) groups which were relatively smaller than that of the IV team ( $\bar{X}=40.1$  cm).

It could be that the IV team' players had greater lower leg strength, which will explain the reason the IV players had larger calf girths which might be an indication of greater calf muscles.

**Table 6B: Comparison of girth measurements (cm) in elite u/16 and u/18 Rugby Union players regarding positional classification.**

Study by: Van Gent and Spamer (2005:54,56)												
Girths (cm)	u/16 (N=21)				u/18 (N=18)				TF vs. LF		H vs. BL	
	Tight forwards (TF)		Loose forwards (LF)		Halves (H)		Back-line (BL)		d-value		d-value	
	$\bar{X}$		$\bar{X}$		$\bar{X}$		$\bar{X}$		d-value		d-value	
	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18
Flexed upper arm	33.6	34.8	33.0	34.3	31.2	33.5	31.7	34.5	0.33	0.29	0.25	0.51*
Forearm	28.5	30.1	27.4	30.0	27.6	28.8	27.7	28.6	0.70*	0.08	0.11	0.09
Ankle	23.5	25.0	23.8	24.7	22.3	23.1	25.4	25.3	0.25	0.23	2.41**	1.74**
Calf	37.8	37.1	38.3	39.9	36.0	37.1	35.2	39.2	0.14	0.85**	0.23	0.63*

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

The results of Van Gent and Spamer (2005:52-58) as seen in Table 6B, demonstrates a practical significant difference in ankle girth ( $d=2.41$ ) between the BL and H players, for the 16 year old players. The 18 year old players showed significant differences for the ankle girth ( $d=1.74$ ) between the H and BL players, whereas between the TF and LF practical significant differences with regards to the calf girth ( $d=0.85$ ) were found. This is consistent with Rugby League (Cheng *et al.*, 2014:549) where it was discovered that props had a greater calf girth measurement compared to the rest of the positional groups. The latter might reveal greater lower body muscle strength and power essential for recurrent tackling and lifting movements (Cheng *et al.*, 2014:550).

### **2.8.2 Girth measurements in Rugby League**

According to the literature, differences in girth measurements do exist between positional groups as well as between forward and backline players (Cheng *et al.*, 2014:549). When comparing positional groups regarding girth measurements (Table 7A) the hit-up forwards and wide-running forwards indicated to have greater flexed and relaxed arm girths compared to the adjustables and outside backs. The hit-up forwards' calf girth significantly differed from all the other positional groups. The reason for the larger calf girth in the props might be associated with lower body muscle strength and power necessary for repeated tackling and lifting movements (Cheng *et al.*, 2014:550). The forward players showed greater values in all measured girths compared to the backline players as illustrated in Table 7A.

Some girth measurements differed statistically significantly between playing position in both Rugby Union and Rugby League, which might be due to differences in fat mass, muscle mass or skeletal size occurring (Heyward & Stolarczyk, 1996:67; Wilders & De Ridder, 2001:97).

No girth measurements in adolescent Sevens Rugby have yet been published.

**Table 7A: Comparison of girth measurements (cm) in elite junior u/18 Rugby League players with regards to positional classification.**

Study by: Cheng <i>et al.</i> (2014:549)									
Girths (cm)	Positional groups								p-value
	Hit-up forwards N=15		Wide-running forwards N=28		Adjustables N=39		Outside-backs N=26		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Arm relaxed	38.1‡	2.1	36.5‡	2.3	33.8	2.0	33.8	1.5	<0.001
Arm flexed and tensed	40.4‡	2.2	38.7‡	2.4	36.5	2.0	36.8	1.7	0.001
Calf	43.9†	2.3	41.3†	2.9	38.5	2.1	39.3	2.1	0.006
Girths (cm)	Positional groups								p-value
	Forward players N=60				Backline players N=56				
	$\bar{X}$		SD		$\bar{X}$		SD		
Arm relaxed	36.7		2.6		33.7		1.7		<0.001
Arm flexed and tensed	38.9		2.6		36.6		1.8		<0.001
Calf	41.8		3.2		38.7		1.8		<0.001

Note:  $\bar{X}$  , mean; SD, standard deviation; †significantly different (p<0.05) from all other positions; ‡significantly different (p<0.05) from adjustables and outside-backs positional group.

## **2.9 BREADTH MEASUREMENTS**

According to the literature, breadth measurements are an indication of skeletal size (Wilders & De Ridder, 2001:98).

### **2.9.1 Breadth measurements in Rugby Union**

Stronger bone and muscle structures are beneficial for tackle ability and to be able to break through tackles of the opposition (Holway & Garvaglia, 2009:1217). Certain playing positions for instance centres and tight forwards are required to have stronger bone and muscle structure in order to power through the oppositions defending onslaught and better scrumming (Holway & Garvaglia, 2009:1217).

**Table 8A: Descriptive statistics of breadth measurements (cm) in elite u/16 and u/18 Rugby Union players regarding positional classification.**

Study by: Van Gent and Spamer (2005:54,56)												
Breadths (cm)	u/16 (N=21)				u/18 (N=18)				TF vs. LF		H vs. BL	
	Tight forwards (TF)		Loose forwards (LF)		Halves (H)		Back-line (BL)		d-value		d-value	
	$\bar{X}$		$\bar{X}$		$\bar{X}$		$\bar{X}$		d-value		d-value	
	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18	u/16	u/18
Humerus	7.4	7.4	7.2	7.6	7.0	6.6	6.9	7.4	0.47	0.20	0.16	0.97**
Femur	10.2	10.1	9.7	10.3	9.4	9.5	9.6	9.9	0.73*	0.21	0.15	0.71*
Wrist	6.2	6.1	6.0	6.0	5.7	5.6	5.8	5.7	0.73*	0.50*	0.54*	0.62*

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Between the H and BL players large practical significant differences were found in the humerus breadth ( $d=0.97$ ) as seen in Table 8A. Moderate large practical significant differences were reached in the femur breadth ( $d=0.73$ ) and wrist breadth ( $d=0.73$ ) between the TF and LF group. The same phenomenon occurred between the H and BL groups regarding the femur breadth ( $d=0.71$ ). Holway and Garvaglia (2009:1217) explain that due to of the positional requirements, centres (forming part of the backline) are subjected to have stronger bone and muscle structure than other backline positions in order for tackling and to be able to power through oppositions at high speed. The latter might indicate why the BL have a larger humerus breadth compared to H in the study of Van Gent and Spamer (2005). A similar argument could be used for the TF compared to LF as props and hookers (forming part of the tight forwards) have to have a larger bone and muscle structure important for scrumming (Holway & Garvaglia, 2009:1217).

### **2.9.2 Breadth measurements in Rugby League**

Both the hit-up forwards and wide-running forwards had a greater femur breadth compared to the adjustables and outside backs (Table 9A), which is consistent with Rugby Union where it was discovered that TF had a larger bone and muscle structure compared to the LF which is beneficial for scrumming (Holway & Garvaglia, 2009:1217). Statistical significant differences regarding the femur breadth were observed with the forward players attaining higher values than the backline players.

Consistent with girth measurements, statistical significant differences also emerged in selected breadth measurements when comparing the positional groups in both Rugby Union and Rugby League. This might be an indication that selected positional groups consisted of larger or smaller skeletal sizes.

To date no breadth measurements on adolescent Sevens Rugby players have been published.

**Table 9A: Comparison of breadth measurements (cm) in junior elite u/18 Rugby League players with regards to positional classification.**

Study by: Cheng <i>et al.</i> (2014:549)									
Bone breadths (cm)	Positional groups								p-value
	Hit-up forwards N=15		Wide-running forwards N=28		Adjustables N=39		Outside-backs N=26		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Humerus	7.9	0.3	7.7	0.3	7.4	0.3	7.6	0.4	0.03
Femur	11.0‡	0.5	10.8‡	0.6	10.3	0.6	10.3	0.5	0.05
Bone breadths (cm)	Positional groups								p-value
	Forward players N=60				Backline players N=56				
	$\bar{X}$		SD		$\bar{X}$		SD		
Humerus	7.6		0.4		7.5		0.4		0.07
Femur	10.8		0.6		10.3		0.5		<0.001

Note:  $\bar{X}$  , mean; SD, standard deviation; ‡significantly different (p<0.05) from adjustables and outside-backs positional group.

## 2.10 BODY MASS INDEX

BMI is a method normally used to evaluate the human body by providing a value that determines whether a person's body mass is in proportion to their stature (Walsh *et al.*, 2011:38). Usually BMI is not done on sport population, but the reason it was included was to serve as an extra measuring parameter.

### 2.10.1 BMI in Rugby Union

Elite athletes in various sports are evolving (Norton & Olds, 2001:781), meaning getting taller and larger (Sedeaud *et al.*, 2013:190). BMI is one of the kinanthropometric variables demonstrating this phenomenon. In Rugby Union BMI scores have increased from  $\text{kg/m}^2$  in 1905-1974 to  $28.6 \text{ kg/m}^2$  in 1975-1999 (Olds, 2001:256). According to the literature, these increases in BMI could be due to increases in training load and strength training combined with a nutritional intake (Sedeaud *et al.*, 2013:190).

**Table 10A: Comparison of successful and less successful u/18 Rugby Union players with regards to BMI ( $\text{kg/m}^2$ ).**

Study by: Adendorff <i>et al.</i> (2004:449)				
Group	N	$\bar{X}$	SD	d-value
Successful group	18	24.9	2.1	0.89**
Less successful group	11	23.1	2.0	

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

In Table 10A a large practical significant difference ( $d=0.89$ ) between the successful and less successful group is clear with the successful group having a higher BMI score. Because stature and body mass are the two components used to calculate BMI (Eston *et al.*, 2009:35), they play a significant role in determining what the BMI scores of the players will be. Thus the reason for the successful group having a higher value could be because of their higher body mass value or more specifically muscle mass. Other reasons for the increasing BMI scores could be explained by an increase in training load and strength training as well as nutritional consumption by the successful group (Sedeaud *et al.*, 2013:190).

### **2.10.2 BMI in Rugby League**

The BMI score of the hit-up forwards in the study of Cheng *et al.* (2014) was significantly different ( $p < 0.001$ ) from all other positional groups. It was already mentioned that the hit-up forwards in the study of Cheng *et al.* (2014) were considerably heavier ( $p < 0.001$ ) compared to the rest of the positional groups, which in itself explains the greater BMI scores of the hit-up forwards. The same phenomenon was visible between the forward and backline players, with the forward players having a superior BMI score ( $p < 0.01$ ) compared to the backline players, mainly because of the forward players possessing a greater body mass.

**Table 11A: Comparison of BMI (kg/m<sup>2</sup>) in junior elite Rugby League players with regards to positional classification.**

Study by: Cheng <i>et al.</i> (2014:549)									
Age group	Positional groups								p-value
	Hit-up forwards N=15		Wide-running forwards N=28		Adjustables N=39		Outside-backs N=26		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
u/18	30.3†	2.1	28.0†	2.8	25.4	1.9	25.3	1.6	<0.001
Age group	Forward players N=60				Backline players N=56				p-value
	Forward players N=60		Backline players N=56		Backline players N=56		Backline players N=56		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
u/18	28.4	3.0	25.4	1.7	25.4	1.7	25.4	1.7	<0.01

Note:  $\bar{X}$  , mean; SD, standard deviation; significant difference (p<0.05); †significantly different (p<0.05) from all other positions.

### 2.10.3 BMI in Sevens Rugby

**Table 12A: Comparison of BMI (kg/m<sup>2</sup>) in Sevens Rugby players as reported by different authors.**

Authors	N	$\bar{X}$	SD
Elloumi <i>et al.</i> (2012:179)	16	26.1	2.4
Granatelli <i>et al.</i> (2014:729)	9	27.7	2.6

Note:  $\bar{X}$ , mean; SD, standard deviation.

The Sevens Rugby players in the study of Granatelli *et al.* (2014) had a higher BMI score compared to the Sevens Rugby players in the study of Elloumi *et al.* (2012:179).

The results demonstrated BMI values to discriminate between successful and less successful players in Rugby Union as well as to differentiate between playing positions in Rugby League. The previously mentioned findings have not yet been confirmed in Sevens Rugby.

## 2.11 SUM OF SKINFOLDS

There exist a strong relationship between subcutaneous fat and total body fat, therefore the sum of several skinfolds can be used to estimate total body fat (Heyward & Stolarczyk, 1996:23).

### 2.11.1 Sum of skinfolds in Rugby Union

The investigation of Durandt *et al.* (2006) yielded no significant differences between the 16 year old and 18 year old players. The study of Spamer and De la Port (2006) also delivered no practical significant differences.

When comparing the u/18 Green squad in the study of Durandt *et al.* (2006) with the u/18 Green squad (2003-season) in the study of Spamer and De la Port (2006), it is quite clear that the players in the study of Spamer and De la Port (2006) had a greater sum of skinfolds ( $\bar{X}$  =76.9 mm vs.  $\bar{X}$  =69.2 mm). This is an interesting occurrence as both teams were elite, and consisted of a similar sample size.

**Table 13A: Comparison of the sum of 7 skinfolds (mm) in elite adolescent Rugby Union players as reported by different authors.**

Authors	Study group	N	$\bar{X}$		SD	p-value	d-value
			u/16	u/18			
Durant <i>et al.</i> (2006:41)	u/16 Green Squad	91	66.8	-	19.2	NS	-
	u/18 Green Squad	79	-	69.2	20.6		-
Spamer and De la Port (2006:178)	u/16 Green Squad-2003 season	71	67.6	-	28.9	-	0.15
	u/16 Green Squad-2004 season	69	73.5	-	39.1	-	
	u/18 Green Squad -2003 season	75	-	76.9	28.3	-	0.17
	u/18 Green Squad -2004 season	71	-	70.8	36.8	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Table 13B represent the results of Durandt *et al.* (2006) indicating a moderate practical significant difference for the sum of skinfolds between the TF and LF ( $d=0.55$ ) as well as for the H and BL ( $d=0.57$ ) in the u/16 age group. In the u/18 category large practical significant difference between the TF and LF ( $d=0.83$ ) were present. The study of Van Gent and Spamer (2005) revealed props having a greater sum of 7 skinfolds compared to all other positions.

The loose forwards in the u/16 category of Durandt *et al.* (2006) indicates a higher sum of skinfolds compared to the loose forwards ( $\bar{X}=64.7$  mm compared to  $\bar{X}=58.8$  mm) of Van Gent and Spamer (2005). The latter might be occurring due to the difference in the sample size of the two studies. The loose forwards of Durandt *et al.* (2006) were a total of 16, whereas the complete sample size of Van Gent and Spamer (2005) consisted of 21 players.

**Table 13B: Comparison of the sum of 7 skinfolds (mm) in elite adolescent Rugby Union players regarding positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$				p-value	d-value
		u/16	u/18	u/16	SD	u/18	SD		
Van Gent and Spamer (2005:54,56)	Tight forwards (TF) (props, hookers and locks)	21	18	69.8	-	82.1	-	-	u/16=0.55* u/18=0.83** (TF vs. LF)
	Loose forwards (LF) (flankers and eight man)			58.8	-	65.5	-	-	
	Halves (H) (scrumhalf and fly-half)			38.5	-	46.0	-	-	u/16=0.57* u/18=0.24 (H vs. BL)
	Back-line (BL) (centers, wings and fullback)			49.9	-	50.8	-	-	
Durant <i>et al.</i> (2006:41)	<b>Individual positions</b>								
	Prop	10	12	110.8	37.6	119.6	42.8	Prop vs. all positions <0.00204	-
	Hooker	7	5	78.2	17.2	80.7	31.9		-
	Lock	10	10	73.6	32.8	68.1	18.9		-
	Loose forwards	16	14	64.7	19.6	62.3	12.3		-
	Scrumhalf	6	8	54.0	18.0	58.3	17.1		-
	Fly-half	8	7	59.3	10.3	57.2	13.6		-
	Wing	14	9	54.7	12.1	57.5	8.5		-
	Centre	12	11	51.2	10.1	63.7	20.5		-
Fullback	8	3	54.8	15.2	55.5	20.1	-		

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; significant difference ( $p < 0.05$ ).

### 2.11.2 Sum of skinfolds in Rugby League

According to the literature, skinfold thickness and the sum of skinfolds could differentiate between selected and non-selected players (Gabbett *et al.*, 2011:1460), as well as between professional and semi-professional players (Gabbett *et al.*, 2011:1457).

**Table 14A: Comparison of the sum of skinfolds (mm) in junior sub-elite Rugby League players as reported by different authors.**

Authors	Age group	N	Elite		Sub-elite				d-value
			$\bar{X}$	SD	u/16		u/18		
					$\bar{X}$	SD	$\bar{X}$	SD	
Gabbett (2009:236) <b><math>\Sigma 4</math> skinfolds</b>	u/16	20	-	-	31.1	17.3	-	-	NS
	u/18	15	-	-	-	-	38.5	19.1	
Gabbett <i>et al.</i> (2009:218) <b><math>\Sigma 7</math> skinfolds</b>	u/16-Elite	28							0.32
	u/16-Sub-elite	36	67.1	14.8	75.1	31.9	-	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; statistical significant difference ( $p < 0.05$ ).

The u/18 group ( $\bar{X} = 38.5$  mm) had a higher sum of 4 skinfolds compared to the u/16 group ( $\bar{X} = 31.1$  mm). However, it was not of any practical or statistical significance. Nonetheless, according to research (Pearson *et al.*, 2006:279), subcutaneous fat increasingly rises in males during childhood, with a clear decrease at around 14-16 years of age.

Although the sub-elite players ( $\bar{X} = 75.1$  mm) had a higher sum of 7 skinfolds compared to the elite players ( $\bar{X} = 67.1$  mm) it was non-significant. These findings are somewhat in agreement with that of Till *et al.* (2001:266) who also discovered a difference in skinfold measurement between playing level, with regional players having a higher sum of skinfolds compared to national players ( $\bar{X} = 40.0$  mm vs.  $\bar{X} = 36.6$  mm). However, the study of Till *et al.* (2011:266) made use of the sum of 4 skinfolds and the sample size consisted of under 13, 14 and 15 players.

**Table 14B: Comparison of the sum of skinfolds (mm) in junior elite and sub-elite Rugby League players as reported by different authors regarding starters and non-starters.**

Authors	Age group	N	Elite					Sub-elite								
			Starters		Non-starters		d-value	u/16		u/18		u/16		u/18		d-value
			Starters		Non-starters			Starters		Starters		Non-starters		Non-starters		
			$\bar{X}$	SD	$\bar{X}$	SD		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Gabbett (2009:237) <b>Σ4 skinfolds</b>	u/16	20	-	-	-	-	-	27.2	7.5	-	-	37.0	25.7	-	-	0.52*
	u/18	15	-	-	-	-	-	-	-	35.1	17.5	-	-	41.8	21.7	0.34
Gabbett <i>et al.</i> (2009:219) <b>Σ7 skinfolds</b>	u/16-Elite	28	68.5	13.6	64.3	17.6	0.27	75.1	13.8	-	-	88.3	37.7	-	-	0.38
	u/16-Sub-elite	36														

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

A medium practical significance ( $d=0.52$ ) emerged in the u/16 age group when the starters were compared to the non-starters. In a study by Gabbett *et al.* (2009:219), similar results were found with sub-elite non-starters having a larger sum of skinfolds compared to the starters in the u/16 category.

In Table 14B no statistical significant differences were found in the elite players with regards to starters and non-starters. Consistent with these findings are those of Gabbett *et al.* (2011:1457) who also reported no significant difference in senior professional Rugby League players between starters ( $\bar{X} = 52.4$  mm) and non-starters ( $\bar{X} = 56.5$  mm). It is interesting to note that the sum of skinfolds of the senior professional Rugby League players were much smaller than the elite u/16 Rugby League players. The sub-elite players, however, had a tendency towards moderate practical significant difference with the starters having a smaller  $\Sigma$ skinfolds compared to the non-starters. Differences also emerged between starters ( $\bar{X} = 68.5$  mm vs.  $\bar{X} = 57.1$  mm) and non-starters ( $\bar{X} = 64.3$  mm vs.  $\bar{X} = 88.3$  mm) of the elite and sub-elite group, with the elite group having a reasonably smaller sum of skinfolds compared to the starters and non-starters of the sub-elite group. The difference in sum of skinfolds between the elite and sub-elite groups could be explained due to the fact that non-elite level players are usually exposed to infrequent matches of short duration and lower playing intensity (Gibbs *et al.*, 1993:699), which might explain why the sub-elite players possess higher body fat and thus a greater sum of skinfolds compared to elite players. These findings are in agreement with Gabbett *et al.* (2011:1457) who reported semi-professional players to have a larger sum of skinfolds compared to professional players.

In Rugby League an increase in skinfold thickness serves as a protective buffer during contact situations, for instance props who are subjected to high incidence of collisions (Meir, 1993:28).

**Table 14C: Comparison of the sum of skinfolds (mm) in junior elite and sub-elite Rugby League players with regards to positional groups as reported by different authors.**

Authors	Positional group	N		$\bar{X}$					p-value	d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18			
Gabbett (2005c:678)	Props	37	-	-	-	-	-	72.0	<0.05†	-	
	Hookers and halves (hookers, halfbacks and five-eighths)	69	-	-	-	-	-	34.7	NS	-	
	Back rowers (second-rowers and locks)	47	-	-	-	-	-	38.2	NS	-	
	Oudside backs (centers, wingers and fullbacks)	87	-	-	-	-	-	33.0	NS	-	
	<b>Individual positions</b>										
	<b>Σ4 skinfolds</b>	Prop	37	-	-	-	-	-	72.0	<0.05#	-
		Hooker	31	-	-	-	-	-	35.9	NS	-
		Second row	36	-	-	-	-	-	39.5	NS	-
		Lock	11	-	-	-	-	-	33.7	NS	-
		Halfback	27	-	-	-	-	-	40.9	NS	-
		Five-eight	11	-	-	-	-	-	24.7	NS	-
		Centre	27	-	-	-	-	-	34.8	NS	-
	Wing	39	-	-	-	-	-	30.7	NS	-	
	Fullback	21	-	-	-	-	-	36.2	NS	-	

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group

**Table 14C: Comparison of the sum of skinfolds (mm) in junior elite and sub-elite Rugby League players with regards to positional groups as reported by different authors.**

Authors	Positional group	N		$\bar{X}$					p-value	d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18		
Gabbett <i>et al.</i> (2009:220)  <b>Σ7 skinfolds</b>	<b>Elite</b>									
	Hit-up forwards (prop and second-row)	28	-	80.2	12.4	-	-	-	NS	1.97**
	Adjustables (hooker, halfback, five-eight and lock)		-	59.6	8.1	-	-	-	<0.05‡	
	Outside backs (centers, wing and fullback)		-	65.4	17.0	-	-	-	NS	
	<b>Sub-elite</b>									
	Hit-up forwards (prop and second-row)	36	-	113.6	21.9	-	-	-	NS	3.22**
	Adjustables (hooker, halfback, five-eight and lock)		-	60.6	7.9	-	-	-	<0.05‡	
	Outside backs (centers, wing and fullback)		-	60.8	25.7	-	-	-	<0.05‡	
Cheng <i>et al.</i> (2014 :549)  <b>Σ7 skinfolds</b>	Hit-up forwards (props)	-	15	-	-	110.5	26.5	-	<0.05†	-
	Wide-running forwards (second rowers and locks)	-	28	-	-	86.7	25.0	-	<0.05†	-
	Adjustables (fullbacks, five-eights, halfbacks and hookers)	-	39	-	-	66.9	16.8	-	NS	-
	Outside backs (wingers and centers)	-	26	-	-	67.0	17.6	-	NS	-

Note:  $\bar{X}$ , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group.

**Table 14C: Comparison of the sum of skinfolds (mm) in junior elite and sub-elite Rugby League players with regards to positional groups as reported by different authors.**

Authors	Positional group	N		$\bar{X}$					p-value	d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16- u/18		
Cheng <i>et al.</i> (2014 :549)  <b>Σ7 skinfolds</b>	<b>Forward and back Units</b>									
	Forward players	-	60	-	-	91.5	27.0	-	<0.01	-
	Backline players	-	56	-	-	67.1	18.3	-		-

Note:  $\bar{X}$  , mean; SD, standard deviation; NS, non-significant; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †significantly different ( $p < 0.05$ ) from all other positional groups; ; #significantly different ( $p < 0.05$ ) from all other positions; ‡significantly different ( $p < 0.05$ ) from hit-up forwards positional group.

Table 14C indicated the props positional group in the study of Gabbett (2005c) having a greater sum of skinfold than any of the other positional groups, which is consistent with previous studies of senior Rugby League players who similarly discovered the props positional subgroup (Gabbett, 2006:1276) or positional groups consisting of props and one other position (Meir *et al.*, 2001:454) to be superior regarding the sum of 4 skinfolds. These findings are consistent with research done on junior players (Till *et al.*, 2013:440). The results of Gabbett *et al.* (2009) showed that the skinfold thickness of the elite hit-up forwards was significantly greater ( $d=1.97$ ) than the adjustables and outside backs while comparing the positional groups. When comparing the sub-elite positional groups, the hit-up forwards had a remarkable higher skinfold thickness ( $d=3.22$ ) compared to the adjustables and outside backs. Hit-up forwards spend a large percentage of game time involved in physical collisions (Gabbett *et al.*, 2009:221), and an increased skinfold thickness will serve as a protective buffer against all the contact they have to endure (Meir, 1993:28). The sub-elite hit-up forwards also had a substantial greater skinfold thickness compared to the elite hit-up forwards. According to research, skinfold thickness (Gabbett *et al.*, 2011:1460) could differentiate between selected and non-selected players, with the selected players competing at professional level and the non-selected players competing at semi-professional level. The sum of 7 skinfolds in the study of Cheng *et al.* (2014) were remarkably greater ( $p=0.003$ ) than any of the other positional groups, while the wide-running forwards ( $\bar{X}=86.7$  mm) had a greater skinfold thickness compared to the adjustables ( $\bar{X}=66.9$  mm) and outside backs ( $\bar{X}=67.0$  mm).

The props in the study of Gabbett (2005c) had the greatest sum of skinfolds compared to all the other individual positions which was of significant value ( $p<0.05$ ). The greater skinfold thickness of the props could be coupled to the fact that because of the high amounts of collisions they have to endure during a game, this greater subcutaneous fat layer could serve as a protective barrier for players in this position (Meir, 1993:28).

It is clear that the forward players' sum of 7 skinfolds was superior to and of statistical significance ( $p<0.01$ ) compared to the backline players. Previous studies (Meir, 1993:28; Meir, 1994:16; Meir *et al.*, 2001:454) on senior Rugby League players reported significant differences among forward and backline players regarding skinfold thickness. Although the results were documented on the sum of 4 skinfolds, similar findings emerged as in the study of Cheng *et al.* (2014).

### 2.11.3 Sum of skinfolds in Sevens Rugby

**Table 15A: Comparison of the sum of skinfolds (mm) in Sevens Rugby players as reported by different authors.**

Authors	Sum of skinfolds	N	$\bar{X}$	SD
Higham <i>et al.</i> (2013:21)	Σ7 skinfolds	18	52.2	11.5
Suarez-Arrones <i>et al.</i> (2014:316)	Σ6 skinfolds	10	61.6	6.0

Note:  $\bar{X}$ , mean; SD, standard deviation.

Interesting to note is that the sum of 6 skinfolds of the players in the study of Suarez-Arrones *et al.* (2014) were higher than the sum of 7 skinfolds of the players in the study of Higham *et al.* (2013). Duthie *et al.* (2003:977) is of the opinion that players competing at higher level have a smaller body fat percentage. Thus as the sum of several skinfolds can be used to estimate total body fat (Heyward & Stolarczyk, 1996:23), it is likely that the reason the sum of 6 skinfolds of the players in the study of Suarez-Arrones *et al.* (2014) were higher than the sum of 7 skinfolds of the players in the study of Higham *et al.* (2013) may be due to different playing levels. The players in the study of Suarez-Arrones *et al.* (2014) only participated domestically whereas the players in the study of Higham *et al.* (2013) participated internationally.

Results indicated that the Σskinfolds is a kinanthropometric variable that can differentiate between different playing levels in both Rugby League and Sevens Rugby. Results also indicated that the sum of skinfolds differed within the positional groups in both Rugby Union and Rugby League.

## 2.12 BODY FAT

Body fat can be beneficial in Rugby (union, league and sevens) especially during contact situations because it serve as a protective buffer (Bell, 1973:71; Meir, 1993:30). However excessive fat will increase body mass and lead to a decrease in acceleration particularly in ball games where speed, explosive power, sprinting and jumping are important requisites (Norton *et al.*, 1996:327). Thus excessive body fat have a negative effect on sport performance (Norton *et al.*, 1996:327).

### **2.12.1 Body fat in Rugby Union**

Body fat percentage could differentiate between successful or less successful players as literature documented that as the level of play increases body fat percentage decreases (Duthie *et al.*, 2003:977).

**Table 16A: Comparison of body fat (%) in elite adolescent Rugby Union players as reported by different authors.**

Authors	Study group	N	$\bar{X}$		SD	p-value	d-value
			u/16	u/18			
Adendorff <i>et al.</i> (2004:449)	Successful group	18	-	9.9	3.8	-	0.22
	Less successful group	11	-	8.9		-	
Durant <i>et al.</i> (2006:54,56)	U16 Green Squad	91	14.5	-	3.4	NS	-
	U18 Green Squad	82	-	14.3	2.7		-
Spamer and De la Port (2006:41)	U16 Green Squad-2003 season	71	14.3	-	3.9	-	0.17
	U16 Green Squad -2004 season	69	15.0	-	4.2	-	
	U18 Green Squad -2003 season	75	-	15.1	3.4	-	0.12
	U18 Green Squad -2004 season	71	-	14.7	4.1	-	
Spamer <i>et al.</i> (2009:54)	New Zealand group (NZ)	24	13.7	-	4.8	-	-
	South Africa group 1 (SA <sub>1</sub> )	43	18.8	-	6.4	-	0.8 (NZ vs. SA <sub>1</sub> )**
	South Africa group 2 (SA <sub>2</sub> )	22	16.0	-	4.0	-	0.5 (NZ vs. SA <sub>2</sub> )*

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; NS, non-significant.

In Table 16A no practical significant differences were found for percentage body fat in the u/16 age group, except for the study by Spamer *et al.* (2009) who discovered large practical significant differences ( $d=0.8$ ) between the NZ and SA<sub>1</sub> group, and only moderate practical significant differences ( $d=0.5$ ) between the NZ and SA<sub>2</sub> group. It should, however, be kept in mind that the NZ group made use of a different formula to calculate percentage body fat than that of the SA groups (Du Plessis, 2007:104). Although it seems that the NZ group had the lowest percentage of body fat of all the groups this was not the case. The percentage body fat of the NZ group may be small but when compared to their skinfolds measurements in Table 16A, one cannot imagine their fat percentage being this small especially when compared to the SA groups. When taking the NZ group out of the equation it is clear that the SA<sub>1</sub> group ( $\bar{X}=18.8$  %) has a relatively higher percentage body fat than the Green Squad ( $\bar{X}=14.5$  %) of Durandt *et al.* (2006) and the Green Squad ( $\bar{X}=14.3$  % - 2003 season) of Spamer and De la Port (2006). As mentioned earlier the SA<sub>1</sub> group, although classified as elite, was only composed of players playing for their high school's first team, whereas the Green Squad of both Durandt *et al.* (2006) and Spamer and De la Port (2006) represented their country at elite level. Duthie *et al.* (2003:977) documented that as the level of play increases, body fat percentage decreases.

In the u/16 age group the SA<sub>1</sub> group ( $\bar{X}=18.8$  %) in the study of Spamer *et al.* (2009) had a higher body fat percentage compared to the Green Squads ( $\bar{X}=14.5$  % and  $\bar{X}=15.0$  %) of both Durandt *et al.* (2006) as well as Spamer and De la Port (2006). According to the literature, percentage body fat will decrease as the playing level increases (Duthie *et al.*, 2003:977). The u/18 age group showed the body fat percentage of both the successful and less successful group of Adendorff *et al.* (2004) to be reasonably smaller in comparison with the other u/18 study samples. This might be linked to the difference in sample sizes with the cohort of Adendorff *et al.* (2004) being considerable smaller than the squads in the study of Durandt *et al.* (2006) and Spamer and De la Port (2006).

Body fat serves as a protective cushion during contact situations (Bell, 1973:11), which is relatively important for positions like props and TF as these positions are in constant contact with the opposition (Duthie *et al.*, 2003:975).

**Table 16B: Comparison of body fat (%) in elite adolescent Rugby Union players regarding positional classification as reported by different authors.**

Authors	Positional group	N		$\bar{X}$						d-value
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18	SD	
Van Gent and Spamer (2005:54,56)	Tight forwards (TF) (props, hookers and locks)	21	18	18.4	-	23.6	-	-	-	u/16=0.48* u/18=1.92** (TF vs.LF)
	Loose forwards (LF) (flankers and eight man)			16.7	-	16.7	-	-		
	Halves (H) (scrumhalf and fly-half)			12.2	-	15.3	-	-	u/16=0.54* u/18=0.35 (H vs. BL)	
	Back-line (BL) (centers, wings and fullback)			14.1	-	14.0	-	-		
Durant <i>et al.</i> (2006:40)	<b>Individual positions</b>									
	Prop	10	13	20.0	5.5	20.0	4.2	-	-	-
	Hooker	7	5	16.4	2.4	15.3	3.7	-	-	-
	Lock	10	11	14.8	4.6	14.2	2.0	-	-	-
	Loose forwards	16	15	14.2	3.1	13.9	1.8	-	-	-
	Scrum half	6	8	13.2	4.2	12.9	2.7	-	-	-
	Fly-half	8	7	13.6	2.0	13.3	2.4	-	-	-
	Wing	14	9	13.3	2.9	13.1	1.6	-	-	-
	Centre	12	11	12.0	1.8	13.8	2.9	-	-	-
Fullback	8	3	13.0	4.6	12.1	3.4	-	-	-	

Authors	Positional group	N		$\bar{X}$						d-value	
		u/16	u/18	u/16	SD	u/18	SD	u/16-u/18	SD		
Delahunt <i>et al.</i> (2013:3254-3255)	Props <sup>c,d,e,f,g,h</sup>	16	-	-	-	-	-	24.5	-	-	
	Hooker <sup>d,e,g,h</sup>	13	-	-	-	-	-	19.7	-	-	
	Second row (lock) <sup>a,h</sup>	19	-	-	-	-	-	17.0	-	-	
	Back row (loose forwards) <sup>a,b</sup>	24	-	-	-	-	-	15.0	-	-	
	Scrumhalf <sup>a,b</sup>	14	-	-	-	-	-	14.4	-	-	
	Out half (fly-half) <sup>a,h</sup>	9	-	-	-	-	-	17.8	-	-	
	Centre <sup>a,b</sup>	16	-	-	-	-	-	14.9	-	-	
	Back three (wings and fullback) <sup>a,b,c,f</sup>	25	-	-	-	-	-	12.7	-	-	
	<b>Forward and back units</b>										
	Forward players	72	-	-	-	-	-	18.5	5.9	0.15	
Backline players	64	-	-	-	-	-	14.3	3.1			

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; statistical significant difference ( $p < 0.05$ ).

Durant *et al.* (2006:40)

- Prop vs. Lock  $p < 0.00001$
- Prop vs. Loose forward  $p < 0.00001$
- Props vs. Scrumhalf  $p < 0.00001$
- Prop vs. Fly-half  $p < 0.00001$
- Props vs. Wing  $p < 0.00001$
- Prop vs. Centre  $p < 0.00001$
- Prop vs. Fullback  $p < 0.00001$

Delahunt *et al.* (2013)

- <sup>a</sup> Significantly different from prop
- <sup>b</sup> Significantly different from hooker
- <sup>c</sup> Significantly different from second row
- <sup>d</sup> Significantly different from back row
- <sup>e</sup> Significantly different from scrum half
- <sup>f</sup> Significantly different from out half
- <sup>g</sup> Significantly different from centre
- <sup>h</sup> Significantly different from back three

Table 16B indicates a large significant difference in percentage body fat ( $d=1.92$ ) between the tight forwards and loose forwards in the study of Van Gent and Spamer (2005). When studying the comparison between the playing positions in the study of Durandt *et al.* (2006) it was evident that the props percentage of body fat was significantly higher than any of the other positions in both the age groups. A high degree of body fat is beneficial to props as it helps to absorb the impact during tackles and collisions (Durandt *et al.*, 2006:44). In the investigation of Delahunt *et al.* (2013), the props appeared to have considerably greater body fat percentage than that of the second row and back row players. Back row players indicated to have significantly less body fat percentage than props and hookers. It was also detected that the back three players (fullback and wings) when compared to the other positions had the lowest percentage body fat. This is not surprising as fullbacks and wings usually perform a greater number of high-intensity activities, like sprinting during the game compared to other positions (Deutsch *et al.*, 1998:567).

A reasonably higher body fat percentage were observed in the loose forwards ( $\bar{X}=16.7\%$ ) of Van Gent and Spamer (2005) compared to the loose forwards ( $\bar{X}=13.9\%$ ) of Durant *et al.* (2006) in the u/18 category. The players of Van Gent and Spamer (2005) although elite, only participated at provincial level, compared to the players of Durandt *et al.* (2006) who competed at national level. As mentioned earlier, Duthie *et al.* (2003:977) documented that players competing at higher elite levels have a smaller percentage body fat. This phenomenon is also applicable for the comparison of the studies by Durandt *et al.* (2006) and Delahunt *et al.* (2013). When comparing the studies of Durant *et al.* (2006) and Delahunt *et al.* (2013) it was evident that higher percentage body fat of the players of Delahunt *et al.* (2013) were attained regarding the following playing positions: props ( $\bar{X}=20.0\%$  compared to  $\bar{X}=24.5\%$ ), hookers ( $\bar{X}=15.3\%$  compared to  $\bar{X}=19.7\%$ ) and fly-halves/out half ( $\bar{X}=13.3\%$  compared to  $\bar{X}=17.8\%$ )

A comparison between forward and backline players indicated considerably greater values for forward players compared to the backline players ( $\bar{X}=18.5\%$  compared to  $\bar{X}=14.3\%$ ). While Bell (1973:71) claims that body fat serves as a protective buffer in contact situations, it is not surprising to observe that the props and tight forwards had higher body fat percentage as these positions, according to Duthie *et al.* (2003:975), are in constant close contact with opponents. It is also not surprising that percentage body fat differs between forward and backline players as these positions have different game demands (Duthie *et al.*, 2003:977).

### **2.12.2 Body fat in Rugby League**

Certain positional groups in Rugby League have a greater percentage of body fat compared to others. For instance props and back-rowers (O'Connor, 1996:22) take benefit out of having an increased body fat percentage as it serves as a protective buffer for them during physical collisions in Rugby League (Meir, 1993:30).

It's evident in Table 17A that the hit-up forwards had a greater body fat percentage compared to other positional groups. The wide-running forwards on the other hand had a larger percentage body fat compared to the adjustables and outside-backs. According to O'Connor (1996:22), props (present in the hit-up forwards positional group) and back-rowers (present in the wide-running forwards positional group) are mainly responsible for the higher percentage body fat present in forwards. Body fat is somewhat beneficial to these positions as they are subjected to a great amount of physical collisions. Forward players had a greater percentage body fat compared to the backline players, most likely as mentioned during the skinfold variable, to serve as a protective layer because of the physical nature related with this position (Meir, 1993:30). Supporting the latter is a study on professional Rugby League players where it was reported that forwards had a significantly higher percentage body fat compared to the backs (Brewer *et al.*, 1994:158). However, in amateur Rugby League players did not differ between forward and backline players (Gabbett, 2000:306). Although body fat provides some benefits during contact situations it should be noted that body fat provides nonproductive weight to the body, leading to a reduction in acceleration and an increase in energy expenditure (Meir, 1993:27).

**Table 17A: Comparison of body fat (%) in junior elite Rugby League players with regards to positional classification.**

Study by: Cheng <i>et al.</i> (2014:549)									
Age group	Positional groups								p-value
	Hit-up forwards N=15		Wide-running forwards N=28		Adjustables N=39		Outside-backs N=26		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
u/18	19.4†	4.8	15.2†	4.4	11.8	2.8	11.8	3.1	0.003
	Forward players N=60				Backline players N=56				
	$\bar{X}$		SD		$\bar{X}$		SD		
	16.1		4.8		11.8		3.2		<0.001

Note:  $\bar{X}$  , mean; SD, standard deviation; significant difference (p<0.05);†significantly different (p<0.05) from all other positions.

### 2.12.3 Body fat in Sevens Rugby

**Table 18A: Comparison of body fat (%) in Sevens Rugby players with regards to forward and backline players.**

Study by: Rienzi <i>et al.</i> (1999:162)					
	Positional group	N	$\bar{X}$	SD	p-value
Body fat %	Total	27	11.7	2.3	-
	Forward players	17	12.1	2.2	<b>NS</b>
	Backline players	13	11.4	2.5	
Body fat kg	Total	27	17.0	3.1	-
	Forward players	17	18.6	3.0	0.03
	Backline players	13	15.9	2.9	

Note:  $\bar{X}$  , mean; SD, standard deviation; significant difference ( $p < 0.05$ ).

When comparing the body fat percentage and body fat in kilograms of the forward and backline players in the study of Rienzi *et al.* (1999) no statistical significant differences emerged. Rienzi *et al.* (1999:163) are of the opinion that the forward and backline players paid a lot of attention to their body weight with the approach to the tournament. This, however, is in contrast to what was discovered in Rugby Union and Rugby League.

Positional group differences regarding percentage body fat were visible in both Rugby Union and Rugby League, however no statistical significant differences in percentage body fat occurred in Sevens Rugby, rather body fat in kilograms differed between Sevens Rugby forward and backline players. The positional groups with higher body fat percentage values were usually the players exposed to the greatest physical collisions during a game. Body fat can be seen as being beneficial to Rugby players having to sustain large amounts of physical contact during a game as it can serve as a protective buffer (Bell, 1973:71; Meir, 1993:30).

## 2.13 SKELETAL MASS

### 2.13.1 Skeletal mass in Rugby Union

**Table 19A: Descriptive statistics of successful and less successful u/18 Rugby Union players with regards to skeletal mass (%).**

Study by: Adendorff <i>et al.</i> (2004:449)				
Study group	N	$\bar{X}$	Standard deviation	d-value
Successful group	18	12.5	1.0	0.77*
Less successful group	11	13.3	1.1	

**Note:**  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$

In Table 19A it is evident that, skeletal mass tended toward a large practical significance but only medium practical differences in percentage skeletal mass ( $d=0.77$ ) occurred when comparing the successful group to the less successful group, with the less successful group having the highest skeletal mass percentage ( $\bar{X} = 13.3\%$ ).

Research on skeletal mass in junior Rugby League and adolescent Sevens Rugby players has not yet been documented.

## 2.14 MUSCLE MASS

Muscle mass increases with age, between 42% - 54% of body weight in boys aged 5-17 years (Malina *et al.*, 2004:150). A large muscle mass enhances performance in strength and power activities (Heyward & Stolarczyk, 1996:143).

### 2.14.1 Muscle mass in Rugby Union

**Table 20A: Comparison of elite u/16 and u/18 South African schoolboy Rugby Union players with regards to muscle mass (%).**

Study by: Spamer and De la Port (2006:178 )					
Study group	N	$\bar{X}$		SD	d-value
		u/16	u/18		
u/16 Green Squad-2003 season	71	63.5	-	5.3	0.35
u/16 Green Squad-2004 season	69	61.3	-	6.3	
u/18 Green Squad -2003 season	75	-	62.0	7.4	0.03
u/18 Green Squad -2004 season	71	-	61.8	3.5	

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

No remarkable differences in muscle mass percentage whatsoever are visible while comparing the same age groups with each other.

### 2.14.2 Muscle mass in Sevens Rugby

**Table 21A: Comparison of muscle mass (%) in Sevens Rugby players with regards to forward and backline players.**

Study by: Rienzi <i>et al.</i> (1999:162)					
	Positional group	N	$\bar{X}$	SD	p-value
Muscle mass %	Total	27	62.4	4.1	-
	Forward players	17	61.8	3.7	NS
	Backline players	13	62.9	4.5	
Muscle mass kg	Total	27	53.0	8.0	-
	Forward players	17	57.8	6.2	<0.01
	Backline players	13	49.5	7.4	

Note:  $\bar{X}$  , mean; SD, standard deviation; significant difference ( $p < 0.05$ ).

When comparing muscle mass percentage and muscle mass in kilograms of the forward and backline players in the study of Rienzi *et al.* (1999), statistical significant differences for only the muscle mass in kilograms emerged.

No significant differences whatsoever occurred in Rugby League or Sevens Rugby with regards to percentage muscle mass, however significant differences were discovered in Sevens Rugby between forward and backline players regarding muscle mass in kilograms.

Research on muscle mass has not yet been documented in junior Rugby League players.

## **2.15 SOMATOTYPING**

When a person's somatotype is determined, it provides a quantitative summary of his or her body as a whole, it describes the current shape and composition of the body. A somatotype is expressed as a three digit value, representing the components endomorphy, mesomorphy and ectomorphy. One should never underestimate the value of somatotyping as it helps with the understanding of variability and composition in human body build (Carter & Heath, 1990).

### **2.15.1 Somatotyping in Rugby Union**

Research in Rugby Union has documented that an endomorphic mesomorph somatotype is more beneficial as it indicates advancement in strength and power (Bale *et al.*, 1984:3). According to the literature, players in higher grades (meaning more successful teams) usually possess a larger physique (Quarrie *et al.*, 1995:268) which is a high priority to coaches and selectors when selecting their teams (Quarrie *et al.*, 1995:263).

**Table 22A: Comparison of somatotyping in elite adolescent Rugby Union players as reported by different authors.**

Authors	Group/ somatotyping	N	$\bar{X}$		SD	d-value
			u/16	u/18		
Adendorff <i>et al.</i> (2004:449)	Successful group (SG) vs. Less successful group (LSG)					
	Endomorphic value (SG)	SG=18	-	4.42	0.94	0.34
	Endomorphic value (LSG)	LSG=11	-	4.09	0.98	
	Mesomorphic value (SG)		-	4.18	0.79	0.29
	Mesomorphic value (LSG)		-	3.90	0.97	
	Ectomorphic value (SG)		-	2.04	0.77	0.82**
	Ectomorphic value (LSG)		-	2.86	1.00	
Spamer and De la Port (2006:178)	u/16 group 2003 season vs. 2004 season	2003 season = 71				
	Endomorphic value (2003 season)	2004 season = 69	2.91	-	1.28	0.16
	Endomorphic value (2004 season)		3.15	-	1.52	
	Mesomorphic value (2003 season)		5.48	-	1.17	0.19
	Mesomorphic value (2004 season)		5.71	-	1.24	
	Ectomorphic value (2003 season)		2.11	-	1.01	0.09
	Ectomorphic value (2004 season)		2.21	-	1.08	
	u/18 group 2003 season vs. 2004 season		2003 season = 75			
	Endomorphic value (2003 season)		-	3.23	1.14	0.09
	Endomorphic value (2004 season)		-	3.10	1.50	

Authors	Group/ somatotyping	N	$\bar{X}$		SD	d-value
			u/16	u/18		
Spamer and De la Port (2006:178)	Mesomorphic value (2003 season)	2004 season = 71	-	5.82	1.89	0.16
	Mesomorphic value (2004 season)		-	5.52	1.90	
	Ectomorphic value (2003 season)		-	1.86	1.06	0.18
	Ectomorphic value (2004 season)		-	1.66	1.11	

Note:  $\bar{X}$  , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

The less successful group in the investigation of Adendorff *et al.* (2004) shows a large practical significant ectomorphic value compared to the successful group ( $d=0.82$ ). This, however, is not surprising since the successful group also had a higher mesomorphic value compared to the less successful group, however, it was of no practical significance. Both the successful and less successful group possess a mesomorph-endomorph somatotype. Literature, states that an endomorphic mesomorph somatotype is more beneficial as it is advantageous in strength and power compared to those with other somatotypes (Bale *et al.*, 1984:3). The results of Spamer and De la Port (2006) indicated no practical significance with regards to any of the somatotype components in both age groups. Nonetheless both age groups possessed favourable somatotypes (endomorph mesomorphs).

When comparing the studies of Adendorff *et al.* (2004) as well as Spamer and De la Port (2006) in terms of the 18 year old players, it is interesting to note that both the groups (successful and less successful) in the study of Adendorff *et al.* (2004) had higher endomorphic values compared to u/18 group (during both seasons) in the study of Spamer and De la Port (2006). In spite the fact of having smaller body fat percentages. When evaluating at the mesomorphy values it is clear that on average the players in the study of Spamer and De la Port (2006) were more muscular and less slender compared to the players in the study of Adendorff *et al.* (2004).

### 2.15.2 Somatotyping in Rugby League

**Table 23A: Comparison of somatotyping in junior elite u/18 Rugby League players with regards to positional classification.**

Study by: Cheng <i>et al.</i> (2014:549)									
Somatotyping	Positional groups								p-value
	Hit-up forwards N=15		Wide-running forwards N=28		Adjustables N=39		Outside-backs N=26		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Endomorphy	4.13	0.84	3.36	1.01	2.63	0.62	2.57	0.68	0.007
Mesomorphy	8.08	0.91	7.15	1.27	6.79	1.05	6.47	0.84	0.04
Ectomorphy	0.59	0.36	1.19	0.85	1.58	0.93	1.83	0.65	0.04
	Forwards N=60				Backs N=56				
Endomorphy	3.6		1.0		2.6		0.7		<0.001
Mesomorphy	7.5		1.3		6.5		0.8		<0.001
Ectomorphy	1.0		0.9		1.7		0.7		<0.001

Note:  $\bar{X}$ , mean; SD, standard deviation; significant difference ( $p < 0.05$ ).

Results in Table 23A revealed that the hit-up forwards had a greater endomorphy and mesomorphy value compared to all other positional groups, whereas the wide-running forwards' endomorphy value was higher than the adjustables and outside-backs. The ectomorphy value of the hit-up forwards was relatively smaller than that of the adjustables and outside-backs. The greater endomorphy values and smaller ectomorphy values of the hit-up forwards compared to all the other positional groups could be explained by the greater body fat percentage of the hit-up forwards as mentioned earlier. Regardless of all the differences occurring in the somatotyping components of the different playing positions all of the players had an endo-mesomorphic type of build, which is in line with the literature on Rugby Union where this type of physique is seen as being beneficial (Bale *et al.*, 1984:3).

The forward players in the study of Cheng *et al.* (2014) displayed superior endomorphy and mesomorphy values but smaller ectomorphy values compared to the backline players which was all statistically significant different ( $p < 0.001$ ). In spite of the differences, both the forward and backline players were endo-mesomorphs. However, consistent with the study of Quarrie *et al.* (1995:268) in Rugby Union, the somatotypes of the forward players in the study of Cheng *et al.*

(2014) were more endo-mesomorphic than those of the backline players. This may imitate the greater demands for strength placed on forward players during scrummaging, rucking and mauling (Quarrie *et al.*, 1995:268).

### 2.15.3 Somatotyping in Sevens Rugby

**Table 24A: Comparison of somatotyping in Sevens Rugby players with regards to forward and backline players.**

Study by: Rienzi <i>et al.</i> (1999:162)							
Components	Positional groups						p-value
	Total N=27		Forward players N=17		Backline players N=13		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Endomorphy	2.3	0.6	2.3	0.5	2.3	0.6	NS
Mesomorphy	5.9	0.9	6.2	0.9	5.7	0.9	NS
Ectomorphy	1.5	0.6	1.3	0.7	1.6	0.6	NS

**Note:**  $\bar{X}$  , mean; SD, standard deviation; NS, non-significant; significant difference ( $p < 0.05$ ).

When comparing the forward players to the backline players with regards to somatotype no differences were detected for any of the components, stating that the forward and backline players were homogeneous regarding their somatotype. These findings are in contrast with that observed in Rugby Union by Quarrie *et al.* (1995:268) who discovered the somatotypes of the forward players to be more endo-mesomorphic than that of the backline players. The Sevens Rugby players in the study of Rienzi *et al.* (1999) were overall classified overall as endomorphic mesomorphs. Players in all three Rugby codes were mostly classified as endo-mesomorphs which according to the literature, is more beneficial towards performance than any other form of somatotype (Bale *et al.*, 1984:3).

Regarding positional differences only significant differences were discovered in Rugby League for the different somatotype components, whereas no significant difference were visible in Sevens Rugby for any of the components, suggesting the Sevens Rugby players to be homogeneous regarding their somatotype.

## **2.16 ADOLESCENT GROWTH AND MATURATION**

It is essential to grasp and fully understand the growth and maturation patterns of adolescents, as these two variables, according to Schubring and Thiel (2014:78), are important requirements for progressing/successful/improved performance and athletic development in elite sports. The following discussion will refer to the changes adolescents encounter regarding growth and maturation. In some cases certain adolescents complete puberty before some even begin to experience physical changes, and because of this it is important to include this section, for the simple reason of each adolescent developing at his/her own unique rate. Sport is only one part, albeit an important one of the experience of growing up, which places many demands on youth (Malina, 2009:8)

Adolescence originated from the Latin verb “adolescere”, which mean “to grow up” or even “to grow into adulthood” (Gouws *et al.*, 2000:2) and can be defined as “a period of dynamic change in physiological capabilities, physical parameters, sexual characteristics and social interaction” (Pearson *et al.*, 2006:279). According to the World Health Organisation, the age of adolescence is between 10-18 years, whereas Malina *et al.* (2004:8) states an age range of 10-22 is more fitting due to the variation existing in the onset and conclusion of adolescence. During this period most of the systems in the body reach maturity both “structurally” and “functionally” (Malina *et al.*, 2004:8).

Structurally, the adolescent growth spurt starts with an increase in the rate of growth in stature. After the rate of growth in stature reaches its climax it begins to slow down (decelerative phase) and finally stops with the onset of adult stature (Malina *et al.*, 2004:8). Functionally, adolescence is normally observed in terms of their sexual maturity, beginning with changes occurring in the neuroendocrine system (before distinct physical changes are clear) and then ends with the completion of mature reproductive function (Malina *et al.*, 2004:8). Secondary sex characteristics (penis, testes and pubic hair development in boys) is also used as a indicator of maturity.

Adolescence, according to Malina (2002:262) and Malina *et al.* (2004:5) is classified into three different (but interacting) processes namely growth, maturation and development. All three occur at the same time and interact. According to Malina (2002:262), it is important for adults (e.g. parents, teachers, coaches and other adults) to be aware of these interactions. Growth and maturation are mutually connected and must be seen as dynamic, and although both of them are biological processes (Malina *et al.*, 2004:6; Malina 2014:157; Rogol *et al.*, 2000:522), each one of them refers to a “specific biological activity” (Malina *et al.*, 2004:4).

Development (refers to changes in behavioural domains) are often used in combination with the terms, growth and maturation (Malina *et al.*, 2004:5), but represents a rather broader meaning. Thus as noted, growth and maturation are biological processes, while development is a behavioural process (Malina, 2014:158).

During this particular section of the Chapter the focus will be only on growth and maturation as development was not part of the goal

### **2.16.1 Growth**

Growth according to Malina *et al.* (2004:4), is the “dominant biological activity for about the first two decades of human life, including of course, nine months of prenatal life”. Malina *et al.* (2004:4) and Malina (2014:157) further explain that the size of the whole body or just specific parts of the body increase during growth. Gallahue and Ozmun (1995:3) is of the opinion that growth is “a quantitative increase in size throughout the life cycle brought about by interaction among the requirements of the task, the biology of the individual and the conditions of the environment”. Growth in children is characterized by an increase in body length, body mass, lean and fat tissue and an increase in organ size (Malina, 2002:262; Malina *et al.*, 2004:4; Malina, 2014:157). Postnatal growth is quite similar in its pattern from one individual to another but when evaluating size attained and rate of growth, substantial individual inconsistency at different ages is found (Malina *et al.*, 2004:41)

Stature (also known as height) and body weight (also known as body mass) is the most common measurements used for growth monitoring, and in growth studies (Malina *et al.*, 2004:42,49; Malina, 2014:159; Rogol *et al.*, 2000:522). An increase in height velocity (Malina *et al.*, 2004:308; Malina, 2014:159) and body mass (Gouws *et al.*, 2000:13) during growth, marks the onset (takeoff) of the adolescent growth spurt (occurs in boys at approximately 12 years of age). With the onset of the latter, maximum increase in the growth of height occurs until it reaches a peak, known as peak height velocity (PHV), occurring in boys at approximately 14 years of age, and averaging 9.5 cm per year (Abbassi, 1998:509; Malina *et al.*, 2004:308). After PHV height steadily starts to decrease, until it eventually reaches zero with the attainment of adult stature (Malina, 2014:159). According to Malina (2014:159), some individuals carry on growing in height into their early twenties. Nonetheless, with the onset of the growth spurt, until PHV is reached, till growth stops are very inconsistent between individuals (Malina, 2014:159).

According to Rogol *et al.* (2000:524) the rate in weight gain also decelerates in a way very similar to that of growth in height, but controversial to height, weight on the other hand can still

increase until late in life (Malina *et al.*, 2004:49; Malina, 2014:159). The adolescent weight spurt in boys is primarily associated with increases in stature, skeletal tissue, and muscle mass (Malina *et al.*, 2004:320). Peak weight velocity occurs after peak height velocity (Malina *et al.*, 2004:318; Malina, 2014:159), with an average increase of 9kg per year (Rogol *et al.*, 2000:524). During adolescence 50% of total body weight in adults is attained.

Body weight, according to Malina (2014:159), is most of the time viewed in terms of a lean and fat component, with the lean component referring to fat free mass. In other words body weight is equal to fat free mass + fat mass. Fat free mass experiences a clear adolescent spurt and growth like pattern than that of height and weight (Malina, 2014:159). Fat mass during childhood and adolescence increases more gradually (Malina, 2014:159) compared to relative fatness, which also increases steadily but with the onset of the adolescent growth spurt, progressively starts declining. Whereas percent body fat reaches its lowermost point at 16-17 years of age and then steadily increases into young adulthood (Malina *et al.*, 2004:114-115).

Malina (2014:159) suggests that most of the other body dimensions including major organs also undergo similar growth patterns to that of weight and height. For instance, according to Rogol *et al.* (2000:524) the increase in muscle mass and maximum loss of fat in the upper arms relates to the time of PHV. In males an increase in muscle mass and skeletal size results in an increase of strength (Rogol *et al.*, 2000:524), this increasement in muscle mass can continue up until the mid-twenties, according to Malina *et al.* (2004:154). On the other hand skeletal weight during early and middle childhood roughly increases at a constant rate whereas it encounters a rapid increase during adolescence (Malina *et al.*, 2004:128). Bone mineral content in boys' increases through up to late adolescence, and even though growth in height slows down total-body bone mineral can continue to increase up until the twenties (Malina *et al.*, 2004:128-129). Adolescents subjected to late or delayed puberty may have a problem in attaining normal amounts of bone mineral content, leading to reduced bone mineral density during adulthood (Rogol *et al.*, 2000:524).

According to Malina *et al.* (2004:83), the development of physique has essential significance in the study of growth, maturation and performance. Physique, most of the time observed in the context of somatotype, refers to the conformation of the body as one/overall (Malina, 2002:266). Physique can serve as important factor regarding the selection and exclusion process in a number of sports (Malina, 2002:266; Malina *et al.*, 2004:633; Malina, 2012:375). Young athletes participating in a specific sport have the tendency to obtain somatotypes, similar to that of adult athletes in the same sport (Malina, 2002:266; Malina *et al.*, 2004:633).

Somatotype usually changes during growth and maturation (Malina *et al.*, 2004:94). In boys the endomorphy component has a tendency to decrease as they get older, which is especially evident during adolescence. On the other hand ectomorphy has a habit of increasing from childhood to adolescence and then later on during late adolescence to decrease. This late decline in ectomorphy is most likely related to increases in mesomorphy which also take place during late adolescence (Malina *et al.*, 2004:94-95).

### **2.16.2 Maturation**

Maturation is a “time component that marks the rate of progress towards the developed state” (Krogman, 1980). Gallahue and Ozmun (1995:16) is, however, of the opinion that it is a “process, which enables individuals to ascertain higher levels of function”. To Malina *et al.* (2004:4) maturation is more difficult to define than growth and can be described as the “process of becoming mature, or the “tempo and timing of progress toward the mature state” according to Malina (1994:390) and Malina and Koziel (2014:424). Maturation is a process; maturity is a state (Malina, 2014:157).

Differences in maturity state become more obvious during the change over into adolescence and the adolescent growth spurt (Malina *et al.*, 2004:628), reflecting individualism in the timing and tempo (as previously mentioned) of development toward the mature biological state (Malina *et al.*, 2004:5; Malina, 2002:262). Timing implies to when specific maturational events take place (e.g., during age with the first appearance of pubic hair in boys and girls) or the age at maximum growth during the growth spurt in adolescence. Tempo implies to the rate which maturation develops (e.g., how fast or how slow youngsters pass from the initial stages of sexual maturation to the mature state). Timing and tempo differ significantly among individuals with regards to maturation.

Malina *et al.* (2004:5) uses the following example to explain better the difference between timing and tempo “two children may be the same size (i.e., have the same level of attained growth), but they can be at quite different places on the path to adult size or maturity. One child may have attained 65% of adult stature, the other may have attained 75%. Individuals end up as adults with a fully ossified skeleton, but they reach this state at different times and attain different adult heights”. This is the fundamental distinction between growth and maturation.

With regards to biological maturity, skeletal maturity (skeletal age), sexual maturity (secondary sex characteristic) and somatic maturity (age at peak height velocity) are the most commonly used indicators (Malina, 1994:390; Malina, 2002:263; Malina *et al.*, 2004:277-278). Skeletal or

pubertal (discussed in the next paragraph) maturity, according to Rogol *et al.* (2000:523), could be used to measure the grade/degree of a child's biological development. However, Buenen *et al.* (1997:225), Mailina *et al.* (2004:278) and Sherar *et al.* (2010:337) are of the opinion that it is probably the best method one can use to assess the status of biological maturity. Not only because children of the same chronological age can sometimes differ too much with regards to their biological maturity status (Malina *et al.*, 2004:337), but also because of skeletal maturity covering the entire growth period (Malina *et al.*, 2004:307; Malina, 2011:942; Rogol *et al.*, 2000:524).

Skeletal age (SA) is expressed in relation to the child's chronological age (CA) leading to the criteria classification of a child, either having an advanced (early maturer), average (average or "on time" maturer) or delayed (late maturer) skeletal age (Malina, 1994:390; Malina *et al.*, 2004:338). If a child's SA is one or more years in advanced of CA, the child will be labeled as an "early maturer". If the SA of the child is within  $\pm 1$  year of CA, the child is labeled an "average maturer", and finally a child whose SA is one or more years behind with regards to CA is labeled a "late maturer". Children start with a cartilage skeleton before they are born and end up with a fully developed skeleton of bone in early adulthood (Malina *et al.*, 2004:278).

Sexual maturation is a sustained procedure extending from sexual differentiation in the period of the embryo through puberty to full sexual maturity and fertility. During this process puberty serves as a transitional period between childhood and adulthood, including the presence of secondary sex characteristics, maturation of the reproductive system and adolescent growth spurt (Abbassi, 1998:507; Cobb, 2000:81; Malina *et al.*, 2004:283). According to Abbassi (1998:507), puberty is comprised of three phases namely the acceleration phase followed by a deceleration phase and finally ending with the termination phase of growth. Puberty can be seen as a dynamic period of development characterized by prompt changes occurring in body size, body shape and body composition. Puberty is a dynamic period of development marked by rapid changes in body size, shape, and composition (Rogol *et al.*, 2000:523). The onset of puberty corresponds to a skeletal (biological) age of 13 years in boys (Rogol *et al.*, 2000:523).

During puberty, according to Gouws *et al.* (2000:11), growth and sex hormone secretion take place. The secondary sex characteristics development in males has a distinct sequence, the testes grow, the skin of the scrotum darkens and the penis lengthens. The growth of the pubic, body and facial hair begins in combination with the development of the underarm and sweat glands. All of the above occurrences usually starts at about 12 years of age (13 years according to Rogol, (2000:253)) and ends at 15 years of age (middle adolescence).

According to Malina and Bouchard (1991:232), body measurements can be used as indicators of somatic maturity, with height being the most popular measurement by far to determine somatic maturity. In controversy Malina *et al.* (2004:293) are of the opinion that maturity cannot be assessed by making use of body measurements, because body size in itself is not an indicator/predictor of maturity. However, if longitudinal data that span adolescence are available, specifically for height, the inflection in the growth curve that marks the adolescent growth spurt can be derived indicators of maturity such as age at the onset of the growth spurt and age at maximum rate of growth during the spurt (age at peak height velocity) (Malina *et al.*, 2004:293).

The most commonly used indicator of somatic maturity is age at start of the growth spurt and peak height velocity, and although maturity cannot be assessed by using body measurements (because body size in itself is not an indicator of maturity).

Advanced maturing males are normally coupled with larger gains in height, weight, weight for height, muscle mass (more mesomorphic), stronger and greater performance in physical tasks, thus better suited for success than later maturing males (Cumming *et al.*, 2009:678; Malina 2002:263). There is a possibility that during all stages of adolescence (13-18 years), early maturing males could be taller than average or late maturing males (Pearson *et al.*, 2006:279). Because of the large variation in adolescent's growth potential inbetween and after puberty, adolescent height is not very reliable for talent identification (Pearson *et al.*, 2006:279). Significant gains in weight occur during the adolescent years with about 40% of adult weight gained between 13-18 years of age in males. The link between weight gain and hormonal processes and their association with puberty leads to maturing males being heavier than their age-matched counterparts (Pearson *et al.*, 2006:279).

Increases in muscle mass of males occupies a large percentage of growth during adolescence (Pearson *et al.*, 2006:279). Early maturing males have remarkably more muscle mass than late maturing males (Pearson *et al.*, 2006:279). During childhood subcutaneous fat progressively rises, characterized with a decrease at about 14-16 years of age.

## **2.17 EARLY AND LATE DEVELOPERS**

To experience sport early in life can have an immense effect in the upbringing of every child. These experiences have a massive impact on a child's self-esteem, not only with regards to sport but also in everyday life. However, there are some factors that might discard the needs

and opportunities children are seeking for in sport, like the recruitment of bigger and more daunting players and the discernment in team selection against smaller, less physical mature and less self-confident children (Orlick, 2002:465).

As noted, children enter the adolescent growth spurt at different ages and progress through it at variable rates (Malina *et al.*, 2004:307), and it is characterized according to the following maturity stages (Malina *et al.*, 2004:338), early (advanced), average (on time) and late (delayed). Children of the same chronological age (categorized as early, average or late maturers) according to Malina *et al.* (2004:337) and Sherar *et al.* (2010:332), can differ greatly in biological maturity status, and with regards to this contrasting maturity status. Size differences among children are also evident, and are most obvious during adolescence at 11 to 16 years of age in boys (Malina, 2002:263 and Malina *et al.*, 2004:340). Furthermore, when comparing a group of boys of the same age, the boys with the earlier biological maturity usually have a tendency to be taller, heavier and stronger (Malina *et al.*, 2004:10,225) and, therefore, more superior athletes than the boys categorized as late maturers.

When reflecting on what was just said and although research has not yet been consulted one cannot help but agree with the statement made by Cumming *et al.* (2009:684) that “most exercise and sport programmes favour early over late maturing males”. Researchers Jones and Bayley (1950:147) documented that adults assumed biological early maturing males to be more socially adjusted and to have more superior physiques and physical abilities, when compared to their later maturing peers. Yes, it is true that this observation was made more than 5 decades ago but does it not still sound familiar nowadays, and still apply to coaches and parents today? According to Cumming *et al.* (2006:1040), one would instinctively expect coaches and parents to favour players, physically better suited for the demands of the sport they partake in.

The selection advantage gained by older players (meaning players still born in the same year but reasonably early/born in the same chronological year but might be advanced or delayed in within a particular age group) has been confirmed by several researchers (Cumming *et al.*, 2006:1040; Cumming *et al.*, 2009:684; Orlick, 2002:465). Simmons and Paul (2001:684), Malina (2002:265,271), Malina *et al.* (2004:625) and Malina (2012:375) documented that in some sport youth are selected or excluded with respect to body size and maturity status. The latter according to Malina (1994:422; 2002:271) are also providers of success. Brewer *et al.* (1995:158) with his study on football players encountered the same outcomes. Furthermore, Malina (2002:267) discovered that youth who are advanced in maturity status, are over-represented in most sport, especially at elite level. The age range when all of the above occur varies between researchers. According to Lefevre *et al.* (1990:432), it is between the ages of 13

to 14 years, Malina (2002:267) is of the opinion that it falls between the a age of 12 to 15 years and finally Malina *et al.* (2004:555) feel it is between 13 and 16 years. Nevertheless one can conclude when looking at the literature above the fact that early male maturing athletes are more successful is generally true.

Although numerous literature states that boys who are advanced in biological maturing are generally more advance performers compared to their later maturing peers, the literature also exists confirming that later maturers usually catch up with their earlier counterparts later in life. A study by Malina *et al.* (2004:628) revealed that delayed maturing boys can catch up to advanced maturing boys regarding growth and skeletal maturity and can be successful in some sport in later adolescence (16 to 18 years of age). Malina (2002:263-264) is rather of the opinion that the dissimilarities between boys of different maturity status regarding their size, strength and performance are minimized or vanished at about 17-19 years of age. This is evident as explained by the following research. Lefevre *et al.* (1990:433) documented that the mean height and mean weight for early maturers was 177.5 cm and 75.1 kg, for average maturers 178.06 cm and 74 kg, and for the late maturers it was 178.0 cm and 73.5 kg. Thus late maturing boys will normally catch up with or even exceed the stature of their earlier maturing counterparts (Malina *et al.*, 2004:341). The reason for the latter could be due to early maturing children stopping to grow in stature first, whereas children in the other two maturity stages remain to grow for longer periods of time (Malina *et al.*, 2004:341). Pearson *et al.* (2006:279) in their study observed differences in weight between early and late maturing adolescents which are more visible during the end of adolescence but become less meaningful during adulthood. However sophisticated muscularity does not continue up to adulthood, leading to early maturing adolescents losing their muscular advantage they had over the late maturing counterparts in adulthood (Beunen *et al.*, 1997:228).

Although it is clear that late maturers have the ability to catch up with their earlier maturing peers, another problem arises, younger and delayed maturing players might be left out or not identified for top level coaching and competition during their early years, even though they may have the ability to develop into elite performers (Simmons & Paull, 2001:679). According to Dudink (1994:592), players selected at an early age have a better chance of being selected later in life as well, because of the “process of recognition”, Malina (2002:271) concurs and adds that being noticed at an early age holds the advantage of expert coaching. To counteract this problem of late maturers being forgotten, Meylan *et al.* (2010:586) are of the opinion that latter maturing players need to be fostered and developed until they reach maturity. However the latter presents a problem to those (i.e. coaches or scouts) making use of early selection

programmes. Philippaerts *et al.* (2006:229) feel that coaches and trainers should be familiar with the features associated with the adolescent growth spurt and must take note that the changes occurring in growth and performance during this particular time are extremely individualized (Malina *et al.*, 2004:337).

It almost seems that the two mature groups switch places the closer they move to adulthood. Does this mean that early developers get their time to shine during childhood and adolescence with the late maturers surpassing them after adolescence and then get the chance to enjoy the fruit of their labour later in life? There is much controversial evidence existing around this. According to Philippaerts *et al.* (2006:229), the best performers during adulthood are not automatically early developing boys, whereas Lefevre *et al.* (1990:433) found that boys who were performing well during adolescence might still have a good chance to perform above the ordinary during adulthood.

Adding to Malina *et al.* (2004:627), there are a range of factors involved in successful athletic performance during childhood and adolescence but just like kinanthropometry, growth and maturity status are also important. However, they are not the only determining factor of successful performance.

To conclude this literature overview it is important to provide a brief conclusion of what was discovered. The unique wealth kinanthropometry offers with regards to Rugby Union and Rugby League was clear from the above mentioned literature, underlying the important role it plays in performance, team selection as well as its ability to differentiate between playing positions. However, research on Sevens Rugby is lacking especially with regards to adolescent players partaking in this particular sport, making it difficult to determine, from the available literature if kinanthropometry has a similar positive effect on Sevens Rugby as with the other two mentioned Rugby codes. To conclude, it is important for coaches, selectors and sport scientists not to write off players lacking the proper or desired physique as many of the players (because of the particular age group investigated) are still developing and because most of the time you are exposed to players of varying maturity statuses (early and late developers).

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# CHAPTER 3

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# KINANTHROPOMETRIC PROFILES OF ELITE U/18 SEVENS RUGBY PLAYERS: A FOCUS ON POSITIONAL STATUS

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## **KINANTHROPOMETRIC PROFILES OF ELITE U/18 SEVENS RUGBY PLAYERS: A FOCUS ON POSITIONAL STATUS**

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### **ABSTRACT**

The purpose of this study was to compile a profile of kinanthropometric characteristics of elite u/18 Sevens Rugby players and to determine if any morphological differences exist between different playing positions. Kinanthropometry data were collected from 164 male elite u/18 Sevens Rugby players ( $17.4 \pm 0.7$  years) competing in a 2 day South African Schools' Rugby u/18 Sevens tournament. Players underwent a kinanthropometric assessment whereby each player's stature, body mass and selected skinfolds, girths and breadths measurements were collected. On average the forward players indicated greater stature, body mass, BMI, body fat (%), skeletal mass (kg) and muscle mass (kg) values compared to backline players. All-rounder players indicated a significantly larger stature, body mass, BMI and muscle mass (kg) compared to the backline players. The somatotype profile indicated a dominant mesomorph somatotype among the players of all playing positions. The Sevens Rugby players overall could be classified as endo-mesomorphs. Results from the current study indicates that kinanthropometry differentiate between playing positions in Sevens Rugby, suggesting that different player positions should be subdivided during match specific training sessions.

**Key Words** rugby sevens, somatotyping, morphology, body composition

## INTRODUCTION

Rugby has become one of the main team sports played worldwide, mostly because of the large number of participants competing (21), and due to the number of spectators attending the events (6). Rugby consists of different codes such as Rugby Union, Rugby League and Sevens Rugby (30,31). During recent years the latter increased in popularity and is now played at domestic and international level around the globe (15). With the launching of the Rugby Sevens World Cup (26), IRB World Sevens Series and acquiring Olympic status to be included in the 2016 games, Sevens Rugby has become one of the fastest growing sport codes (30). In spite of its popularity, Sevens Rugby is also viewed as beneficial to younger players as it serves as a development platform to progress to professional and international Rugby Union (9). Both Rugby Union and Sevens Rugby are contact orientated team sports (30) and are subjected to a great deal of physical collisions such as tackling, hitting rucks and scrummaging (32). According to Meir (22), it is possible that some physical characteristics may be deemed almost compulsory in order to achieve success, especially in collision type sports where deficiencies in kinanthropometric profiles may uncover weaknesses (26). Despite the unique wealth of information kinanthropometry offers (17), no study, according to this research team has been published on the kinanthropometric profiles of adolescent Sevens Rugby players regarding positional differences.

Existing kinanthropometric research with regards to Sevens Rugby is lacking when compared to existing literature in Rugby Union and Rugby League (21). The last mentioned Rugby codes have proven kinanthropometry to be very beneficial towards performance and selection of players (11,12,13,23,24,25,28,34). Nonetheless, research on Sevens Rugby (16) indicated an evolution of physique in adult Sevens Rugby players regarding stature and body mass (26,33), which might be an indication of the demands in the game (10) changing over the years. Positional dissimilarities also emerged, with research discovering forward and backline players to be different (10,26) with regards to their kinanthropometric qualities. Rienzi *et al.* (26) suggested that a specific physique might be related to a certain player position.

Although it is well known in Rugby Union that players are usually divided into forward and backline players when position-specific differences are investigated (8,14), in Sevens Rugby, players should rather be split into three positional categories, namely forward, backline and all-rounder players. Due to the small sample of players available to coaches at Sevens Rugby tournaments along with the increased amount of Sevens Rugby matches on each day and consecutive days, players are often required to act as both forward and backline players during a tournament.

The aim of this study was to compare the positional kinanthropometrical profiles of elite u/18 Sevens Rugby players.

The kinanthropometric data of the Sevens Rugby players represented in the different playing positions might be used by coaches and selectors to serve as norm scales during selection processes and it might also assist coaches in playing players out of position. The results of the current study may further assist sport scientists and coaches to develop enhanced player specific training sessions that adhere to each position's needs.

## **METHODS**

### **Experimental Approach to the Problem**

In this study, a quantitative cross-sectional research design was used to compile the kinanthropometric profiles of elite adolescent Sevens Rugby players. The present study compared kinanthropometrical characteristics between forwards, backs and all-rounders. All the players underwent a kinanthropometric assessment whereby each player's stature, body mass and selected skinfolds, girths and breadths measurements were drawn.

### **Subjects**

A total of 164 elite male adolescent Sevens Rugby players (age,  $\bar{X}$  = 17.4 years,  $\pm 0.7$ ) representing fifteen provincial teams from South Africa and one international team, from Namibia participated in the South African Schools' Rugby Association u/18 Sevens tournament in October 2014. The players were categorized into forwards (N=61), backs (N=91), and all-rounders (N=12). The forwards playing position consisted of props and hookers, the backs playing position consisted of a scrumhalf, first receiver, centre and wing, whereas the all-rounders playing position contained players able to either play as a forward or a back. Ethical permission was granted by the North-West University – NWU-00122-11-A1. The methodology was explained beforehand and all the players participated on a voluntary basis with the option to withdraw at any stage. All the subjects were requested to complete a consent form keeping in mind that players younger than 18 years were expected to provide written consent from a parent or guardian.

### **Kinanthropometry**

All the kinanthropometric measurements (stature, body mass, skinfolds, girths and breadths) were measured twice by trained level II Kinanthropometrists following the standard procedures described by the International Society for the Advancement of Kinanthropometry (ISAK) (29). Each kinanthropometrist was responsible to measure a specific measurement throughout the study for reliability purposes. Body mass was measured with a calibrated electronic scale (Precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg. Stature

was measured with a stadiometer to the nearest 0.1 cm. Skinfolds (mm) were measured on six different sites, namely the triceps, subscapular, supraspinal, abdominal, thigh and calf skinfolds, using a Harpenden skinfold caliper (10.g.mm<sup>2</sup>) according to the procedures in Stewart *et al.* (29). Breadths (cm) were determined at four different sites, namely the femur, humerus, wrist and ankle breadths, using a bone caliper (Cescorf Equipment, Porto Alegre, Brazil), and girths were taken (of the forearm, mid-thigh and calf) using a flexible steel tape (Cescorf Equipment, Porto Alegre, Brazil) to the nearest 0.1 cm. All the breadths and girths were also taken as stated by Stewart *et al.* (29). Body mass index (BMI) was calculated from the stature and body mass measurements (body mass (kg)/height (m<sup>2</sup>)). The sum of the six skinfolds ( $\Sigma 6$  skinfolds, triceps, subscapular, supraspinal, abdominal, thigh and calf), were calculated, whereas body fat percentages were obtained according to the formula of Withers *et al.* (36). The formulas of Martin *et al.* (19) and Martin (20) were used respectively to calculate muscle mass and skeleton mass. The formulas of Carter and Heath (2) were used to calculate the somatotypes to the nearest 0.1 for every component.

### **Statistical Analysis**

The Statistical Data Processing package (SPSS) (18) was used for the statistical analysis of the data. A one-way analysis of variance (ANOVA) was used to determine if any differences existed between players by playing position. Due to the inferential nature of the study (all players participated without random selection) Cohens's (4) effect size (ES) were used to determine practical significance instead of statistical significance (p-values). Effect sizes of 0.2 were considered small, 0.5 as medium and 0.8 were considered as large (4).

### **RESULTS**

The comparison of kinanthropometric measurements between the forward, backline and all-rounder players are summarized in Table 1.

**Table 1: Comparison of kinanthropometric characteristics between different playing positions in elite u/18 Sevens Rugby players.**

Kinanthropometric variables	Total N=164		Forward players N =61		Backline players N=91		All-rounder players N=12		Forwards vs. Backs	Forwards vs. All- rounders	Backs vs. All- rounders	Between positions
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	ES	ES	ES	p-value
	Flexed arm girth (cm)	35.9	2.6	37.5	2.4	34.7	2.3	36.7	1.0	1.2**	0.3	0.9**
Calf girth (cm)	37.9	2.5	39.5	2.1	36.8	2.3	38.4	1.7	1.2**	0.5*	0.7*	<0.001
Forearm girth (cm)	29.3	1.7	30.3	1.4	28.5	1.6	29.6	0.8	1.2**	0.5*	0.7*	<0.001
Mid-thigh girth (cm)	57.2	4.3	59.9	2.8	55.1	4.2	59.2	2.7	1.2**	0.3	1.0**	<0.001
Humerus breadth (cm)	7.1	0.5	7.3	0.4	6.9	0.5	7.1	0.4	0.8**	0.6*	0.2	<0.001
Femur breadth (cm)	9.7	0.7	10.1	0.7	9.4	0.6	10.0	0.8	1.0**	0.1	0.8**	<0.001
Wrist breadth (cm)	5.9	0.3	6.0	0.3	5.8	0.3	5.8	0.4	0.7*	0.6*	0.0	<0.001
Ankle breadth (cm)	7.4	0.5	7.5	0.4	7.2	0.4	7.5	0.7	0.7*	0.0	0.4	<0.001
Tricep skinfold (mm)	9.1	3.2	10.3	3.3	8.1	2.9	10.1	3.5	0.7*	0.1	0.6*	<0.001
Subscapular SF (mm)	9.3	2.3	10.5	2.5	8.4	1.6	10.2	2.5	0.8**	0.1	0.7*	<0.001
Supraspinal SF (mm)	7.9	3.3	9.5	3.9	6.7	2.2	9.1	3.8	0.7*	0.1	0.6*	<0.001
Abdominal SF (mm)	13.4	6.6	16.6	7.8	10.8	4.1	16.2	7.9	0.7*	0.1	0.7*	<0.001
Front thigh SF (mm)	12.4	5.4	15.1	5.7	10.6	4.4	13.0	5.1	0.8**	0.4	0.5*	<0.001
Medial calf SF (mm)	8.2	2.8	9.6	2.9	7.3	2.3	8.7	3.4	0.8**	0.3	0.4	<0.001

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Various large and moderate practical significant differences were found when comparing the forward with the backline players. The forward players presenting greater values in all the measurements compared to the backline players, showing large practical significant differences in the following measurements; all the girth measurements (flexed arm, calf, forearm and mid-thigh,  $d=1.2$ ), humerus ( $d=0.8$ ) and femur ( $d=1.0$ ) breadth measurements as well as the subscapular ( $d=0.8$ ), front thigh ( $d=0.8$ ) and medial calf ( $d=0.8$ ) skinfold measurements. Moderate practical significant differences for the wrist ( $d=0.7$ ) and ankle ( $d=0.7$ ) breadth as well as the triceps ( $d=0.7$ ), supraspinal ( $d=0.7$ ) and abdominal ( $d=0.7$ ) skinfold measurements were found. Comparing the forward players to the all-rounder players only moderate practical significant differences occurred with regards to the calf ( $d=0.5$ ) and forearm ( $d=0.5$ ) girth as well as the humerus ( $d=0.6$ ) and wrist ( $d=0.6$ ) breadth. Large practical significant differences were found between the backline and all-rounder players in the following measurements; flexed arm girth ( $d=0.9$ ), mid-thigh ( $d=1.0$ ) and femur breadth ( $d=0.8$ ). Numerous moderate practical significant differences occurred between the all-rounder players showing greater values compared to the backline players with regards to the calf ( $d=0.7$ ) and forearm ( $d=0.7$ ) girth, tricep ( $d=0.6$ ), subscapular ( $d=0.7$ ), supraspinal

(d=0.6), abdominal (d=0.7) plus front thigh (d=0.5) skinfold measurements. Table 2 presents the comparison of body composition between the different playing positions.

**Table 2: Comparison of the body composition between different playing positions in elite u/18 Sevens Rugby players.**

Body composition	Total N=164		Forward players N=61		Backline players N=91		All-rounder players N=12		Forwards vs. Backs	Forwards vs. All- rounders	Backs vs. All- rounders	Between positions
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	ES	ES	ES	P-value
	Age (years)	17.4	0.7	17.5	0.6	17.3	0.7	17.6	0.5	0.3	0.3	0.5*
Stature (cm)	176.8	6.9	180.9	6.2	173.8	6.0	179.2	4.6	1.1**	0.3	0.9**	<0.001
Body mass (kg)	79.3	10.5	87.8	8.1	73.0	7.7	84.5	6.6	1.8**	0.4	1.5**	<0.001
BMI (kg/m <sup>2</sup> )	25.3	2.4	26.8	2.2	24.2	2.0	26.3	1.5	1.2**	0.3	1.1**	<0.001
Body fat (%)	10.0	3.2	11.7	3.4	8.7	2.3	10.9	3.8	0.9**	0.2	0.6*	<0.001
∑6 skinfolds (mm)	60.3	20.9	71.6	22.4	51.9	14.8	67.3	24.3	0.9**	0.2	0.6*	<0.001
Skeletal mass (%)	12.2	0.9	11.9	0.9	12.4	0.8	11.8	1.1	0.6*	0.1	0.6*	0.001
Skeletal mass (kg)	9.7	1.3	10.5	1.2	9.1	1.0	10.0	1.4	1.2**	0.3	0.7*	<0.001
Muscle mass (%)	59.7	4.8	59.1	4.4	60.1	5.2	59.6	3.8	0.2	0.1	0.1	0.4
Muscle mass (kg)	47.3	6.8	51.8	5.4	43.9	6.0	50.2	3.4	1.3**	0.3	1.1**	<0.001

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

Forward players were superior and noticeably different in stature (d=1.1), body mass (d=1.8), BMI values (d=1.2), body fat (d=0.9), ∑6 skinfolds (d=0.9), skeletal mass (d=1.2) and muscle mass (d=1.3) compared to the backline players. A moderate practical significant difference in percentage skeletal mass (d=0.6) were found between forward and backline players. When comparing the all-rounder players to the backline players large practical significant differences were found in stature (d=0.9), body mass (d=1.5), BMI (d=1.1) and muscle mass in kilograms (d=1.1), with a moderate practical significant difference in body fat (d=0.6), ∑6 skinfolds (d=0.6), percentage skeletal mass (d=0.6) as well as skeletal mass (d=0.7) in kilograms. The somatotype classification between the different playing positions of the elite u/18 Sevens Rugby players are presented in Table 3, while a somatochart plotting the somatotypes of the forward, backline and all-rounder players are presented in Figure 1.

**Table 3: Comparison of the somatotype classification between the different playing positions in elite u/18 Sevens Rugby players.**

Somatotype components	Total N=164		Forward players N=61		Backline players N=91		All-rounder players N=12		Forwards vs. Backs	Forwards vs. All- rounders	Backs vs. All- rounders	Between positions
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	ES	ES	ES	P-value
	Endomorphy	2.9	1.0	3.4	1.1	2.6	0.8	3.3	1.2	0.7*	0.1	0.6*
Mesomorphy	5.8	1.1	6.2	1.2	5.5	1.1	5.9	0.8	0.6*	0.3	0.3	0.001
Ectomorphy	1.7	0.8	1.4	0.8	2.0	0.8	1.4	0.5	0.7*	0.0	0.7*	<0.001

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ .

The dominant somatotype profile among the players and different playing positions were mesomorphy. The overall Sevens Rugby players could be classified as endomorphic mesomorphs. When the forward players were compared to the backline players moderate practical significant differences for all three components (endomorphy, mesomorphy and ectomorphy) were visible, with the forward players having greater endomorphy and mesomorphy values, but smaller ectomorphy values. Moderate practical significant differences were found between the backline and all-rounder players for the endomorphy and ectomorphy components with the backline players having smaller endomorphy values and greater ectomorphy values. The somatochart indicates a clear merge towards the endo-mesomorphic side with the scattering of the somatotypes clearly different between the playing positions.

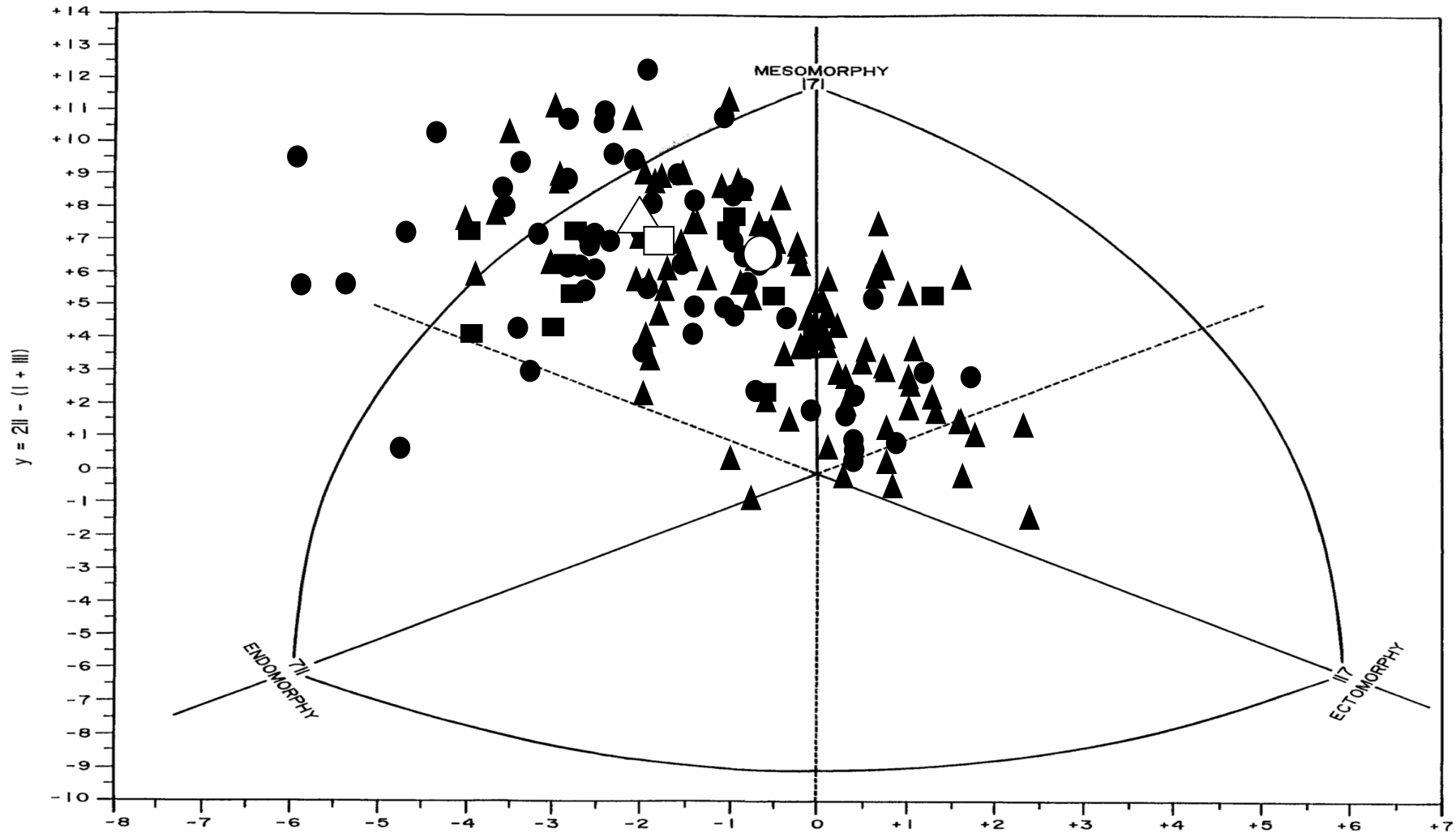


Figure 1: Somatochart: somatotypes of all the positional groups. ▲ = backs, △ = backs average, ● = forwards, ○ = forwards average, ■ = all-rounders, □ = all-rounders average.

## DISCUSSION

The purpose of this study was to compare playing positions and to compile a profile of elite u/18 Sevens Rugby players regarding their kinanthropometrical characteristics. The forward players in this study showed greater values in all kinanthropometric and body composition measurements compared to the backline players, in particular stature, body mass, BMI, percentage fat mass, sum of 6 skinfolds, skeletal mass in kilograms and muscle mass in kilograms. These kinanthropometric differences between forward and backline players were also observed by similar age groups of Rugby Union (5,7,35) and Rugby League (3) players. Supporting literature done on Sevens Rugby regarding playing positions also found forward players present significantly greater values for stature, body mass (10,26), fat mass and muscle mass in kilograms (26) than backline players. This phenomenon could be explained due to the fact that forward players should be bigger and heavier than backline players in order to gain an advantage during scrums, and phases of play (26). A lighter body mass is more beneficial to backs in order to beat opponents by means of acceleration and speed (22).

All-rounder players compared to backline players showed various practical significant differences with the all-rounders being superior in stature, body mass, BMI and muscle mass in kilograms. All-rounder players have the ability to be used either as a forward or backline player which explain the larger body size (indicated by height and weight) (27), than backline players. No significant differences were found between forward and all-rounder players. Significant differences in the kinanthropometric features between different playing positions of this particular study might indicate that positional roles in Sevens Rugby are subjected to a specific physique

Consistent to similar research on Sevens Rugby, Fuller *et al.* (10) and Rienzi *et al.* (26) also discovered significant differences between forward and backline players with regards to stature, body mass and muscle mass (kg) ( $p < 0.01$  and  $p < 0.001$ ). This study discovered practical significant differences between forward and backline players with regards to BMI, body fat percentage,  $\Sigma 6$  skinfolds, skeletal mass (kg) as well as a variety of skinfolds, girth and breadth measurements. However, these practical significant differences were not reported by Rienzi *et al.* (26) and Fuller *et al.* (10). Regarding somatotype, the forward, backline and all-rounder players were all classified as endomorphic mesomorphs. This is consistent with literature which stated Sevens Rugby forward and backline players to be endomorphic mesomorphs (26). However research (26) in Sevens Rugby further stated forward and backline players to be homogeneous regarding their somatotype, while practical significant differences in the present study regarding all three components (endomorph, mesomorph and ectomorph) between forward and backline players emerged. Despite of all the positions having an endomorphic mesomorph type, the forward players had moderate significant higher

endomorph and mesomorph values compared to the backline players, with lower ectomorph values. According to research, individuals with an endomorph mesomorph somatotype have greater strength and power than either mesomorphs or ectomorphs, which is advantageous when competing for the ball in scrums, rucks and mauls (1). Subsequently, due to the contact orientated nature of Sevens Rugby it seems that an endomorph mesomorph somatotype is advantageous. All-rounder players presented with moderate practical significant higher endomorph values compared to the backline players as well as smaller ectomorph values, which emphasizes that all-rounder players are capable to play either as a forward or a backline player. This study is the first to show and describe the differences that exist between the playing positions of elite u/18 Sevens Rugby players regarding their kinanthropometric characteristics. The results clearly show practical significant differences in kinanthropometric features between forward, backline and all-rounder players.

### **PRACTICAL APPLICATIONS**

The kinanthropometric data reported on in this particular study will serve as a norm scale for players in this particular age group. Average scores reported in this study will assist coaches and selectors as it will serve as a norm scale used for team selection. The latter is especially advantageous since players will start specializing in either Rugby Union or Rugby Sevens as the popularity of the Sevens game keeps on increasing (16). It will also assist coaches in deciding the most suited position for players and may even assist in position specific training programmes.

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# CHAPTER 4

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# 4

# THE COMPARISON BETWEEN SUCCESSFUL AND LESS SUCCESSFUL U/18 SEVENS RUGBY PLAYERS IN TERMS OF KINANTHROPOMETRIC CHARACTERISTICS

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**Title:**

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## **A Comparison between successful and less successful u/18 Sevens Rugby teams in terms of kinanthropometric characteristics.**

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**Objectives.** To compare the kinanthropometrical profiles of successful and less successful u/18 sevens rugby players.

**Methods.** A hundred and sixty four male players between the ages of 16 and 18 years participated in the South African Schools' Rugby Association u/18 Sevens tournament in October 2014. Fifteen provincial teams from South Africa and one international team from Namibia participated in this study and were ranked according to their performance during the tournament. Two of the 16 teams withdrew with the onset of the measurements. The top 7 teams on the log were classified as successful while the bottom 7 teams were classified as less successful.

**Results.** Statistical significant differences regarding arm girth ( $p=0.016$ ), forearm girth ( $p=0.002$ ) and wrist breadth ( $p=0.007$ ) were detected, with successful players having higher values compared to the less successful group. Although not significant, a higher prevalence of body mass (80.7 kg vs. 78.1 kg), body mass index ( $25.6 \text{ kg/m}^2$  vs.  $25.0 \text{ kg/m}^2$ ) and muscle mass in kilograms (48.2 kg vs. 46.4 kg) was found amongst the successful players in comparison to the less successful players. Both the successful players and less successful players were classified as endo-mesomorphs.

**Conclusions.** The statistical significant differences in arm girth, forearm girth and wrist breadth suggests that these mentioned kinanthropometric variables may determine whether a player will be successful or less successful.

Kinanthropometry is very beneficial in Rugby, and numerous research projects have been documented the value it has on both Rugby Union,<sup>[1,2,3,4]</sup> and Rugby league<sup>[5,6,7,8]</sup> especially with regards to team selection and performance. It is, therefore, understandable that coaches and selectors place high priority on size and physique when choosing their Rugby players.<sup>[9]</sup> Existing research on Sevens Rugby regarding kinanthropometry is not as well documented compared to Rugby Union and Rugby League,<sup>[10]</sup> which is strange when the increased popularity of Sevens Rugby in recent years is taken into consideration.<sup>[11]</sup> The launching of the Rugby Sevens World Cup,<sup>[12]</sup> IRB World Sevens Series and Sevens Rugby receiving Olympic status, are a few examples of the increased popularity of Sevens Rugby.<sup>[13]</sup> According to Sedeaud *et al.*<sup>[14]</sup> the selection of rugby players regarding their physiques already occurs during the junior stages, where “super sizes” and “large physiques” ignite much attention.

Previous research on adolescent Rugby Union players revealed significant kinanthropometric differences between successful and less successful players regarding their body mass ( $d=0.62$ ), percentage skeletal mass ( $d=0.77$ ), body mass index (BMI) ( $d=0.89$ ), as well as ectomorphic value ( $d=0.82$ ).<sup>[15]</sup> Significant kinanthropometric differences in junior Rugby League players regarding starters and non-starters (successful and less successful) also emerged and included body mass ( $d=0.99$ ,  $p<0.05$ ), as well as stature ( $d=0.79$ ,  $p<0.05$ ).<sup>[6]</sup> Rienzi *et al.*<sup>[12]</sup> on the other hand found no significant differences in kinanthropometric variables between successful and less successful Sevens Rugby players with regards to kinanthropometric values.

In spite of the latter, Rienzi *et al.*<sup>[12]</sup> suggested that certain shortcomings in kinanthropometric profiles amongst players could uncover flaws regarding the players performance during match play. Deficiencies in kinanthropometric profiles of players, especially when investigating adolescent Rugby players between the ages of 16 and 18, could emerge due to dissimilarities in maturity status. According to the literature,<sup>[16]</sup> boys with early biological maturity (early developers) usually have a tendency to be taller, heavier and stronger than boys later in their biological maturity (late developers). Children who benefit from being early developers, tend to perform better in sport like Rugby,<sup>[15]</sup> which is contact orientated<sup>[17]</sup> suggesting that the more comprehensive the kinanthropometric profile, the better. To the knowledge of the research team no other study has documented the comparison between successful and less successful u/18 Sevens Rugby players with regards to such a comprehensive kinanthropometric profile.

The purpose of this study was to compare the kinanthropometric profiles between successful and less successful elite u/18 Sevens Rugby players.

The results of this study may assist coaches and sport scientists to identify limitations in players' kinanthropometric profiles and further assist them during selection processes. The results this study may also serve as norm scales for future Sevens Rugby players of this particular age group with regards to talent identification.

## **Method**

### **Participants**

A total of 164 elite u/18 Sevens Rugby players participating in the South African Schools' Rugby Association u/18 Sevens tournament in October 2014 were recruited for the study. Players with an average age of 17.4 years represented fifteen provincial teams from South Africa and one international team from Namibia. All of the teams were invited to participate in the study, but 2 teams withdrew with the onset of the measurements. Partaking teams were ranked according to their performance during the tournament. The top 7 teams on the log after the completion of the tournament were classified as successful while the bottom 7 teams on the log were classified as less successful. All the players participated on a voluntary basis with the option to withdraw at any stage. All role players were requested to complete a consent form. Players under 18 years of age, parental/guardian written informed consent was obtained. Ethical permission was granted by the North-West University – NWU-00122-11-A1.

### **Kinanthropometric assessment**

Players were measured a day before the onset as well as on the day of the tournament before any physical activity and were asked to wear minimal clothing during the measurement period with all measurements being explained beforehand. Kinanthropometric measurements included: stature (cm), body mass (kg), skinfolds (mm), girths (cm) and breadths (cm). All the variables were measured twice by trained level II Kinanthropometrists. All measurements were done in accordance with the protocol of the International Society for the Advancement of Kinanthropometry.<sup>[18]</sup> One kinanthropometrist measured a specific kinanthropometric measurement throughout the study for reliability purposes. Body mass was measured with a calibrated electronic scale (Precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg. Stature was measured with a stadiometer to the nearest 0.1 cm. Skinfolds (mm) were measured on six different sites, namely the triceps, subscapular, supraspinal, abdominal, thigh and calf, using a Harpenden skinfold caliper (10.g.mm<sup>2</sup>) according to the procedures as suggested by Stewart *et al.* <sup>[18]</sup> Breadths (cm) were determined at four different sites, namely the femur, humerus, wrist and ankle, using a bone caliper (Cescorf Equipment, Porto Alegre, Brazil), and girths were taken (of the forearm, mid-

thigh and calf) using a flexible steel tape (Cescorf Equipment, Porto Alegre, Brazil) to the nearest 0.1 cm. All the breadths and girths were also taken as stated by Stewart *et al.*<sup>[18]</sup> From the stature and body mass measurements, the body mass index (BMI) was calculated (body mass (kg)/height (m<sup>2</sup>). The sum of the six skinfolds ( $\sum$  6 skinfolds; triceps, subscapular, suprascapular, abdominal, thigh and calf), was calculated and the formula of Withers *et al.*<sup>[19]</sup> was used to calculate body fat percentage. Muscle mass and skeleton mass were calculated by making use of the formulas of Martin *et al.*<sup>[20]</sup> and Martin.<sup>[21]</sup> The formulas in Carter and Heath<sup>[22]</sup> were used to calculate the somatotypes to the nearest 0.1 for every component.

### **Statistical procedures**

The Statistical Data Processing package (SPSS)<sup>[23]</sup> was used to process the data. Differences between successful and less successful players were evaluated using an independent t-test. Cohens's<sup>[24]</sup> effect size (ES) were used to determine practical. Effect sizes of 0.2 were considered small, 0.5 as medium and 0.8 were considered as large<sup>[24]</sup>. Statistical significance was accepted when  $p < 0.05$ .

### **Results**

A comparison of the kinanthropometric characteristics between the successful and less successful players together with the mean, standard deviation, practical significance and statistical significance are presented in Table 1.

**Table 1: Comparison of kinanthropometric measurements in successful and less successful elite u/18 Sevens Rugby players.**

Kinanthropometric variables	Successful players (N=81)		Less successful players (N=83)		d-value	p-value
	Mean	SD	Mean	SD		
Arm girth (cm)	36.4	2.5	35.4	2.7	0.4	0.016†
Calf girth (cm)	38.1	2.4	37.7	2.7	0.1	0.413
Forearm girth (cm)	29.7	1.6	28.8	1.8	0.5*	0.002†
Mid-thigh girth (cm)	57.5	3.7	56.8	4.8	0.1	0.348
Humerus breadth (cm)	7.1	0.5	7.0	0.5	0.2	0.117
Femur breadth (cm)	9.7	0.7	9.7	0.8	0.0	0.768
Wrist breadth (cm)	6.0	0.3	5.8	0.3	0.4	0.007†
Ankle breadth (cm)	7.4	0.5	7.4	0.4	0.1	0.456
Tricep skinfold (mm)	8.9	3.0	9.2	3.5	0.1	0.586
Subscapular skinfold (mm)	9.4	2.1	9.2	2.5	0.1	0.755
Supraspinal skinfold (mm)	7.9	2.7	8.0	3.8	0.0	0.854
Abdominal skinfold (mm)	13.5	6.2	13.2	7.1	0.0	0.768
Front thigh skinfold (mm)	12.3	5.2	12.6	5.6	0.1	0.690
Medial calf skinfold (mm)	8.0	2.6	8.5	3.1	0.2	0.278

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †Statistical significant differences:  $p < 0.05$ .

The kinanthropometric results of the successful and less successful provincial u/18 Sevens Rugby players revealed statistical significant differences in the arm girth ( $p=0.016$ ), forearm girth ( $p=0.002$ ) and wrist breadth ( $p=0.007$ ) with the successful players having higher values in all three measurements compared to the less successful players. In addition to standard kinanthropometric measurements, comparisons between kinanthropometric measurements need to be taken and viewed in accordance to one another in order to provide a more comprehensive view of the player's body composition. For instance, research shows that a strong positive relationship exists between body size (stature and body mass) and success in rugby players.<sup>[2,3]</sup> Thus emphasizing the importance of stature and body mass in accordance to one another. The same is true for indirect measurements like body fat, muscle mass and skeletal mass that depend on other measurements in order to be calculated. Body composition results were, therefore, determined and a comparison of these results between the successful and less successful players are presented in Table 2.

**Table 2: Comparison of the body composition in successful and less successful elite u/18 Sevens Rugby players.**

Body composition	Successful players (N=81)		Less successful players (N=83)		d-value	p-value
	Mean	SD	Mean	SD		
Stature (cm)	177.2	6.5	176.5	7.2	0.1	0.552
Body mass (kg)	80.7	9.7	78.1	11.1	0.2	0.113
BMI (kg/m <sup>2</sup> )	25.6	2.2	25.0	2.6	0.3	0.071
Body fat (%)	9.9	2.9	10	3.5	0.0	0.955
∑6 skinfolds (mm)	59.9	19	60.7	22.7	0.0	0.814
Muscle mass (%)	59.9	4.0	59.6	5.5	0.1	0.659
Muscle mass (kg)	48.2	6.2	46.4	7.2	0.3	0.076
Skeletal mass (%)	12.1	0.8	12.3	1.0	0.1	0.411
Skeletal mass (kg)	9.8	1.3	9.5	1.4	0.2	0.234

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †Statistical significant differences:  $p < 0.05$ .

The average means for body composition measurements of the successful and less successful Sevens Rugby players yielded no statistical significant differences for any of the variables, however, successful players had greater body mass (80.7 kg vs. 78.1 kg), BMI (25.6 kg/m<sup>2</sup> vs 25.0 kg/m<sup>2</sup>) and muscle mass (48.2 kg vs. 46.4 kg) values.

The somatotype classification of successful and less successful elite u/18 Sevens Rugby players is presented in Table 3, and a somatochart plotting the somatotypes of the successful and less successful is presented in Figure 1.

**Table 3: Somatotype classification of successful and less successful elite u/18 Sevens Rugby players.**

Components	Successful players (N=81)		Less successful players (N=83)		d-value	p-value
	Mean	SD	Mean	SD		
Endomorphy	2.9	0.9	2.9	1.2	0.0	0.814
Mesomorphy	5.9	1.1	5.7	1.2	0.3	0.107
Ectomorphy	1.6	0.8	1.8	0.9	0.3	0.059

Note:  $\bar{X}$ , mean; SD, standard deviation; large practical significance,  $d \geq 0.8^{**}$ ; medium practical significance,  $d \geq 0.5^*$ ; small practical significance,  $d \geq 0.2$ ; †Statistical significant differences:  $p < 0.05$ .

The somatotype profile of both the successful and less successful players was primarily homogeneous of nature (endomorph mesomorphs), with no statistical significant

differences occurring between the 2 groups. The similarity of the grouping of the somatotypes can be clearly seen for both the successful and less successful players. A definite migration towards the endo-mesomorphic side on the somatochart is also visible.

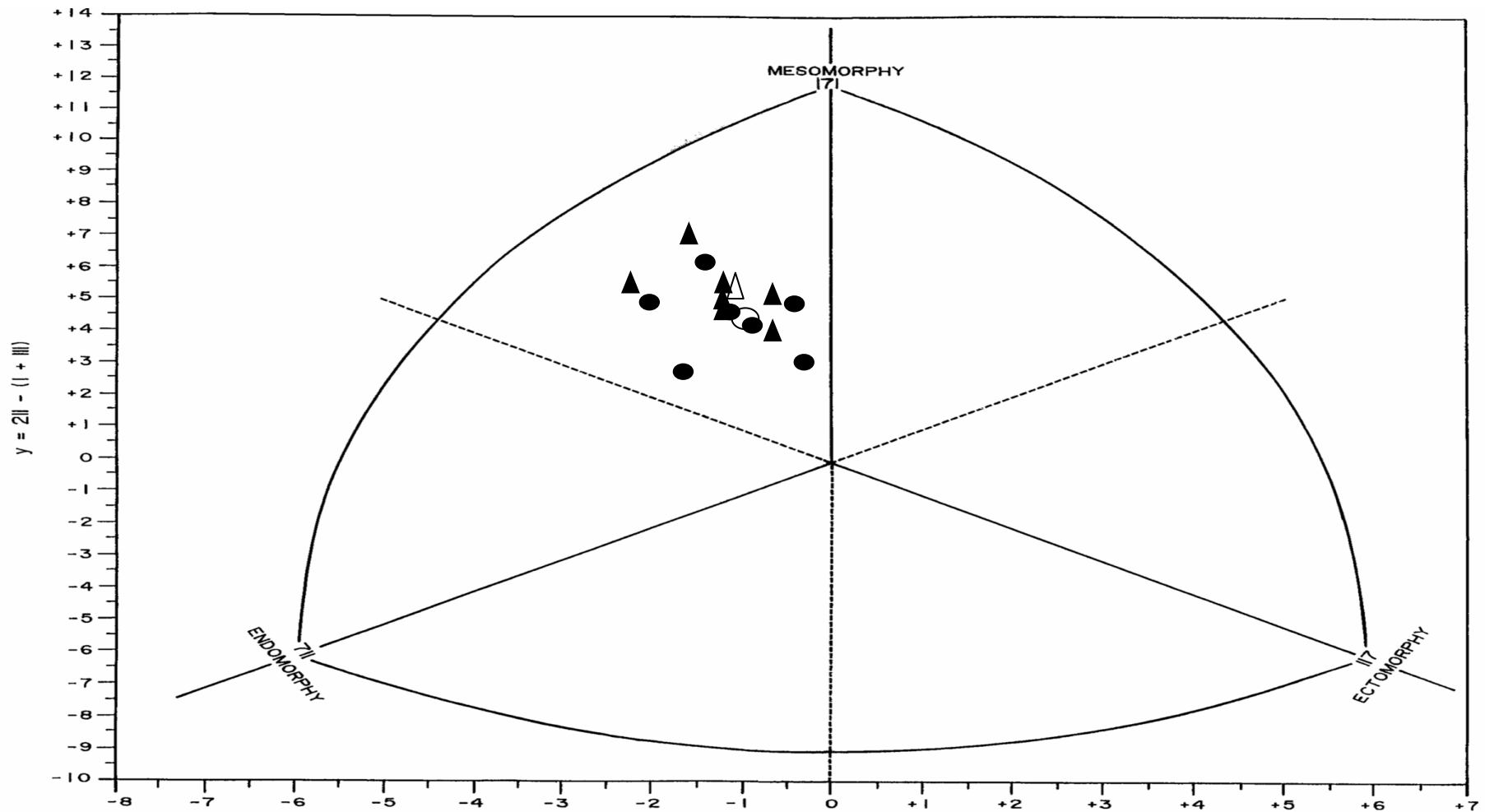


Figure 1: Somatochart: somatotypes of all the successful and less successful players. ▲ = successful players, △ = average of the successful players, ● = less successful players, ○ = average of the less successful players.

## **Discussion**

This is the first study of its kind and to the research teams' knowledge no study exists where the kinanthropometrical profiles of successful and less successful u/18 Sevens Rugby players have been compared.

The successful players had statistical significant higher arm and forearm girth values as well as a higher wrist breadth value suggesting a larger bone and muscle structure which can be favourable with regards to scrumming, tackling and to power through the opposition.<sup>[25]</sup> The superior values regarding the arm and forearm girth might also be an indication of greater muscle size in the arms of the successful players, which might be beneficial when handing of opponents with the one arm while in possession of the ball with the other arm. Contesting of balls during mauls may be another reason why successful players presented higher arm and forearm girth values.

Regarding somatotype, both the successful group and less successful group were predominantly mesomorphic, this is consistent with the study of Rienzi *et al.*<sup>[12]</sup> who also discovered a majority of mesomorphy among Sevens Rugby players. None of the somatotype components showed of statistical significant difference and both the successful players and less successful players were classified as endomorphic mesomorphs. The latter is beneficial as previous research has documented that individuals with endomorphic mesomorph somatotypes have greater strength and power than either mesomorphs or ectomorphic mesomorphs, which is valuable when competing for the ball in scrums, rucks and mauls.<sup>[26]</sup> The contact orientation of Sevens Rugby emphasizes the nature of an endo-mesomorph somatotype.<sup>[13]</sup>

Although no statistical significant differences were observed regarding the body composition variables, the successful players in this study were on average heavier and had greater BMI as well as muscle mass (kg) values compared to the less successful players. Research in Rugby Union<sup>[2,3,14]</sup> and Rugby League<sup>[6]</sup> have discovered a large body size (indicated by height and weight)<sup>[27]</sup> to be a substantial forecaster of success. In a study on adolescent Rugby Union players it was discovered that successful players had greater body mass and BMI values,<sup>[15]</sup> nonetheless controversial to the findings of the present study, the results were of medium and large practical significance. Adendorff *et al.*<sup>[15]</sup> revealed that early developers were more prone to be found in the successful group whereas late developers were more likely to be found in the less successful group. According to Malina,<sup>[28]</sup> maturity status and body size are strong predictors of success and although this particular study did not focus on determining the players' maturity status it most certainly is a factor that might have played a

role. In another study on senior Rugby League players it was found that selected players (successful) had a statistically significantly smaller sum of skinfolds compared to the non-selected (unsuccessful) players, which is also controversial to the present study's findings.<sup>[7]</sup> The difference in findings might be due to the small differences that exist between the characteristics of Rugby League, Rugby Union and Sevens Rugby.

### **Conclusion**

The aim of this study was to investigate the kinanthropometrical characteristics of elite u/18 Sevens Rugby players and to compare the successful players with the less successful players regarding their kinanthropometrical variables. The statistically significant differences in arm girth, forearm girth and wrist breadth suggest that the mentioned kinanthropometric variables may determine whether a player will be successful or less successful. No significant differences regarding body composition were found between the successful and less successful players. Both groups of players revealed a homogenous somatotype, namely an endomorphic mesomorph somatotype. The results of this study will help to identify limitations in players kinanthropometric profiles and assist coaches and sport scientists during selection processes. The results from the current study may further serve as norm scales for Sevens Rugby players of this particular age group for future talent identification. However, it is not evident if kinanthropometric characteristics can determine whether a Sevens Rugby player is going to be successful or less successful. Future research on this particular subject is necessary to determine if differences will someday exist.

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# CHAPTER 5

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# **5 SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS**

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**5.1. SUMMARY**

**5.2. CONCLUSION**

**5.3. LIMITATIONS**

**5.4. RECOMMENDATIONS**

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## 5.1 SUMMARY

The aims of this study were firstly to investigate the differences that exist between playing positions among elite adolescent Sevens Rugby players regarding their kinanthropometric characteristics and secondly to determine if kinanthropometrical variables distinguish successful players from less successful players. The problem statement in Chapter 1 outlines the inconsistency of research findings with regards to kinanthropometric features not only in adolescent Sevens Rugby players, but also adult Sevens Rugby players, with emphasis on the limited data available. To date no study containing information on adolescent Sevens Rugby players could be found. When taken into account that Sevens Rugby has grown in popularity over the last few years (Higham *et al.*, 2012:277) and since the announcement that it will be part of the Olympic Games in 2016, it is certainly a sport that should not be disregarded. The lack of information resulted in the formulation of the research questions for this study. How do the kinanthropometrical players positional profiles of elite u/18 Sevens Rugby players compare? How do the kinanthropometric profiles between successful and less successful elite u/18 Sevens Rugby players compare?

Therefore, the objectives of the investigation were the following:

- To compare the kinanthropometrical players positional profiles of elite u/18 Sevens Rugby players.
- To compare the kinanthropometric profiles between successful and less successful elite u/18 Sevens Rugby players.

In order to achieve the objectives of this particular investigation, firstly a literature overview in Chapter 2 regarding the kinanthropometrical characteristics of adolescent Rugby Union and Rugby league players was provided, since no research to the knowledge of the research team exists pertaining to adolescent Sevens Rugby players. As adolescence is a sensitive time in a boy's life (Malina, 2014:160), and elite athletes pass through a vulnerable stage of development (Schubring & Thiel, 2014:78), it was important to evaluate the changes adolescents encounter regarding their growth and maturation.

In Chapters 3 a kinanthropometric profile of the different playing positions in u/18 Sevens Rugby was compiled. Chapter 4 shows the difference between successful and less successful players regarding their kinanthropometrical features.

## **5.2 CONCLUSION**

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

***Hypothesis 1: Significant kinanthropometric differences will be found between playing positional profiles of elite u/18 Sevens Rugby players.***

The fact that differences between playing positions did emerge indicates that hypothesis 1 can be accepted. Forward players had greater values in almost all the kinanthropometric measurements when compared to the backline players with various practical significant differences occurring. When the forward players were compared to the all-rounder players only moderate practical significant differences were discovered. All-rounder players compared to the backline players also discovered practical significant differences with regards to some of the kinanthropometric measurements, however these differences were not as considerable as when the forward players were compared to the backline players. These differences between playing positions were also found in adolescent Rugby Union and Rugby League players but to a lesser extent which is consistent with literature (Rienzi, 1999:163).

***Hypothesis 2: Significant kinanthropometric profile differences will occur between the successful and less successful u/18 Sevens Rugby players.***

Hypothesis 2 are rejected based on the results that limited statistical significant differences between the successful and less successful players were detected. Although the successful players were taller and heavier than the less successful players the results were not significant. These findings are controversial to that discovered in Rugby Union and Rugby League that found significant differences occurring between different playing levels (successful vs. less successful).

This study is the first to conduct such a comprehensive kinanthropometric profile of elite u/18 Sevens Rugby players. While observing the adolescent Sevens Rugby players of this particular study it was obvious that the players differ in terms of their kinanthropometric characteristics. Differences especially regarding playing positions were noticeable. However despite these differences occurring amongst the adolescent Sevens Rugby players the possibility for these kinanthropometric measurements to determine whether an adolescent Sevens Rugby player will be successful or less successful did not feature prominently. Nonetheless the discoveries made will be beneficial regarding team selection and position selection.

### **5.3 LIMITATIONS**

The limitations of this study which could be surmounted in future research are:

- The sample size of the present studies' playing positions varied greatly with the backline players containing more players than the forward and all-rounder players.
- Participants were not asked to mention which position they played in Rugby Union which would have given an indication of what Rugby Union player position is mainly selected (i.e. locks, loose forwards) to compile a Sevens Rugby team as the literature states that it consists mainly of loose forwards and back-line players (Dziedzic & Higham, 2014:305).
- Two of the teams withdrew from the study with one of the teams being the tournament winners leading to a possible weakening of the successful group.
- No opportunity arose to collect performance specific measurements such as speed and agility besides kinanthropometry which is also an important requisite of Sevens Rugby players.
- The age group worked with could also have been a limitation as the players still underwent growth and maturational changes, which could have had an influence on their kinanthropometrical due to the fact that they are still developing.

### **5.4 RECOMMENDATIONS**

Regarding the knowledge gained from this investigation, it is recommended that further research of this nature is done while keeping the following aspects in mind:

- The sample size of the study could be better distributed so that all the positional groups contain more or less the same number of participants.
- By knowing which position the participants played in Rugby Union one can make a more detailed conclusion on why Sevens Rugby players differ to such an extent according to positional classification.

- Coaches must take kinanthropometrical variables into consideration before players are referred to a specific position as each position is subjected to a different role and characteristics.
  
- It is strongly recommended to include the maximum sample size of players to ensure a accurate reflection of the data and the results.

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# APPENDICES

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# APPENDICES

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<b>APPENDIX A</b>	<b>Letter of ethical approval</b>
<b>APPENDIX B</b>	<b>Language editing certificate</b>
<b>APPENDIX C</b>	<b>Informed consent forms</b>
<b>APPENDIX D</b>	<b>Kinanthropometric performance data collection form</b>
<b>APPENDIX E</b>	<b>Formulas</b>
<b>APPENDIX F</b>	<b>Instructions for authors from the Journal of Strength and Conditioning Research and the South African Journal of Sports Medicine</b>

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# APPENDIX A LETTER OF ETHICAL APPROVAL

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NORTH-WEST UNIVERSITY  
YUNIBESITHI 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>

**Ethics Committee**  
Tel +27 18 299 4849  
Email [Ethics@nwu.ac.za](mailto:Ethics@nwu.ac.za)

**ETHICS APPROVAL OF PROJECT**

The North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby approves your project 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 project may be initiated, using the ethics number below.

<b>Project title:</b> Physical and Psychological demands placed on elite South African junior sevens Rugby players.																															
<b>Project Leader:</b> P.H. van den Berg																															
<b>Ethics number:</b>	<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="padding: 2px;">N</td> <td style="padding: 2px;">W</td> <td style="padding: 2px;">U</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">2</td> <td style="padding: 2px;">2</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">A</td> <td style="padding: 2px;">1</td> </tr> <tr> <td colspan="3" style="font-size: 8px;">Institution</td> <td></td> <td colspan="4" style="font-size: 8px;">Project Number</td> <td></td> <td colspan="2" style="font-size: 8px;">Year</td> <td colspan="4" style="font-size: 8px;">Status</td> </tr> </table> <p style="font-size: 8px; margin-top: 2px;">STATUS: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation</p>	N	W	U	-	0	0	1	2	2	-	1	1	-	A	1	Institution				Project Number					Year		Status			
N	W	U	-	0	0	1	2	2	-	1	1	-	A	1																	
Institution				Project Number					Year		Status																				
<b>Approval date:</b> 2011-11-21	<b>Expiry date:</b> 2016-11-20																														

Special conditions of the approval (if any): None

**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 project leader (principle investigator) must report in the prescribed format to the NWU-RERC:
  - annually (or as otherwise requested) on the progress of the project,
  - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-RERC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-RERC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-RERC retains the right to:
  - request access to any information or data at any time during the course or after completion of the project;
  - withdraw or postpone approval if:
    - any unethical principles or practices of the project are revealed or suspected,
    - it becomes apparent that any relevant information was withheld from the NWU-RERC or that information has been false or misrepresented,
    - the required annual report and reporting of adverse events was not done timely and accurately,
    - new institutional rules, national legislation or international conventions deem it necessary.

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

Yours sincerely

**Linda du Plessis**

Digitally signed by Linda du Plessis  
DN: cn=Linda du Plessis, o=North-West University, ou=Vice-Rector,  
c=ZA  
email=Linda.duPlessis@nwu.ac.za  
Date: 2015.05.13 13:56:35 +0200

**Prof Linda du Plessis**  
Chair NWU Research Ethics Regulatory Committee (RERC)

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# APPENDIX B LANGUAGE EDITING CERTIFICATE

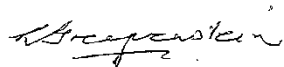
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ENGLISH LANGUAGE EDITING CERTIFICATION

This is to certify that the English language editing of this Dissertation by Mr A. Zandberg was done by Prof L. A. Greyvenstein.



Lesley Ann Greyvenstein (Prof)  
P O Box 6601  
Flamwood  
Klerksaorp  
2572  
Tel: 018 468 7335 / 082 9744 505

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# APPENDIX C

# GENERAL INFORMATION

# QUESTIONNAIRE AND

# INFORMED CONSENT

# FORM

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CONFIDENTIAL

**Informed consent form**

**PART 1**

**1. School/Institute:**

School for Biokinetics, Recreation and Sport Science

**2. Title of the project/trial:**

PHYSIOLOGICAL DEMANDS PLACED ON ELITE, SOUTH AFRICA JUNIOR SEVENS RUGBY PLAYERS.

**3. Full names, surname and qualifications of project leader:**

Pieter van den Berg, B.A., B.A. (Hons) and M.A.

**4. Rank/position of supervisor:**

Lecturer and program leader

**5. Full names, surname and qualifications of supervisor of the project:**

Andries Zandberg, B.Sc (Hons)

**6. Name and address of supervising medical officer (if applicable):**

Not applicable

**7. Aims of this project**

The aims of this project are to determine:

- The kinanthropometrical and physiological profile of elite junior Sevens Rugby players.
- The work:rest ratio of elite junior Sevens Rugby players.

**8. Explanation of the nature of all procedures, including identification of new procedures:**

a) *Collection procedures and selection of rugby players.*

9. All the elite junior male Sevens Rugby players who were selected to represent their respective provinces at the national junior Sevens Rugby week in 2014 will take part in the project.

**a) Procedures**

i. Anthropometric measurements and components:

The following anthropometric components will be determined in accordance with the methods of Marfell-Jones *et al.* (2006). Body composition, fat mass and skeletal mass will be analysed in this section. Body fatness will be determined through the sum of the following skinfolds (SUM 6SF): triceps, subscapular, abdominal, supraspinal; front thigh and calf skinfolds and according to the formulas of Whitters *et al.* (1987:198). Muscle and skeletal mass will be calculated using the formulas of Lee *et al.* (2000:796) and Martin *et al.* (as quoted by Drinkwater & Mazza, 1994:103). The following anthropometric variables will be measured under the section of muscle and skeletal mass: body stature and body mass; flexed arm, thigh and calf girth; triceps, thigh and calf skinfolds as well as ankle, femur, humerus and wrist breadths.

ii Time-motion analysis:

The players will be subjected to play with a GPS unit connected to vest that will be provided.

**10. Description of the benefits which may be expected from this project:**

The results of this study could enable coaches, trainers, officials and players to understand Sevens Rugby better with regards to the physiological demands that the sport code place on the different role players at elite level as well as to enable them to develop match specific training programs. This ought, therefore, to enhance the role players' overall performance and development.

**Signature:**.....

**Date:**.....

**Project leader**

**Contact detail for any questions directed to the Project Leader:** [pieter.vandenberg@nwu.ac.za](mailto:pieter.vandenberg@nwu.ac.za)

**Tel:** +2718 299 1802

**Fax:** +2718 299 2022

**PART 2**

**To the subject signing the consent as part 3 of this document:**

You are invited to participate in a research project as described in paragraph 2 of Part 1 of this document. It is important that you read/listen to and understand the following general principles, which apply to all participants in this research project:

1. Participants in this project is voluntary.
2. You will be free to withdraw from the project at any stage without having to explain the reasons for your withdrawal. However, we would like to request that you would rather not withdraw without a thorough consideration of your decision, since it may have an effect on the statistical reliability of the results of this project.
3. We encourage you to ask questions at any stage about the project and procedures to the project leader or the personnel, who will readily give more information. They will discuss all procedures with you.
4. If you are a minor, we need the written approval of your parent or guardian before you may participate.
5. We require that you indemnify the University from any liability due to detrimental effects of treatment by University staff or students or other subjects to yourself or anybody else. We also require indemnity from liability of the University regarding any treatment to yourself or another person due to participation in this project, as explained in Part 1. Lastly it is required to abandon any claim against the University regarding treatment of yourself or another person due to participation in this project as described in Part 1.

**PART 3**

**Consent**

**Title of the project:** PHYSIOLOGICAL DEMANDS PLACED ON ELITE, SOUTH AFRICA JUNIOR SEVENS RUGBY PLAYERS.

I, the undersigned..... (Full names)  
read/listened to the information on the project in PART 1 and PART 2 of this document and I declare that I understand the information. I had the opportunity to discuss aspects of the project with the project leader and I declare that I participate in the project as a volunteer. I hereby give my consent to be a subject in this project.



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# APPENDIX D

# KINANTHROPOMETRIC

# PERFORMANCE DATA

# COLLECTION FORM

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**Kinanthropometrical measurements of u/18 R players:**

Name and Surname \_\_\_\_\_ Birth Date \_\_\_\_\_

High School \_\_\_\_\_ Province \_\_\_\_\_

Language \_\_\_\_\_ Race \_\_\_\_\_

Position in Sevens (ex. forward, back, or all-rounder)

\_\_\_\_\_

Station 1			
	Measure 1	Measure 2	Measure 3
Body length			
Body mass			
Station 2			
Girth measurements	Measure 1	Measure 2	Measure 3
Arm (flexed and tensed)			
Calf			
Forearm			
Mid-thigh			
Station 3			
Breadth measurements	Measure 1	Measure 2	Measure 3
Humerus			
Femur			
Wrist			
Ankle			
Station 4			
Landmarks			
Station 5			
Skinfolds 1	Measure 1	Measure 2	Measure 3
Triceps			
Subscapular			
Supraspinal			
Station 6			
Skinfolds 2	Measure 1	Measure 2	Measure 3
Abdominal			
Front thigh			
Medial calf			

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# APPENDIX E KINANTHROPOMETRIC FORMULAS

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## **Kinanthropometric Formulas:**

### **BMI Formula:**

Stature and body mass were used to calculate the Body Mass Index (BMI), by dividing the weight in kilograms via the square of height in meters (Eston *et al.*, 2009:35).

### **Body fat percentage:**

The sum of the six skinfolds ( $\sum$  6 skinfolds), was calculated and the formula of Withers *et al.* (1987:197) was used to calculate body fat percentage:

$$\text{Body density} = 1.10326 - 0.00031 (\text{Age}) - 0.0036 (\sum 6 \text{ skinfolds})$$

Where: ( $\sum$  6 skinfolds) = sum of triceps, subscapular, supraspinal, abdominal, front thigh & medial calf skinfold measures.

$$\text{Estimated fat percentage} = (495/\text{Body Density}) - 450$$

### **Muscle mass and Skeletal mass:**

Muscle mass and skeleton mass were calculated by making use of the formulas of Martin *et al.* (1990:731) and Martin (1991:194)

$$\text{Estimated muscle mass (kg)} = (\text{STAT} \times (0.0553 \times \text{CMTG}^2 + 0.0987 \times \text{FG}^2 + 0.0331 \times \text{CCG}^2) - 2445)/1000$$

Where: STAT = stature (cm);

CMTG = corrected mid-thigh girth (cm)

$$\text{CMTG} = \text{MTG} - \text{Pi} \times \text{FTSF} (\text{mm})/10; \text{Pi} = 3.1416$$

FG = uncorrected forearm girth

CCG = corrected calf girth (cm)

$$CCG = CG - \pi \times MCSF \text{ (mm)}/10$$

$$\text{Estimated skeletal mass (kg)} = 0.00006 \times \text{STAT} \times (\text{FEMRB} + \text{HUMRB} + \\ \text{WRSTB} + \text{ANKLB})^2$$

Where: STAT = stature (cm)

FEMRB = femur breadth (cm)

HUMRB = humerus breadth (cm)

WRSTB = wrist breadth (cm)

ANKLB = ankle breadth (cm)

### **Somatotyping:**

The formulas in Carter and Heath (1990:374) were used to calculate the somatotypes to the nearest 0.1 for every component. The somatotypes of the Sevens Rugby players were calculated as follows:

$$\text{Endomorphy} = -0.7182 + 0.1451 (\sum \text{ of skinfolds} \times 170.18/\text{STAT}) - \\ 0.00068 (\sum \text{ of skinfolds} \times 170.18/\text{STAT})^2 \\ 0.0000014 (\sum \text{ of skinfolds} \times 170.18/\text{STAT})^3$$

Where:  $\sum$  of skinfolds = sum of triceps, subscapular, supraspinal skinfolds

STAT = stature (cm)

$$\text{Mesomorphy} = 0.858 (\text{HUMB}) + 0.601 (\text{FEMB}) + 0.188 (\text{CAG}) + \\ 0.161 (\text{CCG}) - 0.131 (\text{STAT}) + 4.5$$

Where: HUMB = humerus breadth (cm)

FEMRB = femur breadth (cm)

CAG = corrected arm girth; (flexed arm girth (cm) –

triceps skinfold (mm)/10)

CCG = corrected calf girth; (calf girth (cm) –

calf skinfold (mm)/10)

STAT = stature (cm)

Ectomorphy =  $(\text{HWR} < 0.732) - 28.58$

Where:  $\text{HWR} = \text{STAT}^3 / \text{MASS}$

STAT = Stature (cm)

MASS = mass (kg)

Note: If:  $\text{HWR} < 40.75$ , but  $> 38.25$ , then

Ectomorphy =  $\text{HWR} \times 0.463 - 17.63$

Note: If:  $\text{HWR} \leq 38.25$ , then

Ectomorphy = 0.1

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# APPENDIX F INSTRUCTIONS FOR AUTHORS

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### **MANUSCRIPT SUBMISSION GUIDELINES**

Manuscripts should be submitted online at <http://www.editorialmanager.com/JSCR> or by email following the instructions below. If email is used to submit the paper (we encourage on-line submission), only one copy is required of each document including a copyright form.

1. If by email, authors should submit a MicrosoftWord (.doc) file.
2. A cover letter must accompany the manuscript and state the following: "This manuscript is original and not previously published, nor is it being considered elsewhere until a decision is made as to its acceptability by the JSCR Editorial Review Board." Please include the corresponding author's full contact information, including address, email, and phone number.
3. All authors should be aware of the publication and be able to defend the paper and its findings and should have signed off on the final version that is submitted. For additional details related to authorship, see "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" at <http://www.icmje.org/>.
4. The NSCA and the Editorial Board of the JSCR have endorsed the American College of Sports Medicine's policies with regards to animal and human experimentation. Their guidelines can be found online at <http://www.editorialmanager.com/msse/>. Please read these policies carefully. Each manuscript must show that they have had Institutional Board approval for their research and appropriate consent has been obtained pursuant to law. All manuscripts must have this clearly stated in the methods section of the paper or the manuscript will not be considered for publication.
5. All manuscripts must be double-spaced with an additional space between paragraphs. The paper should include a minimum of 1-inch margins and page numbers in the upper right corner next to the running head. Authors must use terminology based upon the International System of Units (SI). A full list of SI units can be accessed online at <http://physics.nist.gov/>.
6. The JSCR endorses the same policies as the American College of Sports Medicine in that the language is English for the publication. "Authors who speak English as a second language are encouraged to seek the assistance of a colleague experienced in writing for English language journals. Authors are encouraged to use nonsexist language as defined in the American Psychologist 30:682- 684, 1975, and to be sensitive to the semantic description of persons with

chronic diseases and disabilities, as outlined in an editorial in *Medicine & Science in Sports & Exercise*, 23(11), 1991. As a general rule, only standardized abbreviations and symbols should be used. If unfamiliar abbreviations are employed, they should be defined when they first appear in the text. Authors should follow Webster's Tenth Collegiate Dictionary for spelling, compounding, and division of words. Trademark names should be capitalized and the spelling verified. Chemical or generic names should precede the trade name or abbreviation of a drug the first time it is used in the text."

7. There is no word limitation but authors are instructed to be concise and accurate in their presentation and length will be evaluated by the Editor and reviewers for appropriateness.

## **MANUSCRIPT PREPARATION**

### **1. Title Page**

The title page should include the manuscript title, brief running head, laboratory(s) where the research was conducted, authors' full name(s) spelled out with middle initials, department(s), institution(s), full mailing address of corresponding author including telephone and fax numbers, and email address, and disclosure of funding received for this work from any of the following organizations: National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI); and other(s).

### **2. Blind Title Page**

A second title page should be included that contains only the manuscript title. This will be used to send to the reviewers in our double blind process of review. Do not place identifying information in the Acknowledgement portion of the paper or anywhere else in the manuscript.

### **3. Abstract and Key Words**

On a separate sheet of paper, the manuscript must have an abstract with a limit of 250 words followed by 3 – 6 key words not used in the title. The abstract should have sentences (no headings) related to the purpose of the study, brief methods, results, conclusions and practical applications.

### **4. Text**

The text must contain the following sections with titles in ALL CAPS in this exact order:

A. Introduction. This section is a careful development of the hypotheses of the study leading to the purpose of the investigation. In most cases use no subheadings in this section and try to limit it to 4 – 6 concisely written paragraphs.

B. Methods. Within the METHODS section, the following subheadings are required in the following order: "Experimental Approach to the Problem," where the author(s) show how their study design will be able to test the hypotheses developed in the introduction and give some basic rationales for the choices made for the independent and dependent variables used in the study; "Subjects," where the authors include the Institutional Review Board or Ethics Committee approval of their project and appropriate informed consent has been gained. All subject characteristics that are not dependent variables of the study should be included in this section and not in the RESULTS; "Procedures," in this section the methods used are presented with

the concept of “replication of the study” kept in mind. “Statistical Analyses,” here is where you clearly state your statistical approach to the analysis of the data set(s). It is important that you include your alpha level for significance (e.g.,  $P \# 0.05$ ). Please place your statistical power in the manuscript for the  $n$  size used and reliability of the dependent measures with intra-class correlations (ICC Rs). Additional subheadings can be used but should be limited.

C. Results. Present the results of your study in this section. Put the most important findings in Figure or Table format and less important findings in the text. Do not include data that is not part of the experimental design or that has been published before.

D. Discussion. Discuss the meaning of the results of your study in this section. Relate them to the literature that currently exists and make sure you bring the paper to completion with each of your hypotheses. Limit obvious statements like, “more research is needed.”

E. Practical Applications. In this section, tell the “coach” or practitioner how your data can be applied and used. It is the distinctive characteristic of the JSCR and supports the mission of “Bridging the Gap” for the NSCA between the laboratory and the field practitioner.

## 5. References

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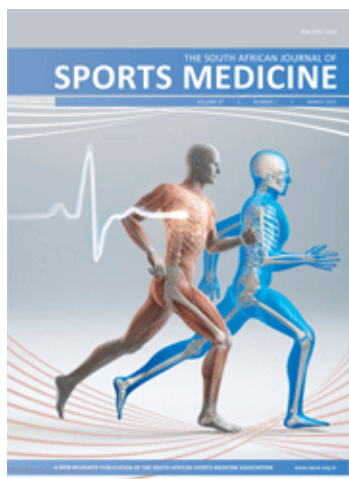
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