A description of the profiles of U18 rugby players who attended the Craven Week tournament between 2002-2012.

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Candidate declaration

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Abstract

Rugby union has rich tradition in South Africa with the national team having won the Rugby World Cup in 1995 and 2007. The major rugby nations South Africa competes against have clearly defined rugby talent identification (TID) and development (TDE) pathways. These pathways are not as well described in South Africa where the South African Rugby Union (SARU) has adopted a model of identifying talent at an early age through competition. For example, national competitions occur at U13 (Craven Week), U16 (Grant Khomo Week) and U18 (Craven Week and Academy Week) levels. Previous research on talent identification has highlighted the pitfalls of early talent identification. In particular different rates of maturation can influence the manifestation of talent. In a collision sport such as rugby the early maturers have a distinct advantage. An added complexity in the South African context is the need to provide an appropriate development environment within which transformation can take place. At all levels in South African professional rugby, white players dominate team selection. One of the reasons suggested for this dominance is the physical size of white players compared to their black and mixed race (coloured) counterparts. Rugby is a contact sport and physical size is associated with success, so the need to quantify physical difference between racial groups at a junior level over time is important.

The first objective of the thesis was to examine the profiles of U18 Craven Week rugby players to gain insight into the development pathway from U13 to U18. A second aim was to understand factors influencing transformation by measuring the physical profiles of the various racial groups over time. The thesis consists of two studies. The specific objective of the first study was quantify how many players in the 2005 U13 Craven Week (n=349) participated in the subsequent U16 Grant Khomo and U18 Craven Week. The study showed that 31.5% of the players who played in the U13 Craven Week, were selected to play at U16 Grant Khomo Week and 24.1% were selected for the U18 Craven Week tournaments. Another interpretation is that 76% of the players selected for the U13 tournament did not play at the U18 Craven Week tournament.

The objective of the second study was to determine whether there are differences in body mass, stature and body mass index (BMI) between racial groups in U18 Craven Week players. Another objective was to determine whether these measurements changed between 2002-2012. Self-reported body mass and stature were obtained from U18 players (n=4007) who attended the national tournament during this period. BMI was calculated for each player. The body mass, stature and BMI of these players in South Africa were significantly different between racial groups. For example, white players were 9.8 kg heavier than black players, who were 2.3 kg heavier than coloured players ($p<0.0001$). The body mass of all groups increased from 2002-2012 ($p < 0.0001$). White players were 7.0 cm taller than black players, who were 0.5 cm taller than coloured players ($p < 0.0001$). The stature of players did not change significantly during the study period. The average BMI of white players was 0.9 kg.m^{-2} greater than black players who were on average 0.7 kg.m^{-2} greater than coloured players ($p<0.0001$). The BMI of all groups changed similarly over the study period.

To conclude, these results question the effectiveness of the u13 tournament in identifying talent and providing an effective development pathway to U18 Craven Week. The SARU also needs to be aware of the ongoing disparities in size between the racial groups playing rugby at an U18 level in South Africa. These size differences may have implications for transforming the game and making it representative of the South African population.

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CHAPTER ONE

Introduction

Background and research problem

Since the start of the professional era in rugby union in 1995 there has been phenomenal growth in the game. World rugby now has 105 full member unions and 3.2 million registered players (Howell, 2017; World Rugby, 2016). The onset of professionalism and the increase in popularity of the game has resulted in increasing demands on players at younger ages (Durandt, Hendricks, Marshall, Roux, & Hare, 2015).

These increasing demands in junior sport are not unique to rugby. There is a growing trend of early specialisation in junior competitive sports. Many coaches believe they can identify talent in primary school (before the age of 12) and then convince parents that their child should specialise in one sport at an early age to ensure the best chance of success (Jayanthi, LaBella, Fischer, Pasulka, & Dugas, 2015). These coaches believe that intense practice and a high level of competition before the age of 12 is required for players to succeed. This trend of intense competition can be seen in South African junior rugby where U13 primary school players can play more that 24 games in a 3 month season (average of two per week) (Durandt et al., 2015). One of the reasons for this intense level of competition in junior rugby is that players are trying to qualify for the national U13 Craven Week Tournament. The South African Rugby Union (SARU) has a pyramid model of sports participation and talent identification where the best players have to qualify for U13 (Craven Week), U16 (Grant Khomo Week) and U18 (Craven Week) National tournaments to enter the player pathway. Most experts agree that promoting participation should take precedence over competition at U13 level as a result of the vastly different maturation ages within the same chronological age group (Balyi, 2012; Jayanthi, Pinkham, Dugas, Patrick, & LaBella, 2013). The problems due to maturational variation are exacerbated in rugby because of the importance of size. This results in youth coaches choosing the biggest players and not necessarily those with the most talent. The pyramid model of sport participation has been criticised for forcing young players to move up in the sport (through competition) or move out of the sport. This current SARU method of talent identification (TID) and talent development (TDE) has been criticised as a contribution factor for the high levels of player drop out at pre-teen and teen levels (Lambert & Durandt, 2010). This emphasis on performance at a young age provides the background to the first objective of this thesis which is to examine the physical profiles of U18 Craven Week players to gain insight into the development pathway from U13 to U18.

The development of rugby in South Africa faces some unique political and socioeconomic challenges. From the early 1950's the National party started to introduce legislation which formed the backbone of apartheid (separate development for South African racial groups). The legislation segregated public areas in South Africa effectively denying access of black and coloured South Africans to top level sports coaching and training facilities (Pinsky, 2014). The apartheid era laws not only affected sport but also resulted in the general economic strata following racial lines with black and coloured racial groups generally being positioned in the lower socioeconomic categories and whites in the highest or most affluent category (Armstrong, Lambert, & Lambert, 2011). South Africa was banned by the International Rugby Board (IRB) from playing international rugby from 1984-1992 as a result of its apartheid policies. It is for this reason that transformation in sport is seen as a national priority (SRSA, 2012). Rugby at all senior professional levels in South Africa is still dominated by white players despite the vast investments SARU has made into development programmes to expedite transformation (DuToit, Durandt, Joshua, & Masimla, 2012). SARU hosts a national competition tournament for U18 players each year. This tournament is meant to be the pinnacle of SARU's youth talent identification and development programme. Trends in player demographics at this tournament will arguably be reflected at the adult level, a few years later and provide information about the extent of transformation in rugby.

Several studies have investigated how players from different ethnic groups in specific countries may have morphologies that could enhance their overall performance in rugby union (Cheng et al., 2014; Krause et al., 2015; Zemski, Slater, & Broad, 2015). It is not known whether these findings have relevance to youth rugby in South Africa. Therefore the second objective of this thesis was to determine whether body mass, stature and body mass index (BMI) differs between racial groups in South African U18 rugby players chosen to represent their provinces at the national tournament. Another question was to determine whether these measurements changed significantly between 2002-2012.

Thesis aim and objectives

Two studies were formulated to answer specific questions. The objectives of each chapter are presented below:

Study 1 (Chapter 3)

To gain insight into the development pathway of rugby in South Africa by measuring how many players who attended U18 National Craven Week had attended the U13 and U16 National Craven Weeks.

Study 2 (Chapter 4)

To understand factors influencing transformation in South African rugby by measuring the physical profiles of the various racial groups at the U18 National Craven Week over time (2002-2012).

Aligned to the objectives, the following specific questions will be answered in this thesis:

1. How many players who attended U13 Craven Week go on to attend U16 and U18 Craven week?
2. What are the physical profiles of the U18 players from various racial groups at Craven Week between 2002-2012?
3. Have these profiles change over time?
4. How do these various profiles compare to the general population?
5. How do these various profiles compare to other international rugby players of the same age?

The next section will be a literature review of factors related to talent identification and development of rugby within a South African context. This will be followed by two experimental chapters as outlined above. The final section will synthesize and interpret the results.

CHAPTER TWO

Literature review

Introduction

Rugby union is a team sport characterized by intermittent, short duration bouts of high intensity activity involving collisions between players. The players need to be physically strong and powerful to meet these demands (Cunniffe, Proctor, Baker, & Davies, 2009). A rugby team consists of eight forwards and seven backline players. In general the forwards are required to compete for and retrieve the ball and are generally heavier, taller and slower than the backline players. The main function of the backline players is to gain field position and score points (Lombard, Durandt, Masimla, Green, & Lambert, 2015; Smart, Hopkins, Quarrie, & Gill, 2011).

The demands of the game have increased with the onset of the professional era and the implementation of specific rule changes (Sedeaud, Vidalin, Tafflet, Marc, & Toussaint, 2013). The game has evolved with an increase in the number of tackles and rucks leading to a more physical and high intensity type game (Quarrie & Hopkins, 2007). These increased demands at a senior level have also been transferred to the junior level of the game. A recent study showed that elite U16 rugby players cover a similar distance compared to senior players (Read, Ben Jones, Padraic, et al., 2017a). In addition the study showed that the big shift in physicality in the game happens between U16 and U18. At an U18 level the demands of the game are similar to the senior game. To meet these demands players are generally becoming bigger, faster and stronger at all levels in both senior and junior rugby (Lombard et al., 2015; Olds, 2001; Sedeaud et al., 2013; 2012). These advances in physical characteristic of both junior and senior players have been attributed to increased training time, improvement in nutritional and conditioning strategies (specifically strength training) and the use of ergogenic aids (Lombard et al., 2015; Olds, 2001; Sedeaud et al., 2013).

The increased training and competition demands in rugby and other sports has resulted in a growing trend of early specialisation in junior competitive sports. Many coaches believe they can identify talent in primary school (before the age of 12) and then convince parents that their children should specialise in one sport at an early age to ensure the best chance of success (Jayanthi et al., 2015). They believe that intense practice and a high level of competition before the age of 12 is required for players to succeed. The South African Rugby Union (SARU) has a pyramid model of sports participation, which has been criticised as a contribution factor for the high levels of player drop out at pre-teen and teen levels (Lambert & Durandt, 2010). Countries like New Zealand and Australia have clearly developed rugby development pathways. These pathways are developed with specific rules, coaching material and conditioning advice to create pathways that are appropriate from a developmental perspective to keep players in the system for as long as possible (Lambert & Durandt, 2010).

Traditional talent identification and development models focus on identifying current performance instead of future potential. This is problematic in youth as they mature at different levels. This problem is exacerbated in a sport like rugby where size, speed and strength are considered important factors contributing to performance (Howard, Cumming, Atkinson, & Malina, 2016). New talent development models have been introduced recently which provide a framework for sports to introduce systems that are developmentally appropriate. These include the Developmental Model of Sports Participation (DMSP), the Long Term Participant Development Model (LTPD) and the Composite youth Developmental Model (CYD).

The examination of any existing talent identification and development framework must start off by defining the context within which the model will operate. The environment within which athletes find themselves is determined by a multitude of interrelated factors. These factors are related to the society itself (resources and attitudes, regulations, history etc.), the type of sport and the specific actions of the sport's governing body (Digel, 2002). South Africa has a legacy of apartheid which included legislation segregating public areas in South Africa, effectively denying access of black and coloured South Africans to top level sports coaching and training facilities (Armstrong et al., 2011; Pinsky, 2014).

South Africa was banned by the International Rugby Board (IRB) from playing international rugby from 1984-1992 as a result of its apartheid policies. Although separate rugby organisations catered for coloured and black players during apartheid, most of the resources went into developing the structures that catered for white players. It is for this reason that transformation in sport is now seen as a national priority (SRSA, 2012). Rugby at all senior professional levels in South Africa is still dominated by white players despite the vast investments of SARU into development programmes to expedite transformation (DuToit et al., 2012).

The SARU has been criticised because the majority of Springboks produced are from traditional rugby schools that have predominantly white scholars (Parker, 2013). SARU claims to have many black and coloured players participating at a youth level but the majority of these players are from previously disadvantaged communities and may not have access to facilities, coaches and the level of competition required to progress through the current player development pathway (Durandt, Lambert, & Green, 2013).

It is important that the reasons for this slow pace of transformation is examined within the socioeconomic context. Socioeconomic status (SES) is the social standing of an individual or group and is usually measured by education, income or occupational status (White & McTeer, 2012). Socioeconomic status has been shown to affect physical development, participation rates and physical performance (Armstrong et al., 2011; Bogin, 2013; Klein, Fröhlich, Pieter, & Emrich, 2016; Malina, 2004; White & McTeer, 2012). One therefore needs to try and ascertain what affect the socioeconomic status of black and coloured people in South Africa has had on their physical development. The available scientific data show that using stature as a marker, there was a stagnant growth trend in the black population between 1900-1970, whereas the white population continued to increase at 0.5 cm per decade (Henneberg & van den Berg, 1990). A study in the 1980's on black and white children in South Africa showed that the white children were significantly taller and heavier at all ages (Hawley, Rousham, Norris, Pettifor, & Cameron, 2009). A more recent study showed that socioeconomic status can also effect general motor and sports specific performance (Armstrong et al., 2011).

The SARU hosts a national competition tournament for u18 players each year. Trends in player demographics at this tournament may help provide information about the extent and progress of transformation in rugby.

To provide context to the research questions that follow a literature review has been completed. The review firstly focuses on factors effecting talent identification and development and secondly it explores the sport of youth rugby in the South African context.

Growth and development in relation to human performance

Sports performance in childhood, adolescence and adulthood it is affected by patterns of growth and development (Lloyd & Oliver, 2013). These patterns need to be understood to determine the affect they have on talent identification, development and ultimately sports performance itself. A broad range of terminology is used to describe concepts related to the development process. There are no officially accepted definitions. Therefore the terminology will be defined for purposes of this review. A number of the concepts will be defined but in addition some context and detail will be provided to explain their relevance.

Maturation is the process of biological systems becoming more mature or the process one undergoes to reach adult status in terms of physical, cognitive and emotional functioning. Maturation is used to describe the rate of progress to reach adult status. Outcomes are observed or measured to chart the progress towards maturity (Malina, Rogol, Cumming, Coelho e Silva, & Figueiredo, 2015).

Maturation takes place at differing rates in specific biological systems such as the reproductive and skeletal systems. Sexual maturity occurs when the reproductive system is fully functional. Skeletal maturity occurs when the skeleton is fully ossified. Maturation occurs at different rates between individuals (Malina, 2014). The rate of maturation is determined by a combination of many factors (e.g. genetics, obesity, nutrition, training, socioeconomic factors, stress and environmental chemicals), some of which will be discussed later in this review. Maturational milestones are often described using chronological and biological age.

Chronological age refers to how old people are from their date of birth. The first year of life is referred to as **infancy**. The chronological years can be divided into specific categories as follows:

- **Childhood** can be split into three phases (Lloyd & Oliver, 2013):
    - Early childhood 1-4.9 years
    - Middle childhood 5-7.9 years
    - Late childhood age 8 to the start of adolescence
- **Adolescence** usually begins with the onset of puberty. Adolescence ends when full stature is attained. This period ranges from 8-19 years in girls and 10-22 years of age in boys (Lloyd & Oliver, 2013).

Biological age refers to how close people are to their fully mature state. Most youth sports are organized according to chronological age. The reason for this is that chronological age is easier to establish compared to biological age and does not have the individual variance associated with biological age. The maturation process cannot be directly measured and therefore specific indicators are used to help estimate maturational levels or biological age. The three most common measures of biological maturation are skeletal, sexual and somatic age (Malina et al., 2015). They can be described as follows:

Skeletal age is determined by taking a radiograph of the hand-wrist skeleton. All children start with a skeleton of cartilage prenatally and develop to have a skeleton of bone in adulthood. The bones are assessed by quantification of the degree of ossification. It is considered the best method of assessing maturational age but is not practical due to the equipment, expertise and cost required. Another limitation is the radiation dose children will be exposed to (Lloyd & Oliver, 2013).

Sexual age is determined by the observation of secondary sexual characteristics that indicate pubertal status. An assessment of these characteristics includes pubic and axillary hair in boys and girls. The development of genitalia and voice changes are also used in boys and the development of breasts, genitalia and age of menarche are used in girls (Malina et al., 2015). The difficulty with these types of measurements is in securing permission to undertake them and the precision of the measurement .

Somatic age is determined by tracking growth and weight gain in children and adolescents. Anthropometry refers to a group of methods used to measure the human body. These are practical and widely used. Body mass and stature are the most popular measures of overall body size (Lloyd & Oliver, 2013). Although these measures are easy to use one must be aware of the measurement error for each method and the limitations of predictive equations (Malina et al., 2015).

Growth is one element of maturation and is often used as a more specific term to describe a quantitative increase in size or stature of the body.

Peak height velocity refers to the period during adolescence at which children are growing at their fastest (figure 1). Children grow on average 6 cm a year and gain 2.3 kg per year until they reach their growth spurt (Malina, 2004). The start of the growth spurt and adolescence is around 9 to 10 years for girls and 11 to 12 years for boys. On average the fastest growing period for girls is at 12 years of age and for boys at 14 years of age. These are only average growth markers as a high level of variation exists among individuals.

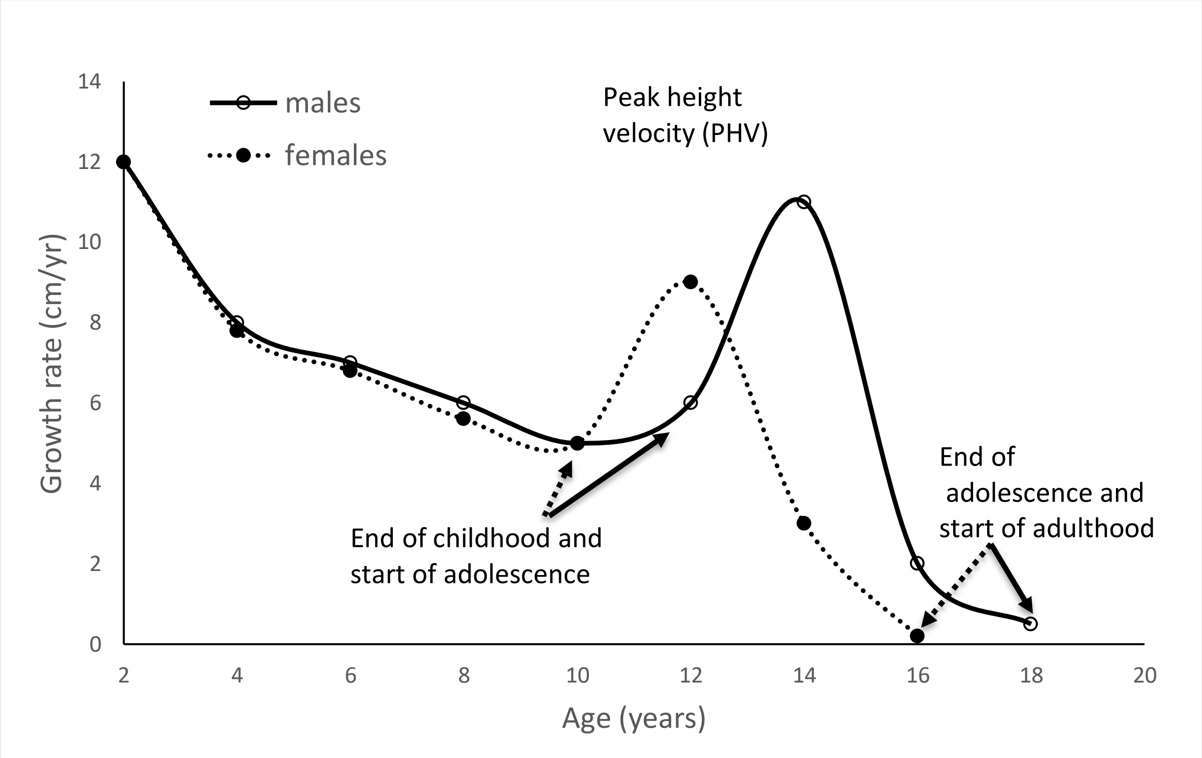


Figure 1*: Rate of growth and stature in males and females (adapted and redrawn from* (Lloyd & Oliver, 2013).

Early maturers refers to children whose maturational ages are at least one year greater than their chronological ages (Vealey & Chase, 2015). Early maturing boys are usually taller, heavier and have more muscle mass compared to their peers. Malina et al. (2004) showed how adolescent (12-17 years) early maturing boys had a distinct advantage in strength, speed, agility and power activities compared to late and average maturing boys. This physical advantage allows these boys to outperform their peers in specific youth sports activities (Malina, Bouchard, & Bar-Or, 2004). The prevalence of early maturing males in specific sports is not only as a result of superior physical and functional capacity but also as a result of receiving preferential treatment. This preferential treatment results in more opportunities for competition, specialized coaching, and access to training resources (Howard et al., 2016; Torres-Unda et al., 2016; Wierike, Elferink-Gemser, Tromp, Vaeyens, & Visscher, 2015). These early maturing individuals are also likely to be identified earlier and have more positive perceptions of self (Malina et al., 2015). This trend has been demonstrated in a number of sports including rugby and soccer (Howard et al., 2016).

Average maturers refers to children whose maturational age is within one year of their chronological age.

Late Maturers refers to children whose maturational ages are at least one year less than their chronological ages. While earlier maturers have a physical and functional advantage in adolescence, the late maturers catch up and often surpass their early maturing counterparts in adulthood (Pearson, Naughton, & Torode, 2006). Talented yet late maturing boys may therefore be overlooked (Till, Cobley, O'Hara, Chapman, & Cooke, 2013b). This problem has been highlighted in rugby union where size, speed and strength are considered important factors contributing to performance in the game (Howard et al., 2016). There is research which suggests that motor performance in late maturing boys continued to improve from 18-30 years of age, whereas early and average maturers showed little change or a decline (Lefevre, Beunen, Steens, Claessens, & Renson, 1990). A recent study followed 55 division 1 (14 year old) Serbian soccer players until they were 22 years old to determine what percentage made it to an elite level (Ostojic & Castagna, 2014). At the age of 14 they were all assessed to determine their maturity levels. Forty eight percent of the players originally selected in the group of 55 were early maturers and only 20 percent were classified as late maturers. After eight years 33% of these players made it to elite level. Sixty percent of the players were late maturers and only 12% were early maturers. This research highlights the challenge for coaches and administrators dealing with talent identification and developmental in children and adolescents.

Development is a broader term referring to all physical and psychological changes that an individual would undergo in a life time. Physical growth and maturation are part of development, but development is more qualitative. While growth and maturation stop at specific ages, development continues through life (Vealey & Chase, 2015).

Relative age effect (RAE) is a phenomenon in sport where older children are over represented in a team compared to slightly younger children within the same chronological age group. The RAE has been shown in individual and team sports at both at professional and amateur level (e.g. soccer, basketball, cricket, rugby, tennis, volleyball and swimming) (Cobley, Abraham, & Baker, 2008; Grobler, Shaw, & Coopoo, 2016; Gutierrez Diaz Del Campo, Pastor Vicedo, Gonzalez Villora, & Contreras Jordan, 2010; Lewis, Morgan, & Cooper, 2015; Torres-Unda et al., 2016; Vealey & Chase, 2015). It does not occur in every sport; studies on pre-professional dancers and Olympic taekwondo athletes found no relative age (Albuquerque et al., 2012; van Rossum, 2006). The RAE is attributed to maturational differences related to age, where the older athletes are more developed than the younger athletes, providing them with a competitive advantage. This competitive advantage usually starts at an early age, positioning the older athletes for initial talent selection and prioritized development. This process where older, more physically mature athletes receive more chances for selection, has been called "survival of the fittest" (Christensen, Pedersen, & Position, 2008). In contrast those athletes who are born later in the year (4th quarter players) are often less physically mature, resulting in a greater chance of deselection (dropping out of the player pathway). These players are forced to find alternative means of re-engaging with the pathway and those who successfully navigate this experience are proposed to develop resilience. This process of re-emergence has been called "evolution of the fittest" (Christensen et al., 2008; Hardy, Evans, Rees, Woodman, & Warr, 2016). It has also been suggested that the level of competition in a sport determines early selection policies possibly increasing the chances of observing the RAE (Jones, Lawrence, & Hardy, 2018).

A recent study of super elite rugby players (players selected from the top 10 international teams) showed a reversal of the RAE for specific positions. There was a reversal of the RAE for forwards but not for backs (Jones et al., 2018; McCarthy, Collins, & Court, 2016). It was suggested that a possible reason for this reversal could be the stronger psychological profile developed by younger players who have had to cope with the challenges (training and competing against bigger players and possible deselection) of initially being at a disadvantage. The authors contend that the younger boys who receive enough support can overcome these challenges and enhance their psychological resilience enabling them to perform at an elite level (Jones et al., 2018). This reversal trend has also been demonstrated in club rugby, where players who were born in the last two quarters of the year showed more "mental toughness" and a greater percentage made it to the senior team as opposed to the physically older players (McCarthy & Collins, 2014). These cases of the reversal of the RAE effect shows the complexity of talent development and how those players who are initially younger, but manage to stay in the system, have an equal or better chance of succeeding. This illustrates how important it is to support and keep players in the system for as long as possible.

Lastly a recent study by Kearney (2017) reviewed online data for 8751 male professional rugby players from Australia, New Zealand, England and South Africa to establish the prevalence of the relative age effect. They divided team positions into three forward and back categories to establish if the RAE was position specific. South Africa was the only country that showed the RAE for all forward and backline groupings. The author makes the comment that "the over-representation of players born in the first quarter of the year and the under-representation of players born in the final quarter of the year suggests an inherent inefficiency within talent development systems whereby players are accessing support and opportunities on the basis of current maturation status rather than future potential" (p.3) (Kearney, 2017). These findings in South African professional players mirror those found in 13 to 16 year old school players (Grobler et al., 2016). These data show that the RAE may be influencing talent development to a greater extent in South Africa than in other major rugby playing nations.

Talent identification and development

Talent Identification (TID) is described as the process of recognizing current participants in a specific sport who have the potential to excel. Talent development (TDE) involves creating an optimal environment within which this potential can best be developed (Vaeyens, Lenoir, Williams, & Philippaerts, 2008).

TID and TDE models and protocols have traditionally had limited success with a low predictive value for success as adults (Suppiah, Low, & Chia, 2015; Vaeyens et al., 2008). The talent identification literature in rugby has mainly focused on anthropometric and physiological performance measures to differentiate between talented and less talented players or to attempt to predict success (Fontana, Colosio, Da Lozzo, & Pogliaghi, 2017; Gabbett, Jenkins, & Abernethy, 2010; Gabbett, Kelly, Ralph, & Driscoll, 2009; Pienaar & Spamer, 1998; Spamer & Hare, 2001; Till et al., 2011). In one of the first studies in rugby union talent identification, Pienaar et al. (1998) used anthropometric and rugby specific skill tests to predict final selection in a group of players initially selected for a national U13 tournament (Craven Week). The selection favoured early matures who were bigger taller and had better rugby skills. A subsequent follow up study did not track whether these talented young players were again selected at U18 provincial level (Spamer & Hare, 2001). Similar cross sectional studies in rugby league in U15 and U16 players showed how anthropometric, skill and physiological tests could differentiate between starters, non-starters and elite versus sub elite players (Gabbett et al., 2009; 2010).

Many of the protocols do not consider maturation and the complexities it creates (e.g. early versus late maturers and the relative age effect) (Till et al., 2013b). Most protocols are primarily focused on current performance instead of future potential. Many of the physical qualities that ensure elite performance as an adult are only evident in late adolescence (Vaeyens et al., 2008). Till et al. (2013a) tried to address the limitations of cross sectional studies by monitoring the longitudinal development of anthropometric and physiological characteristics in 13 to 16 year old rugby league players. The study showed that the early maturing group had greater anthropometric and physiological characteristics than the late maturing group. Despite this the late maturers improved in all measures at a greater degree than the early maturing group. This study highlighted the pitfalls of a snap shot approach to talent identification. Till et al. (2015) went on to retrospectively investigate differences in anthropometric and fitness characteristics of junior Rugby League players who were assessed between the age of 13-15 years old. The aim of the study was to assess how theses variables affected the players progression to amateur, academy or professional level play. All the fitness measures showed significant differences between amateur and professional players, with professionals outperforming the amateurs. In addition to this there were two other significant findings. Firstly, there was no difference in height, body mass or age between the groups suggesting that for this group size and maturation did not affect career progression. The authors suggest that this group had already become relatively homogenous as a result of the performance demands of the sport. Secondly there were no significant fitness differences between those who progressed to academy and professional level. This may suggest that although anthropometric and physiological characteristics contribute towards career progression, there are other factors such as technical, tactical and psycho-social development that also play a role (Till & Jones, 2015). In a subsequent study Till et al. (2016) retrospectively grouped 580 rugby league players according to career attainment level (amateur, academy and professional). These players had been assessed using anthropometric and fitness measures at U13,U14 and U15. The key finding showed that birth quartile 4 and Pivots (stand offs, scrum half and hooker) showed the greatest potential for reaching a professional level of play. Anthropometry (sum of 4 skinfolds) measures and fitness were significantly greater in future professionals compared to amateur players for U14 and u15 players. Although fitness contributed to career attainment, size and early maturation did not contribute. In fact, the data showed the opposite with late maturing players with lower body mass more likely to succeed. These results highlight the dangers of early selection polices.

The traditional or standard models of talent identification have focused on identifying physical abilities to try and predict future potential, but have neglected cognitive, technical and psychological predictors of performance (Till et al., 2011; Tredrea, Ben Dascombe, Sanctuary, & Scanlan, 2017). Despite all these limitations sport bodies continue to spend exorbitant amounts on traditional TID and TDE programmes. Manchester City soccer academy reportedly costs 12 million pounds per year to run and has only sold one graduate at an international level for 21 million pounds since it was established in 2014 (Pickering & Kiely, 2017).

Although TID and TDE can be defined as separate processes they are actually interlinked. For example, gifted individuals can only reach their full potential if they are provided with the appropriate developmental opportunities (Vaeyens et al., 2008). It is for this reason that a number of developmental models propose stages of development based on maturational status that combine the TID and TDE processes. A number of TID and TDE models have been developed. The next section examines some of the key concepts (early specialisation, deliberate practice and hereditary aspects of talent) and models used in TID and TDE.

Early Specialisation

Early specialisation can be defined as year round participation in one sport with the exclusion of all other sports due to the intensity and duration of the training in that sport (Jayanthi et al., 2015). Early specialisation occurs when someone specialises while they are still in primary school (6-12 years of age) rather than waiting until they are in high school, (13-18 years of age). Early specialisation is not a new phenomenon in TID and TDE. It was initially popularised by the Soviet Union and other eastern bloc countries in the 1950's as part of their efforts to raise the standard of their sport to enable the countries to dominate at an international level (Gonçalves, Rama L, & Figueiredo, 2012). Although the pitfalls within the Soviet system are well known, early specialisation as an integral part of talent identification and development has continued to gain ground (Jayanthi et al., 2013).

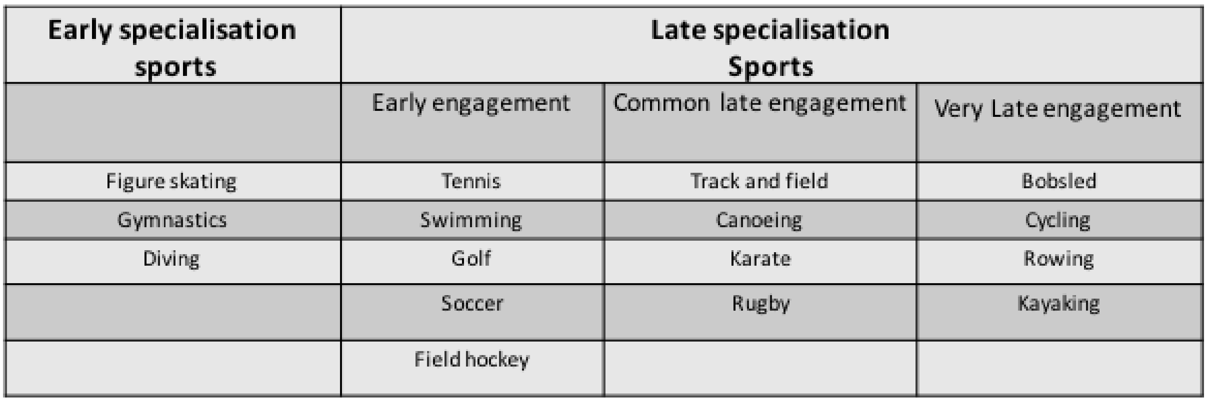
The reasons for this growing trend are that there is a perception that early intensive training is required for success (Suppiah et al., 2015). Also parents believe that their child has a greater chance at success, income and education if they specialise early (Jayanthi et al., 2015). Furthermore, the media has created models of success out of sports protégés like Tiger Woods who is reported to have shot a score of 48 for 9 holes at the age of 3 (Glick, 1990). He is used as an example of proof for the model of early specialisation. Sport is also big business and private academies and the professional coaches have a financial interest in providing year-round training. Books in the popular media like Malcolm Gladwell's "Outliers" and Mathew Syed's "Bounce" have helped promote concepts like the 10 000-hour rule and deliberate practice (Gladwell, 2008; Syed, 2010).

Deliberate practice is used by many to justify the need for early specialisation. Deliberate practice as a concept originates from the research of Simon and Chase (Simon & Chase, 1973) in chess players where they claimed that 10 000 hours of practice was mandatory to attain an expert level of performance. This research was built on by Ericsson et al. (1993) who showed a similar trend in violin players. He implied that any player could become an expert with enough deliberate practice from an early age. Ericsson et al. (1993) defined deliberate practice as high quality, focused practice that was not inherently enjoyable and completed with the primary purpose of improving performance. The framework developed by Ericsson's work suggests that athletes must specialize in their main sport and start deliberate practice at a young age to attain an expert level of performance (Côté & Hancock, 2014).

Most sport scientists agree that deliberate practice is necessary to achieve a level of expert performance. However, there is disagreement about whether intense practice should begin in early childhood to the exclusion of other sports. Research has not demonstrated that early intense training is essential for attaining elite level performance (Baker, Cote, & Abernethy, 2003; Jayanthi et al., 2015; 2013; Macnamara, 2016; Macnamara, Moreau, & Hambrick, 2016). Research on deliberate practice has been criticised for its methodology and a recent meta-analysis by McNamara et al. (2016) concludes that only 18% of skill acquisition in sport can be attributed to deliberate practice. In contrast for most sports there is evidence that early diversification (i.e. sampling several different sports from a young age) will lead to success (Baker et al., 2003; Helsen, Starkes, & Hodges, 1998; Hodges & Starkes, 1996; Moesch, Elbe, Hauge, & Wikman, 2011). The current research provides a compelling case for concluding that reaching an expert level of performance in sport is not solely reliant on deliberate practice. Deliberate practice plays a role alongside numerous other factors including one's innate talent, which will be discussed in the next section.

Some have tried to classify sports as early or late specialisation sports based on the complexity of the sport related to muscle control and coordination (Table 1) (Balyi, Way, & Higgs, 2013). This has been done to distinguish between those sports that need early intense participation with the exclusion of other sports. Gymnastics, diving and figure skating have been identified as early specialisation sports, whereas most of your other team and individual sports are categorised as late specialisation sport.

Table 1: Examples of early and late specialisation sports (adapted and redrawn from Balyi et al., 2013).



Early specialisation sports	Late specialisation Sports		
	Early engagement	Common late engagement	Very Late engagement
Figure skating	Tennis	Track and field	Bobsled
Gymnastics	Swimming	Canoeing	Cycling
Diving	Golf	Karate	Rowing
	Soccer	Rugby	Kayaking
	Field hockey		

Hereditary aspect of talent

Ericsson et al. (2009) suggests that performance is not limited by genetic factors but by engagement in deliberate practise. They claimed that deliberate practice selectively activates dormant genes that are contained in all healthy people. There is no evidence in the literature to support this claim (Tucker & Collins, 2012). On the contrary there is strong evidence to support that elite performance is a product or interaction between training (and other factors determined by the environment within which the athletes live) and genetic factors (Tucker & Collins, 2012; Vaeyens et al., 2008).

There is sufficient evidence to conclude that talent is partially influenced by genetic factors (Pickering & Kiely, 2017). This can be seen by considering some of the physiological determinants of performance. Height is determined by both genetic factors and the environment. Height is highly heritable with 80% of its variance controlled by specific genes (Silventoinen et al., 2003). Height is a prerequisite for performance in specific sports such as volleyball, basketball, and netball. Other key physiological determinants of performance have also shown a high degree of hereditability. These include $VO_{2max,}$ where 50% baseline maximal oxygen uptake is heritable (Bouchard et al., 2000). Also 45-99.5% of muscle fibre type is inherited (Komi et al., 1977; Simoneau & Bouchard, 1995), whereas strength is estimated to be around 53% heritable (Zempo et al., 2017).

In addition to these physiological determinants of performance, the non-physical traits related to performance in sport such as the ability to tolerate stress, resilience (Petito et al., 2016; Sanhueza, Zambrano, Bahamondes-Avila, & Salazar, 2016) and motivation to exercise (Schutte, Nederend, Hudziak, Bartels, & de Geus, 2017) also have a genetic component. What is also apparent is that not only are the baseline determinates of performance highly heritable, but also the ability of these determinates to adapt to exercise and training (Pickering & Kiely, 2017). It is logical to consider testing for baseline measurements of performance and adaptability as predictors of talent, since they are heritable. However, available technology and understanding of genetic information is not yet at a point where it can be used to predict those who are most likely to reach elite status (Pickering & Kiely, 2017).

Pyramid model of sports participation

The pyramid model of sports participation has been described as the standard model of talent development (Bailey & Collins, 2013). The model is based on the premise that participants are introduced to sport (i.e. they participate in practice and competition), and will move up the triangle to elite sports participation (figure 2). The model also dictates that fundamental movement skills

(FMS) should be taught through physical education at the base of the triangle. These FMS are further developed as participants move up the pyramid to more challenging environments and higher levels of competitions (e.g. progressing from school to club and university or regional levels of competition). The model has been criticised for being too simple (Abbott, Button, Pepping, & Collins, 2004; Gulbin, Croser, Morley, & Weissensteiner, 2013). It does not consider the individual differences of participants as a result of differences in growth and maturation. In addition, it creates an impression that a person moves up or moves out of sport. Ideally players should be able to re-enter at a later stage, or to continue participation in recreational sport.

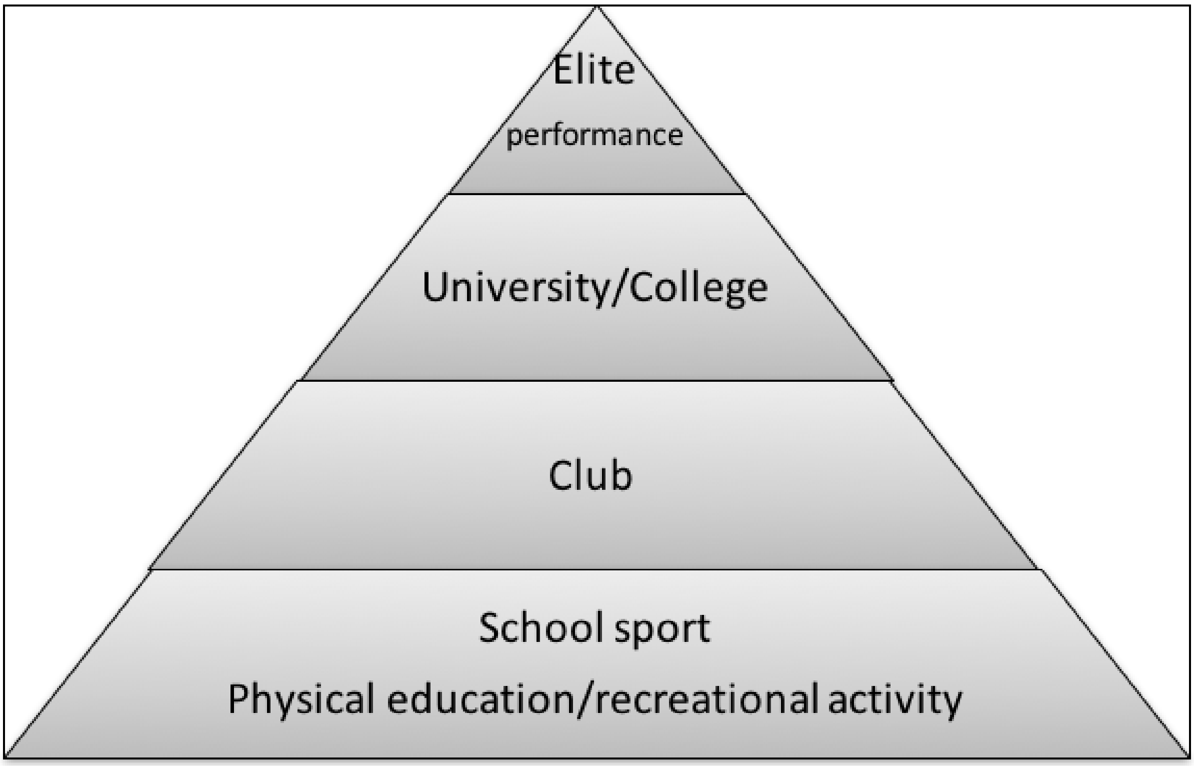


Figure 2: Pyramid model of sports participation (adapted and redrawn from Bailey & Collins, 2013*).*

Differentiated Model of Giftedness and Talent (DMGT)

The DMGT makes a distinction between natural untrained abilities (gifts) which must be developed into talent (expertise and skills) (figure 3). This model acknowledges that talent development is dependent on both innate abilities (nature) and how these are developed (nurture) by the environment. Gagne´(2012) describes the natural ability domains as Intellectual, creative, socio-affective and sensorimotor. This is much broader than the standard model of development which considers mainly physical ability.

Gifted individuals are those who have an innate ability that places them within the top 10% of their peers. The DMGT acknowledges the complexity of recognizing giftedness and emphasizes that one should attempt to recognize the "rate of learning" as opposed to the current state of learning or skill. The developmental process is seen as a process of transforming gifts into talent. The developmental process is dependent on a trio of catalysts (Intrapersonal, environmental and chance). The model acknowledges that chance can also play a role in the development process (e.g. opportunities or injuries).

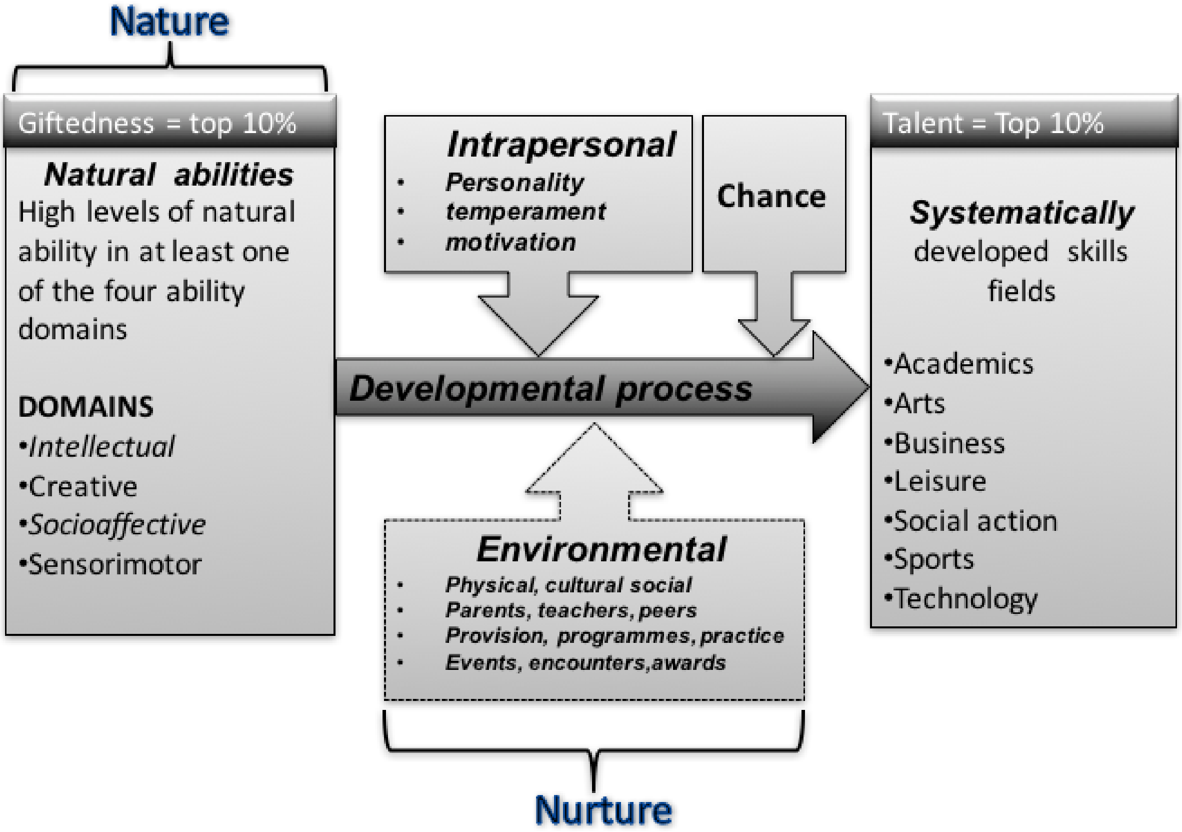


Figure 3: The Differentiated Model of Giftedness and Talent (adapted and redrawn from Gagne, 2012).

Development Model of Sports participation (DMSP)

The DMSP proposes specific trajectories based on the type of sports one will be participating in (figure 4). The model differentiates between early and late specialisation sports, providing stages of participation which dictate levels of deliberate play and deliberate practice. The model highlights two key concepts; (i) deliberate play, and (ii) diversification (Côté & Hancock, 2014).

Côté (2014) describes deliberate play as sport activities in childhood that are inherently enjoyable as opposed to organized sport, as opposed to adult led practices with an emphasis on deliberate practice. The concept of diversification refers to a person being involved in sampling different types of sporting activities during childhood. For late specialisation sports the model has three stages of development; (i) sampling years (ages 6-12), (ii) specializing years (ages 13-15), and (iii) the investment years (ages 16+). The sampling years are focused on trying different activities with deliberate play having precedence over deliberate practice. As the child moves into high school (specializing years), they may be required to focus on fewer sport activities. There is also a gradual transition from play to practice. To move onto elite sport they will probably need to specialize in one sport. This model advocates that even those children who do not continue with competitive sport in high school will, as a result of their sampling years, be likely to continue with recreation activities. The model discourages early specialisation in late specialisation sports. The model also warns that early specialisation with an emphasize on deliberate practice increases the risks of burn out and injury (Jayanthi et al., 2015; Mostafavifar, Best, & Myer, 2013; Post et al., 2017).

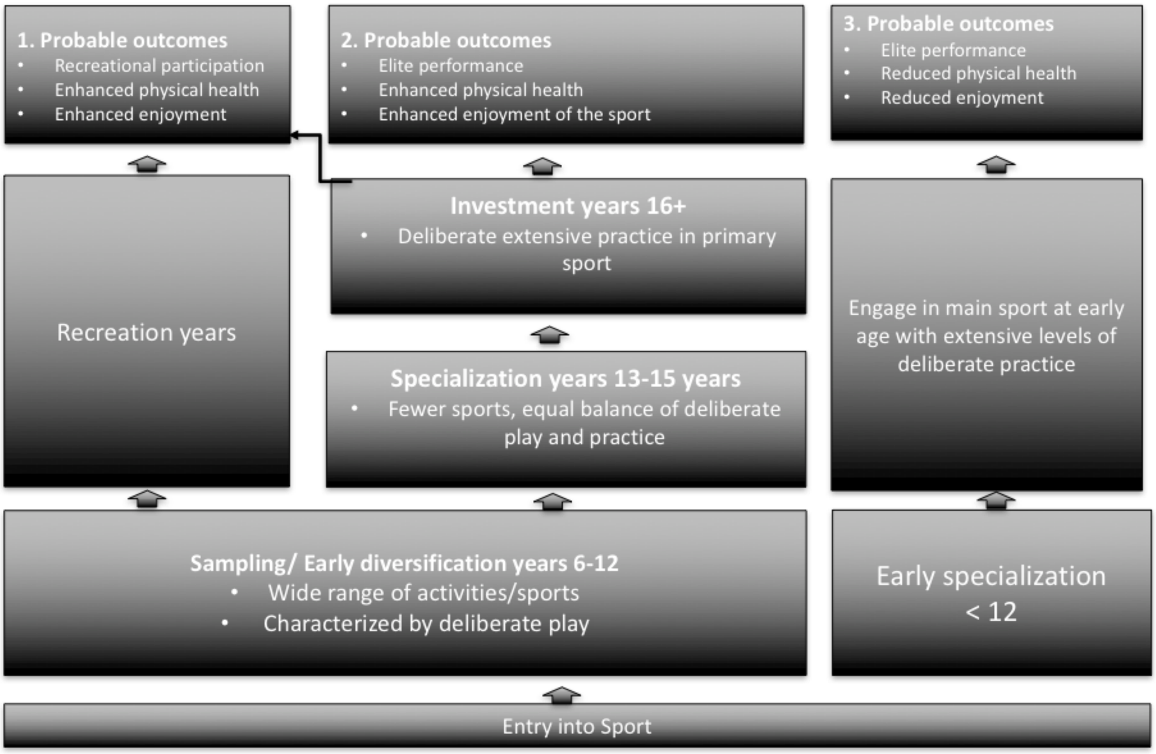


Figure 4: The Developmental Model of Sports Participation (DMSP) (adapted and redrawn from Côté & Vierimaa, 2014).

Long Term Participant Development Model (LTPD)

The LTPD model was developed in 1990 by Istvan Balyi. The model has been refined over the years and has developed from a four to seven stage model as depicted in figure 5. The name of the model initially started out as the Long Term Athlete Development Model (LTPD) but to be more inclusive was later changed in specific settings to the Long Term Participant Development model (Balyi, 2012). The LTPD model was initially accepted and implemented from grass root level to Olympic level by Canada and has also been implemented in a number of sports within the United Kingdom and now in South Africa (Balyi, 2012). The model attempts to describe athlete development, training, competition and recovery based on biological maturation as opposed to chronological age. The model provides a plan for parents and coaches to follow to optimise sport and development. The model uses the different growth stages that children go through to prescribe the appropriate level and type of physical activity (Balyi et al., 2013).

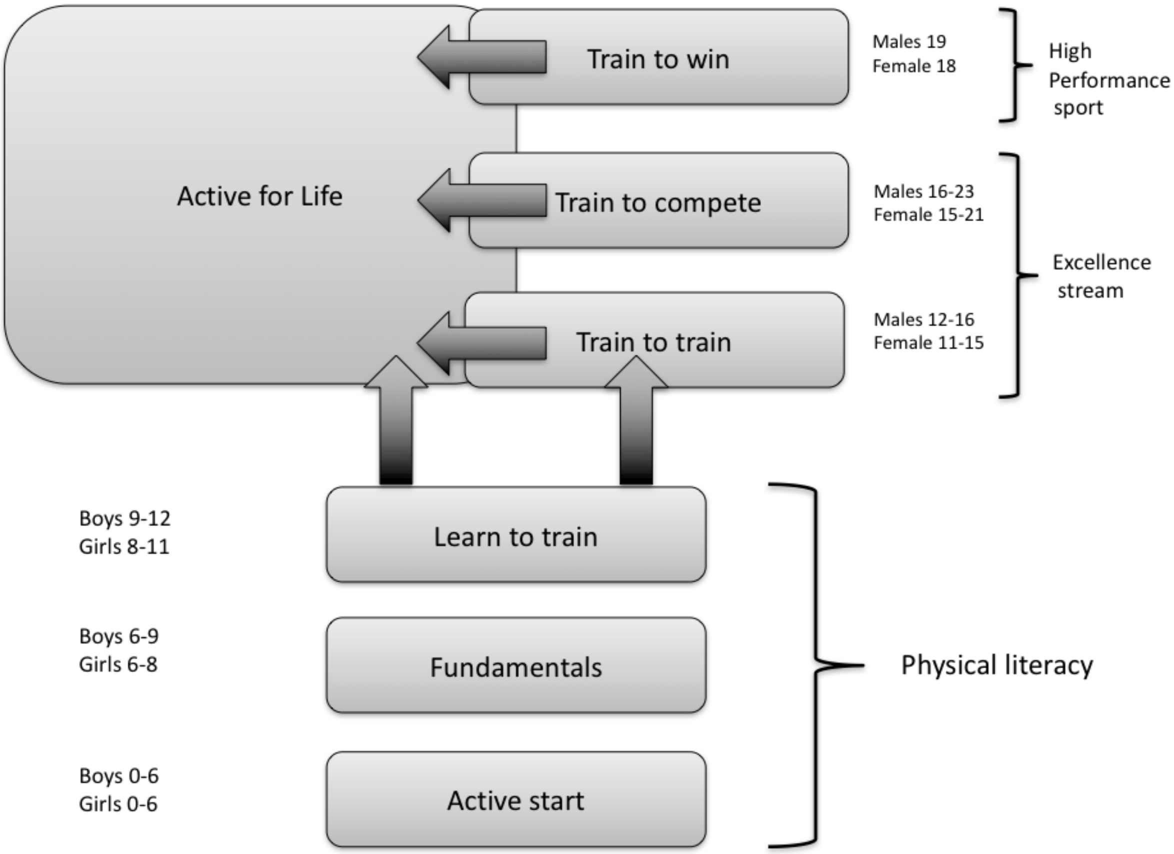


Figure 5: Long Term Participant Development (LTPD) (adapted and redrawn from Balyi, 2012).

The key features and criticisms of some of these features are described:

Physical literacy
Physical literacy is the development of fundamental movement (e.g. walk, run, jump, throw, kick and hit) skills and fundamental sport skills (applying a fundamental movement in a sport specific manner e.g. learning to kick a rugby ball, bowl a cricket ball or to hit with a cricket bat). LTPD claims that children who do not learn these fundamental skills are less likely to be physically active, negatively affecting their levels of physical activity for health and sports performance. The child who is physically literate is more likely to continue to exercise into adulthood as they feel more capable and therefore confident in participating (active for life).

Periodisation
LTPD explains and promotes the concept of periodisation. In its most basic form periodisation provides a framework for planning (e.g. a weekly or monthly plan for physical activity). This planning relates to physical activity and competition. The framework helps one plan the type, volume, duration and intensity of activity over time in relation to the different periods of the season and competition for a specific sport. If one has clearly documented the planning and actual implementation (how much and how hard) then this gathered evidence or information becomes very helpful in adjusting the training for the next cycle or competition depending on performance.

Specialisation

LTPD classifies sports either as early or late specialisation sports and advises that those participating in late specialisation sports only specialise in high school.

Chronological age versus Biological maturity

The LTPD model highlights a key area that needs to be considered related to the child's rate of maturation (how fast they mature). It explains the concepts of chronological and biological age and explains some of the implications for coaches.

Competition

The LTPD model gives practical examples of regulating the amount of competition at the various stages of development. Often athletes compete too regularly at a young age when they should be spending more time practicing. These are only general guidelines and must be applied taking the specific sport and the variables that affect it in to consideration (Table 2).

Stages of Long Term Participant Development (Balyi, 2012)

The LTPD model advocates stages of development which dictate the type duration and intensity of the activities. The stages are briefly described below and in table 2:

Active Start (Boys 0-6 yrs / Girls 0-6 yrs)

The objective of this stage is to allow children to learn fundamental movements which are linked together into play. This developmental stage allows for the enhancement of brain function, social skills, motor skills, leadership and imagination. Physical play is also important in developing strong bones and muscles. Physical activity should be fun and part of a child's daily life.

FUNdamentals (Boys 6-9 yrs / Girls 6-8 yrs)

The objective of this stage is to learn fundamental movement skills and build motor skills. The model advocates that skill development be creative and include fun activities. Building one skill upon another is crucial for overall development; missing one building block may be detrimental to the athlete's performance at a later stage. In line with being active for life, irrespective of the athlete's final level of competition, the gains achieved from this stage will assist in improving health. In line with its specialisation policy a wide range of various sports must be encouraged; players should play a number of different sports.

Learning to Train (Boys 9-12 yrs / Girls 8-11 yrs)

The objective of this stage is to learn overall sports skills.

The greatest improvements in motor development and motor coordination can be achieved during this period. Fundamental skills are continued while more complex sport skills are mastered. The athlete continues to strengthen through the use of body weight, Swiss ball and medicine ball exercises. Improvement of flexibility is achieved through games.

Training to Train (Boys 12-16 yrs / Girls 11-15 yrs)

This period allows for accelerated development of aerobic, speed and strength training. Athletes consolidate their sport specific skills and tactics as athletes, now aiming to win and play to their best.

Learning and Training to Compete (Boys 16-23 yrs / Girls 15-23 yrs)

The objective of this stage is to optimize the “engine” (what has already been created by the previous phases) and learn to compete. Meaning that the aim is on learning to compete and not competition itself. The emphasis on the stage is to allow for the improvement of performance. The athlete must have achieved all ’training to train’ objectives before starting the “training to compete”.

Training to Win (Boys 23 yrs + / Girls 23 yrs +)

The objective of this stage is to achieve podium performances. This athlete is a high performance athlete that requires individual attention and training. The focus is now on improving all areas to promote performance. All areas such as physical, technical, tactical and mental should be fully developed.

Table 2: Key Aspects of the Seven Stage Model (adapted from Balyi, 2012)

Training to Train	Learning to Compete	Training to Compete	Training to Win
Boys 12-16 / Girls 11-15	Boys 16-20 Girls 15-19	Boys 20-23 Girls 19-23	Boys 19+ / Girls 18 +
Aerobic base, speed, strength and sport skill	Optimize the engine and learn to compete		Podium Performances
• 60% training 40% competition	• 40% training 60% competition		• 25% training 75% competition
• Cope with challenges of competition	• Perform sport specific skills under various competitive conditions		• Training to allow peak performance
• As a rule of thumb hours of training per week should not exceed age	• Athlete needs to improve weak physical areas		• Rest to prevent athlete burnout
• Practice matches and competitive drills	• Individually tailored fitness, recovery and technical programs		• Training of high intensity nature
• Narrow athlete focus down to 2-3 sports	• Narrow athlete focus down to 1-2 sport		• High performance athlete

Criticism of the LTPD model

The LTPD model has recently received a high level of criticism (Ford et al., 2011; Lloyd et al., 2015). The specific areas of criticism include:

Windows of opportunity and trainability

The LTPD model advocates that there are specific “windows of opportunity” or time periods that exist where specific physical attributes such as speed, endurance, strength and flexibility should be trained (Balyi & Hamilton, 2004). These windows of opportunity are seen as “critical periods” where a specific attribute should be trained otherwise the athlete will not reach their full potential (Ford et al., 2011). Ford et al. (2011) show that there is no evidence to support the “windows of opportunity” theory. They acknowledge that there are sensitive periods of development, but they contend that as a result of differing individual maturation rates, all components of fitness are trainable to some degree.

10 000-hour rule

Another criticism of LTPD is the acceptance of the 10 000 hours rule, where the authors maintain that one needs to reach 10 000 hours of deliberate practice to reach an expert level of performance (Lloyd et al., 2015). The acceptance of this rule has inadvertently promoted early specialisation as parents and coaches strive to get in many hours of deliberate practise at an early age (Jayanthi et al., 2015).

Youth Physical Development (YPD) and Composite Youth Development model (CYD)

The Composite Youth Development (CYD) model is an update of the original Youth Physical Development (YPD) model. The YPD model will first be discussed and then the changes that were made to produce the CYD model will be explained.

The YPD model was introduced in reaction to many of the criticisms related to existing athletic development models as detailed above. The authors attempted to develop an evidence-based strategy for development from childhood to adulthood (Lloyd & Oliver, 2012). Although figure 6 depicts the current CYD model, the only differences between the CYD and YPD model is that talent development and psycho-social aspects have been added (Lloyd et al., 2015). The YPD model focused mainly on developing physical athleticism. Despite this emphasis on physical development the name and detail explain that the idea of developing fundamental movement and sports specific skills is for children to have an opportunity for recreation or high performance physical activity (Lloyd & Oliver, 2012).

Central components of the YPD model

Trainability

The YPD model differs from the LTPD model in that it is supported by scientific evidence and translates this, showing how all fitness components are trainable at all stages of development (Lloyd & Oliver, 2012). The model shows how all the different components of fitness are trainable but the emphasis does change (the bigger and bolder the lettering the more emphasis is placed developing a specific component of fitness as depicted in figure 6) as the child matures. Coaches and practitioners are instructed to delay or advance certain aspects of the model based on the maturity status of an individual (e.g. early versus late maturer).

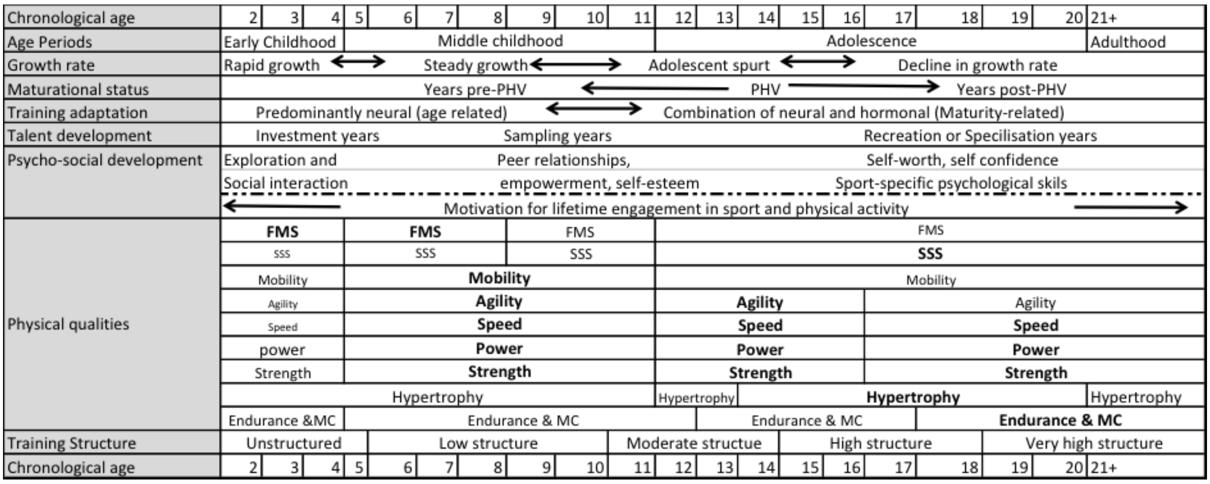
Movement competency and muscular strength

The YPD model emphasises the importance of developing fundamental movement skills (FMS) from a young age. This is similar to the objectives of the LTPD. The difference between the two models is that the YPD model structure does not regard the FMS skills phase of development as completely distinct from the Sport Specific skills (SSS) phase of development. These two skills are seen as interlinked with an early bias towards developing FMS but that as the child matures the emphasis changes to SSS. Despite the change in emphasis the two skills are always trained. The model also advocates early exposure to resistance training for both the development of FMS, SSS and injury prevention.

Criticism of the YPD and changes to create the CYD

The Youth Physical Development (YPD) model has been criticised for focusing solely on the development of physical athleticism and not providing a specific talent development pathway

(Lloyd et al., 2015). It was for this reason that the CYD model has adapted the talent development section from the DMSP model and added it to the YPD model. The DMSP model referred to early childhood, sampling years and specialising years as previously discussed. The CYD model uses the term “Investment years” instead of “childhood” but the description of this phase and the sampling and specialisation years are similar (Figure 6). In addition individuals may transition between recreation and specialisation. The model provides a framework but provides very few worked examples, perhaps these will be developed over time as people use the model in different circumstances. A novel element which has also been added is a pathway for psychosocial development. Psychosocial parameters are provided which practitioners need to consider when structuring development programs for children.



Chronological age	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21+				
Age Periods	Early Childhood	Middle childhood	Adolescence	Adulthood	
Growth rate	Rapid growth ⟷	Steady growth ⟷	Adolescent spurt ⟷	Decline in growth rate	
Maturational status	Years pre-PHV ←	PHV →	Years post-PHV		
Training adaptation	Predominantly neural (age related) ⟷	Combination of neural and hormonal (Maturity-related)			
Talent development	Investment years	Sampling years	Recreation or Specilisation years		
Psycho-social development	Exploration and Social interaction	Peer relationships, empowerment, self-esteem	Self-worth, self confidence Sport-specific psychological skils		
	← Motivation for lifetime engagement in sport and physical activity →				
Physical qualities	**FMS**	**FMS**	FMS	FMS	
	SSS	SSS	SSS	**SSS**	
	Mobility	**Mobility**	Mobility		
	Agility	**Agility**	**Agility**	Agility	
	Speed	**Speed**	**Speed**	**Speed**	
	power	**Power**	**Power**	**Power**	
	Strength	**Strength**	**Strength**	**Strength**	
	Hypertrophy	Hypertrophy	**Hypertrophy**	Hypertrophy	
	Endurance &MC	Endurance & MC	Endurance & MC	**Endurance & MC**	
Training Structure	Unstructured	Low structure	Moderate structue	High structure	Very high structure
Chronological age	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21+				

Figure 6: Composite youth development model (CYD) (adapted and redrawn from Lloyd et al., 2015).
PHV = Peak height velocity; FMS = fundamental movement skills; SSS = Sport Specific skills.

In conclusion we have discussed several models of development. The pyramid model is simple and is based on competition and participants moving up the triangle to higher levels of elite sport or moving out of the sport. This model was followed by model the LTPD model which attempted to consider factors such as maturation, specialisation, competition and training volume. This model proved popular as it gave a number of maturation specific practical recommendations that were taken up by many federations which used them as a framework for developing specific sport development programmes. The problem with this model is that several of its key principles were not based on scientific evidence. The concerns with the LTPD model led to the development of the YPD and CYD models. The CYD model takes components from several models as its name suggests and creates a practical science based model.

The History of rugby union

The origin of modern day rugby union can be traced back to the game of football that was played in the town of Rugby in Warwickshire between 1749 and 1823. The game had few rules with a variable number of boys playing in a single game (more than 200 boys in some games). The games could continue for several days. Touchlines were introduced and a ball could be caught and kicked but running with the ball was not allowed. It is claimed that during a game in 1823 a pupil of Rugby school called William Web Ellis picked up the ball during a game and instead of stopping to kick the ball, took the ball in his arms and ran with it (Johnson, 2015). The rule of being able to run with the ball only appeared in the rule book in 1841, but the rules and popularity of the game spread as Rugby school boys moved onwards towards universities such as Oxford and Cambridge (Johnson, 2015). The first university match took place in 1871. In 1863 the football association was established to formalize the laws of the game. These laws included a law outlawing running with the ball. Despite this the school of rugby had carried on with their own version of the game (Humphrys, 2017).

Through the influence of former Rugby pupils, rugby clubs sprang up all over Britain and even in some of the colonies. Despite the spread of the game there was still considerable variations in the laws. In 1871 a meeting took place where 21 clubs were represented and the Rugby Football Union (RFU) was founded. One of the first tasks was to deputize three former Rugby pupils who were lawyers to compile the laws of the game.

Following the establishment of the RFU, the Scottish Football Union was established in 1873. This was followed by the Irish Rugby Union in 1879 and the South Wales Football Union in 1880. An International championship was established in 1882. France joined in 1910 to form the five Nations competition. With rugby growing in popularity and international participation the need for an international governing body became apparent and the International Rugby Board (IRB) was formed in 1886 (RFU, 2015).

The newer clubs in the north of England began forming their own leagues and wanted more autonomy. They also wanted to pay players for loss of earnings when they missed work as a result of playing. The RFU fearing professionalism insisted that the game retain its amateur status. The two parties were unable to reach agreement and on the 29th of August 1895, 22 of the leading Northern clubs formed the Northern Rugby union, which from 1922 became known as Rugby League (BBC, 2015). This split set rugby league on the path of professionalism whereas rugby union remained an amateur sport until 1995. Since the start of the professional era there has been phenomenal growth in the game. World rugby as of December 2017, has 105 full member unions and 16 associates (Howell, 2017). In 2016 world rugby claimed to have 3.2 million registered players and 5.3 million non-registered players (World Rugby, 2016).

Rugby in South Africa

South Africa won both the 1995 and 2007 Rugby World Cups and has long tradition of rugby participation. In 1862 the first official rugby match took place in South Africa organised by the headmaster of Bishops College, Mr George Ogilvie. The game was played between the Army and the Civil service (Pinsky, 2014). In 1889 the whites only South African Rugby Board was founded, followed eight years later by the South African Coloured Rugby Football Board, which was founded to oversee matches between black South Africans. In 1906-1907 South Africa fielded its first all-white national team on a tour of the British Isles.

Throughout the first half of the 19th century Afrikaner nationalism grew and became associated with rugby as many Afrikaners saw success in rugby as a way to justify their supposed superiority as a civilisation (Pinsky, 2014). From the early 1950’s the National party started to introduce legislation which formed the backbone of apartheid (separate development for South African racial groups). The legislation segregated public areas in South Africa effectively denying access of black and coloured South Africans to top level sports coaching and training facilities (Pinsky, 2014). The apartheid era laws not only affected sport but also resulted in the general economic strata following racial lines with black and coloured racial groups generally being positioned in the lower socioeconomic categories and whites in the highest or most affluent category (Armstrong et al., 2011). South Africa was banned by the IRB from playing international rugby from 1984-1992 as a result of its apartheid policies.

In the 1990’s South Africa was moving towards democracy and on 19 January 1992 the South African Rugby Football union (SARFU) was established as a non-racial governing body. In the same year South Africa was awarded the hosting of the 1995 Rugby World Cup. In April 1994 Nelson Mandela was elected as the South Africa's first democratically elected president. He supported South Africa hosting the Rugby World Cup. South Africa went on to win the final against New Zealand. This was a critical moment in attempting to redefine the "Springbok" (traditional name for the South African national rugby team) as a symbol of a nation united instead of its former association with apartheid. Despite this fairy-tale story of South Africa winning the 1995 World Cup, this was only the start of a slow transformation process in rugby (Pinsky, 2014).

Transformation in South African Rugby

Transformation in the South African context is an active and legislated process of eliminating discrimination as a result of the policies of apartheid (SRSA, 2011). Ideally the process of transformation in sport should be accomplished through creating equal opportunity and access to facilities, coaching and education. In sport a specific element of transformation is the process of making representative teams reflect the demographics (demographic representation) of the South African population (SRSA, 2011). The population in the South Africa comprises 80% black, 9% coloured and 8% white (STATS, 2014).

To accelerate this process the South African government has placed pressure on National federations to make teams representative (demographic representation) by specific dates agreed upon by these federations and Department of Sport and Recreation South Africa (SRSA). In February 2015 SARU released its Strategic Transformation Plan (STP). This plan detailed various elements of transformation including: demographic representation; access to the game (including women and children); skills and capacity development; sports performance; community development and social responsibility and corporate governance. In relation to demographic representation it detailed how set transformation targets would be reached by 2019 (Green, 2015). A target of at least 50% generic black representation for all teams (provincial and national representative teams) was agreed to by SARU and SRSA. "Generic " is defined by SRSA as ,coloured (those of mixed origin) and Indian players. It was also explained that within the 50% representation there is an expectation that half of those will be black African. "Black African" is defined as a South African player from an indigenous African tribe (Green, 2015).

The background to SARU releasing an official STP was that despite all South Africans being eligible for provincial and national representation since 1992, most of these teams remained predominantly white (players). A study , "Playing time between senior rugby players of different ethnic groups across all levels of South African Rugby, 2007-2011" showed that senior professional rugby in South Africa was still dominated by white players (DuToit et al., 2012). The study tracked playing time for white, coloured and black professional players in provincial and international representative rugby competitions (Vodacom, Currie Cup, Super Rugby and Springboks) from 2007-2011. White representation was shown to be over 70% in all competitions and there had been no significant change in this representation over the 5 year period. This posed the question of why transformation in South Africa has not worked or why is it taking place at a slower rate than expected?

As previously discussed, talent identification and development is a complex process which is dependent on the athlete's natural talent but also on the environment within which the talent is developed (Gagné, 1993; Vaeyens et al., 2008). The environment within which athletes find themselves is determined by a multitude of interrelated factors. These factors are related to the society itself (resources and attitudes, regulations, history etc.), the type of sport and the specific actions of the sport's governing body (Digel, 2002). The history of rugby in South Africa, as previously discussed, provides the context within which transformation must be seen. In the next section we will discuss examples of specific development programmes that SARU and other rugby unions have initiated in an attempt to shape the rugby development environment. We will also discuss the effect of socioeconomic factors on physical development.

Rugby Development pathways/programmes

Earlier on in this review we examined some of the characteristics of development models. We will now look at examples of countries that have clearly defined rugby development pathways/programmes and compare these to South Africa.

Australia and New Zealand have well defined long term talent development models compared to South Africa (Lambert & Durandt, 2010). In New Zealand, the rugby development pathway is clearly defined from a young age. A programme called “Small Blacks rugby” provides rules, coaching material and conditioning advice to assist junior players and coaches. The programme specifies level of contact, size of the fields and the number of players. The aim is to reduce the risk of injury and play a format of the game that is age appropriate from an developmental perspective, and in particular to encourage skill development (Lambert & Durandt, 2010).

Australia has a similar system for its juniors; players are divided into specific age categories, which each have their own set of rules and adaptations. In South Africa the various provinces have implemented programmes with adjusted rules for juniors. However, there is no coordinated or standardised programme for junior rugby development in South Africa (Lambert & Durandt, 2010). Some have suggested that as a result of the high number of players within the junior ranks (table 3) in South Africa that SARU has never had to place emphasis on junior development (Lambert & Durandt, 2010).

Table 3: Registered rugby players in South Africa, New Zealand and Australia in 2010 and 2016 (Lambert & Durandt, 2010; WorldRugby, 2016)

Age groups	South Africa	New Zealand	Australia
Pre-teens	239 614	63 924	25 609
Teens	148 779	40 257	20 002
Seniors	84 522	27 203	37179
Total 2010	472 915	131 384	82 790
Total 2016	405 438	150 000	230 000

The large dropout rates in 2010 in South African rugby (table 3), as players go from pre-teens to teens and seniors, may be symptomatic of a system that works on the “survival of the fittest”. This high dropout rate may also be related to socioeconomic circumstances in South Africa. This will be discussed in the next section.

Weight grade rugby

One unique element of the New Zealand rugby union’s player development programme is creating leagues and competitions in specific territories that use weight grade rugby. In weight grade rugby, there are weight cut off categories for players to play above or below their chronological age group. The goal of this format is to ensure players are similarly sized (World Rugby, 2014). This system has been implemented in most of the territories with large urban populations where there are enough players. The system was implemented as certain children from specific ethnic backgrounds tend to develop earlier than the average player their age. The fear was that this phenomenon would cause a high dropout rate due to parents fearing that their children would be injured when playing against similarly aged but bigger boys (World Rugby, 2014). Weight grade rugby was initially trialled at a junior level but now there are senior under 85 kg leagues for adults. An under 85 kg U20 league was trialled in 2017 in some territories in an attempt to reduce the high fall out rate between school and club rugby (Auckland rugby, 2016). Although the number of weight grade leagues and competitions are growing in New Zealand, it has not been taken up on a large scale by other rugby playing countries, although some countries like Scotland and Australia have tried to create special dispensations for players who are extremely large or small (World Rugby, 2014).

Several rugby unions, including the RFU and SARU have recently commissioned reviews of weight grade rugby (Lambert, Forbes, & Brown, 2010; C. Morgan, 2017). These reviews highlighted the following factors that unions should consider before implementing weight grade rugby:

- There is currently no scientific evidence that weight grade rugby reduces the risk of injury.
- Players matched for weight may not be matched from a physiological, psychological, cognitive or skills perspective.
- Peer group participation is a big driver for participation and separating players from their peers may effect this.
- There have been examples in New Zealand rugby of individuals and teams using extreme measures in an attempt to make weight categories.
- One may need a highly developed infrastructure to implement and police a weight grade based playing system.
- The weight grade system is only used in urban areas in New Zealand where there are sufficient numbers to implement it successfully.

Schools rugby in South Africa

School rugby in South Africa has always been considered the key to rugby's development strategy (Durandt et al., 2013). The high number of schools and youth players in various age groups testifies to this (Lambert & Durandt, 2010). One of the criticisms levelled at SARU is that most of the Springboks are produced from so-called traditional rugby schools; these schools are still predominantly white schools (Parker, 2013; Smith, 2015). In 2013 SARU commissioned a survey to quantify the level of participation in rugby at a school level. The survey showed that there were 1147 high schools and 1315 primary schools who played rugby in 2012 (Durandt et al., 2013). One of the main findings of the survey was that several primary and high schools were stopping rugby at their schools. In 2012, 72 (6%) high schools had stopped playing rugby in that year while only 36 had started playing. In the primary schools 98 (8%) had stopped playing rugby, while only 32 had started playing (Durandt et al., 2013). The main reasons provided for this were:

- Lack of interest from pupils
- The lack of coaches (there are few trained coaches at schools), facilities and resources to propagate the game.
- One key area highlighted was that there was no set format/structure advocated by SARU in relation to rugby at the U6-U9 level

The survey was not able to provide the number of black, coloured and white players in primary schools and high schools, as not all schools were prepared to answer this question. What was evident, however, was that there were many black and coloured players playing rugby, but the vast majority of these players were from previously disadvantaged communities and did not have access to facilities, coaches and levels of competition required to produce high level players.

Youth Tournaments

The SARU organises annual national youth tournaments at U13 (Craven Week), U16 (Grant Khomo week) and U18 (Craven Week and Academy Week) level. Each province holds trials and sends representative teams to these national tournaments. The aim of these tournaments is to create a talent development pathway for youth rugby from U13 to U18 Level.

The first Craven Week Tournament was staged in July 1964. The idea for a national schools tournament arose out of a necessity to bring the top school boys together to celebrate the 75th anniversary of the South African Rugby board. The tournament was named after the famous Springbok rugby player and coach Dr Danie Craven. The tournament is today rated as one of the top school boy rugby tournaments in the world (Nienaber, 2013). The tournament has a reputation for unearthing and helping to develop some of the top rugby talent in South Africa. The number of Springboks to have passed through this tournament attests to this fact (Colquhoun, Grieb, & Heath, 2009).

The initial aim of the tournament was to invite representative school teams from every provincial region within South Africa. The 15 teams who participated in the first Craven Week were: Boland; Border; Eastern Province; Easter Transvaal; Griqualand West; Natal; North Eastern Cape; Northern Transvaal; Orange Free State; Rhodesia; South West Africa; South Western Districts; Transvaal ; Western Province; Western Transvaal (Rugby365, 2014). The number of teams invited to compete in subsequent years has fluctuated, ranging from 20 to a peak of 32 teams in 2000. Since then the administrators have kept the number of teams under 22 with the teams representing the 14 provinces and with some provinces, such as Eastern Province, Border and the Blue Bulls being allowed to send two teams to the tournament. The additional teams were named “Country Districts teams” to signify that they were made up of players chosen from the outlying areas of those specific provinces. In addition to the South African provincial teams, Namibia and Zimbabwe usually send their national schools team. In 1974 it was decided that a South African (SA) schools team would be selected from the South African players at the tournament. Since then it has become an annual occurrence. This team has often played against foreign teams or other local representative teams such as the SA Academy team.

The tournament has been shaped by a number of key changes over the years. Prior to 1980, in accordance with the apartheid policies of the time, only white boys were invited to participate in the tournament. In 1980 Dr Craven forced the organisers of the tournament to invite players representing all race groups. In 1992 the former SA Rugby Board (SARB) and SA Rugby Union (SARU) united to form the South African Rugby Football Union (SARFU)(Pinsky, 2014). In 1996 it was decided to formally introduce a quota system to increase the number of players of colour (defined as players who were black or coloured) at the Craven Week tournament. The details about the initial quota targets are lacking. The SARU can presently only provide documentation as far back as 2002 which shows that the required ratio of players of colour to white in 2002 was 6:16 with a minimum of 3 players of colour being on the field at all time (Booysen, 2002). This quota has gradually increased and in 2009 the requirement was for teams to select 13 white players and a minimum of 9 players of colour (SASA, 2009). In 2009 the South African Schools Rugby Association decided to change the word “quota” and to rather use the word “targets”. The revised requirements also stipulated that a minimum of four players of colour be required to be on the field at all times. Teams that could not meet these targets needed to provide written justification three weeks before the start of the tournament (SASA, 2009). The current target is 11 players of colour and 11 white players per team (Green, 2015).

In 1987 the SARB introduced a separate youth project tournament for school boys who did not make the provincial Craven Week team. The basic idea was that the school provincial “A” side would go to Craven Week while the provincial “B” side would go to this tournament, which became known as the Academy Week. By 1991 sixteen teams were competing in this competition. The quotas for this tournament were different to Craven Week, with a minimum of 50% players of colour being required in each team. The idea of Academy Week was to increase the opportunities for those players not selected for their provincial “A” teams.

There have been concerns over increasing demands placed on U13 players at a provincial and national level related to the number of games and the mismatch in size of the players (Durandt et al., 2015; SASS, 2014). Most experts agree that promoting participation should take precedence over competition at U13 level as a result of the vastly different maturation ages within the same chronological age group (Balyi, 2012). This is exacerbated in rugby because of the importance of size, which results in many coaches at this age group choosing the biggest boys and not necessarily those with the most talent.

SARU development programmes and initiatives

Jurie Roux the CEO of SARU claims that since 1992 the federation has spent over R 500 million rand on development programmes to assist with transformation (Roux, 2015). The aim of these development programmes was to try and create structures which would promote transformation. A few examples of these programmes include:

Nike All Stars programme

This programme ran for 1999-2002, with an emphasis on identifying and developing young talent and focused on players from 12-15 years of aged (DuToit et al., 2012). Players from all racial groups were selected nationally and invited to training camps with high level coaches. Some of the most talented players were provided with bursaries from the top rugby schools in South Africa.

Spoornet Rugby Excellence programme

The Spoornet programme was similar to the Nike all starts programme but was for senior players and ran from 1998-2002 (DuToit et al., 2012). The top black and coloured senior players were invited to training camps and provided with medical and financial assistance where required. The aim of the programme was to provide support to the players who were selected for the programme, to ensure they stayed in the system.

Green and Elite Squads

The green squads ran from 2003-2006 and the elite squads ran from 2007-2009 (DuToit et al., 2012). The aim of these squads was to provide additional coaching, nutritional, conditioning and medical support to players. Squads of talented players (30 players per squad) in each of the 14 provincial rugby unions at U16, U17, U18, U19, U20 were selected. These players received support from their provincial unions who had to report to SARU on the progress of each player over time. The aim for these squads was for them to have equal representation of white and players of colour. The exact representation was not tracked.

Mobile Team training system (MTTS)

The Sport Science Institute of South Africa (SSISA) designed mobile gyms called the Mobile Team Training System (MTTS). These were shipping containers that were modified and refurbished with strength and conditioning equipment and placed at rural rugby clubs. (DuToit et al., 2012). The aim of the programme was to provide access to strength and conditioning facilities for players from previously disadvantaged communities who lived in rural areas. This programme ran from 2003 to 2017, with 40 gyms being distributed around the country during this period. When these MTTS were placed in a community, training on strength and conditioning was also provided and these clubs received ongoing support until 2017. Most of these gyms were funded by the South African National Lotteries Board (NLB). This funding has now ceased, and although the most of the gyms are still being used these clubs no longer receive support from SARU due to the NLB funding for this project having ceased. SARU won the International Rugby Board (IRB) development award for this project in 2012.

SARU regional academies

In 2012 SARU received R35 million in funding from the NLB to establish regional rugby academies to promote black and coloured rugby talent (Reeves, 2016). These academies were established in the following provinces: Border; South Western Districts; Boland and Eastern Province. The aim of these academies was to help U19 and U21 black and coloured players to transition from junior to senior rugby. The academies were an attempt to provide an ideal development environment for young talented black and coloured players who had not been accepted into other professional teams. The players were provided with accommodation, coaching, conditioning, gym access, medical services, top level competition and an opportunities to study. These academies were operational from 2013-2016. The SARU closed all four of these academies in 2016 as a result of not being able to secure funding to sustain them financially (Zingisa, 2016). A major drawback of this project was that the academies were not able to attract enough high quality black and coloured players. This may have been as a result of these academies not being able to compensate players at market related rates for a professional sport (Personal communication: H Scriba, SARU Manager Academy Operations). In February 2018 SARU announced a new initiative where the aim is to place 30 of the top U19 and U20 black and coloured players at a national academy for four months of the year. The players would remain contracted to their unions but would be seconded to the national academy for four months of the year. The success of the project is dependent on the unions releasing these players. The main aim of the academy is to ensure that these young players are helped to remain and move up into the senior provincial and super rugby pathway. The players will receive expert coaching, conditioning and medical support during their stay (Ray, 2018).

Socioeconomic status and physical development

Socioeconomic status (SES) is the social standing of an individual or group and is usually measured by education, income or occupational status (White & McTeer, 2012). In South Africa between 1948 and 1994 individual socioeconomic opportunities and the development of community level infrastructure was institutionalised by the system of apartheid (Burgard, 2002). This resulted in the general economic strata following racial lines, with black and coloured people being positioned in the lower socioeconomic categories and the whites in the highest or most affluent categories (Armstrong et al., 2011).

Socioeconomic status has been shown to affect physical development, participation rates and physical performance (Armstrong et al., 2011; Bogin, 2013; Klein et al., 2016; Malina, 2004; White & McTeer, 2012). It is therefore important to try and ascertain what affect the socioeconomic status of black and coloured people in South Africa has had on their physical development. Tobias (1990) observed a negative or stagnant secular trend in stature from the early twentieth century to 1970 for South

African black adult males. The stature of white adults over a similar period increased 0.5 cm per decade (Henneberg & van den Berg, 1990). These stagnant trends in growth have resulted in South Africa being used as a model to prove the effect of socioeconomic status on secular growth trends (Bogin, 2013; Burgard, 2002). These differences in the height and weight of black and white South Africans has been confirmed in more recent studies. A study performed in the 1980's on black and white children showed that the white children were significantly taller and heavier at all ages (Chaning-Pearce & Solomon, 1986). A study by Hawley et al. (2009), examined a cohort of South African black and white urban children at 1962 and at 2001. They showed significant increases in skeletal maturity and stature of urban black children compared to no significant increases in white children. This shows that there may be a positive trend developing in the general black population, particularly in those people who move to urban areas (Hawley et al., 2009). Despite the significant trend the black children weighed less and were shorter than their white counterparts.

The socioeconomic status as mentioned can also effect general motor and sports specific performance. The differences can be pronounced and manifest from an early age. This was shown in a study of 10 295 South African children between the ages of 6 and 13 years of age. All the children were tested with a modified EUROFIT test battery (Armstrong et al., 2011). The white male children were significantly heavier and taller than their coloured and black counterparts. The black boys were on average 10 cm shorter and 6 kg lighter than the white boys. Furthermore the white boys outperformed the black and coloured boys children on most of the tests of physical ability except for flexibility. When these results were adjusted for socioeconomic status, the anthropometrical and performance differences were greatly reduced. This study clearly shows the importance of socioeconomic status on physical development.

Demands of the game

Quantification of the demands of a sport especially during match play are important for developing training strategies to replicate and improve match performance (Read, Ben Jones, Padraic, et al., 2017a). These data in youth rugby can also assist to create more effective talent identification and development strategies related to the specific physiological requirements of the game and positions within a team (Read, Ben Jones, Phibbs, et al., 2017b). The advent of technologies such as Time Motion Analysis (TMA) and more recently, Global Positioning Systems (GPS) technology have improved the ability of researchers to more accurately quantify the specific physiological demands of the game (Cunniffe et al., 2009; Lacome, Piscione, Hager, & Bourdin, 2013).

The initial focus for the quantification of the demands of rugby was on senior adult rugby but more recently there have been data presented regarding youth rugby. We will review an example of data for senior adult rugby and then examine the data for youth rugby.

Cunniffe et al. (2009) studied senior elite club players in the Guinness Premiership. From a general physiological perspective they showed that the players' mean and peak heart rates were 172 and 200 bpm^{-1} respectively. They were exercising at 80 to 85% of VO_2max during the game. The backs spent more time at 80-90% HRmax than the forwards, whereas the forwards spent more time at 90 to 95% HRmax than the backs. These data show the high intensity nature of the game. The intermittent nature of the game was shown by the movement data where players spent 72% of the time standing and walking, 19% jogging, 3% cruising, 4% striding, 1% high intensity running, and 1% sprinting. This represents a work-to-rest ratio of 1:5.7 (meaning that for every 1 minute of running there was almost 6 minutes of low intensity activity). This may seem like a long period of low intensity activity but these periods are filled with pushing and pulling activities in rucks, mauls and scrums and were not quantified by GPS in this study. Players covered on average 6953 m in a game with the backs (7227 m) covering on average more distance that the forwards (6680 m). Accelerations and sprints are another component of the game. The players performed 87 moderate intensity runs (>14 km.h^{-1}). Backs performed a greater number of sprints (34 vs. 19) at higher speeds (>20 km.h^{-1}) as opposed to the forwards who completed a great number of lower speed (6-12 km.h^{-1}) sprints (315 vs. 229). Game impacts were also measured in this study. The game impacts were divided into 3 categories (heavy, very heavy and severe). The forwards had more overall impacts compared to the backs (789 vs. 1274).

Several recent studies have focused on the quantification of the demands of youth rugby in an attempt to better identify and develop youth players (Cunningham et al., 2016; Deutsch, Maw, Jenkins, & Reaburn, 1998; Hartwig, Naughton, & Searl, 2011; Read, Ben Jones, Padraic, et al., 2017a; Read, Ben Jones, Phibbs, et al., 2017b; Venter, Opperman, & Opperman, 2011). Hartwig et al. (2011) conducted time motion analysis research on a group of 118 Australian male adolescent rugby players, aged 14 to 18 and examined training versus game demands. These players covered on average 4000 m per game and there was no significant differences between backs and forwards in distance covered. The average duration of sprints was 2 seconds and the players completed on average 22 sprints per game. Deutsch et al. (1998) examined data on elite U19 players and showed that backs covered significantly more distance during match play compared to forwards (6540 m vs. 4240 m). A study using U20 international level players showed that the total distance covered was greater for backs than forwards (6230 vs. 5370 m) (Cunningham et al., 2016). These distances were comparable to distances covered in senior rugby.

Although these studies all looked at youth rugby they did not quantify the differences between the various age groups within youth rugby. This is important as the approach to training adolescent athletes needs to be specific to the various ages in this key period of physical growth and biological maturation (Read, Ben Jones, Padraic, et al., 2017a). Read et.al (2017a) looked at the magnitude of differences between playing positions and age groups within adolescent (U16, U18 and U20) representative rugby in England. From a locomotor perspective the total distance covered was analysed using velocity zones specific to rugby (Low Speed Running LSR: 0–3.33 m.s^{-1} and High Speed Running HSR: >3.33 m.s^{-1}). Player load (PL) was measured to quantify the external load that players' experienced. This measurement represents the accumulated accelerations in the 3 axes of movement. Player load slow (PL$_{slow}$) was data analysed where velocity was <2 m.s^{-1}, to identify static exertions. The player load and locomotor variables were all analysed relative to the amount of time spent on the field (m.min^{-1}), as a result of the varying game time with different age groups.

The data from the study showed that for all age groups relative distance covered and HSR.min^{-1} was greater for backs with the magnitude of the differences being greater in the older age groups. The forwards had higher values of PL.min^{-1}and PL$_{slow}$.min^{-1} per minute than backs for all age groups, showing the more physical nature of forward play. These data replicates the differences between forwards and backs in senior rugby. When comparing between age groups the data showed the relative distance covered, HSR.min^{-1} and PL.min^{-1} all decreased with age for both backs and forwards. In contrast to these measures which decreased with age, PL$_{slow}$.min^{-1} was the only performance measure that increased with age. The rationale for this is an inverse relationship between HSR, PL.min^{-1} and physical contract (a decrease in locomotor values with an increase in contact) . The PL$_{slow}$.min^{-1} does seem to plateau at U18 meaning that the big shift in physicality in the game happens between U16 and U18. This finding has implications for training strategies used by coaches and trainers when progressing players from U16 to U18. They need to be prepared for this physical challenge. The U16's relative distance covered is comparable to senior players, but the big barrier for players based on the data in this study would be the increase in the amount of physical contact.

Physical size and success in rugby

Factors contributing to performance in rugby are multifaceted and include physiological ability, technical skills, tactical, age, maturation and psychological acumen (Fontana et al., 2017; Howard et al., 2016; Jones et al., 2018; McCarthy & Collins, 2014; Sedeaud et al., 2012; Smart et al., 2011; Till et al., 2011). Physical size of players is also positively associated with success in rugby (Barr, Newton, & Sheppard, 2014; Gabbett et al., 2009; 2010; Olds, 2001; Sedeaud et al., 2012; 2013; Till et al., 2011; 2013b)). For example, at recent World Cup events, teams that were more successful had the heaviest and tallest players (Barr et al., 2014; Sedeaud et al., 2012). In addition, the importance of size is emphasized by the study of Olds (2001), which showed that the body mass of international rugby players increased by 2.6 kg per decade between 1905 and 1999, well above the secular trend for body mass increases in young males over the same period. Also a recent study of elite level under 20 players showed that body mass increased by 20% over a 13 year period (1998–2010) (Lombard et al., 2015). Several studies have investigated the various reasons for this size increase, including the onset of professionalism, law changes, conditioning and improved nutritional strategies (Berthelot et al., 2015; Olds, 2001; Quarrie & Hopkins, 2007; Sedeaud et al., 2012; 2013; 2014). In France, for example, the number of foreign-based rugby players at an elite level has increased from 2% in 1988 to 36% in 2013. The foreign-based players are significantly taller and heavier than the local French players (Sedeaud et al., 2013). Sedeaud et al. (2013) describes how this process has come about as a result of the natural process of teams selecting bigger and stronger players until the native group of players was depleted. The teams were then forced to start buying bigger players from around the world.

A recent study by Fontana et al. (2017) retrospectively analysed the anthropometric and functional characteristics of 531 male U16 players Italian rugby players who went on to play at a national or international level. They compared the players to their source population and showed that only 2% of the source population possess the combination of body mass and height that existed in this group of players. These data reflect the trend of coaches picking "super-sized players". This trend of players becoming taller and heavier is also evident in other contact and non-contact sports such as American football (Anzell, Potteiger, Kraemer, & Otieno, 2013; Sedeaud et al., 2014), soccer (Buchheit et al., 2014), swimming and sprint athletics (Charles & Bejan, 2009). The research above shows that physical size plays an import role in rugby success.

The source population of a country may have many anthropometric variations (Olds, 2001; Rush, Freitas, & Plank, 2009; Zemski et al., 2015). These variations are at times also associated with certain racial groups (Malina, 2009). Three studies have examined the impact of morphology on performance in rugby union and rugby league, particularly the impact of racial groups (Cheng et al., 2014; Krause et al., 2015; Zemski et al., 2015). Zemski et al. (2015) examined the body composition traits of 37 international Australian rugby athletes of Caucasian and Polynesian descent. They showed that while there were no whole body composition differences between the two groups, there were significant regional differences. The authors concluded that the physical demands of rugby may be better complemented by the specific body composition traits of the Polynesian athletes.

Cheng et al. (2014) assessed various anthropometric parameters of 116 (Polynesian and non-Polynesian) Australian junior rugby league players (average age was 17 years). The Polynesian players were taller (181.0 vs. 178.0 cm), heavier (90.6 vs. 84.7 kg) and had a greater mesomorphic classification (7.6 vs. 6.7) compared to non-Polynesians. The authors concluded that there was a potential bias for selecting Polynesian players and early maturing athletes as a result of the advantage their size and mass provides in rugby.

A third study by Krause et al. (2015) highlighted the complexity of size on performance. This study showed there is not always a direct correlation between size and physical performance in rugby specific fitness tests. They studied 485 Australian male community rugby union players at U12, U13, U14 and U15 level. Twenty one percent of these players were from an Islander heritage (Maori or Pacific Islander). The body mass, stature, speed (10, 30 and 40 m sprints) and lower leg power (vertical jump) of the players were measured. The authors divided the data into age-specific tertiles (thirds). They concluded physical size was not always predictive of superior performance in the rugby specific performance tests. They did however find that the Islanders were in the upper tertiles for body mass, height and BMI in the younger group. This may have been as a result of early maturation in Islanders; however, this could not be verified because maturation was not measured in the study. The Islanders in the older group were in the upper tertiles for relative peak power and height.

Table 4 provides the body mass and stature data from several rugby union studies completed in different countries on junior players. These can be used to help create a range of values within which other junior players can be compared to.

*Table 4: Body mass (kg) and stature (cm) for several rugby union studies completed in different countries. *The exact age in months of these players was not provided.*

Author	Country	Age	Level	Stature	Body mass
Darrall-Jones et al. 2015	England	16.9 ± 0.5	English Academy	183.5 ± 7.2	88.3 ± 11.9
Vaz et al. 2015	Portugal	17.9 ± 0.5	National team	179.1 ± 7.0	82.9 ± 13.4
Delahunt et al. 2013	Ireland	16.9 ± 0.8	Elite schools	180 ± 6.37	78.64 ± 8.57
Durandt et al. 2006	South Africa	18*	Elite schools	179 ± 6.7	84.9 ± 8.3

Conclusion

Rugby Union has a rich tradition in South Africa with the national team having won both the 1995 and 2007 World Cups. The game of rugby union has evolved since becoming professional in 1995, with the emphasis on bigger, faster and more powerful players. As a result the size of players has increased at a faster rate than the source population (Olds, 2001; Sedeaud et al., 2013). Several studies have shown that the physical size of rugby players is positively associated with success (Barr et al., 2014; Olds, 2001; Sedeaud et al., 2012; Vaz, Morais, Rocha, & James, 2014). These developments have impacted on the development pathways in rugby with the changes to the professional game filtering down to youth rugby. A confirmation of this is the large size increases in youth players (u20) over the last decade (Lombard et al., 2015).

The SARU uses a specific model of talent identification called the pyramid model of sports participation. This model relies on its National youth tournaments (U13, U16 and U18) to identify and develop talent. This model has been criticised for contributing to the high dropout rates in youth rugby (Lambert & Durandt, 2010). Research in South Africa on the relative age effect in junior and senior rugby has confirmed this by showing that there is an over-representation of players born in the first quarter of the year (Grobler et al., 2016; Kearney, 2017). This indicates inefficiencies within the talent identification systems. It may be beneficial at this time for SARU to review its current model of talent identification and development in the light of newer models such as the Composite Youth Development Model. This new model is a composite of several models which have a more solid scientific basis than the one currently utilised.

Talent identification and development within rugby and other sports in South Africa has become an area of focus as a result of transformation being seen as a national priority (SRSA, 2012). South Africa's apartheid history has created socioeconomic restraints which may be affecting SARU's efforts at transformation. Senior professional rugby at all levels is still dominated by white players (DuToit et al., 2012). A contributing factor to this lack of transformation could be the socioeconomic status of black and coloured players. Research recently conducted in South Africa on 10 295 children aged 6-13 years showed that economic status can effect general development, motor development and sport specific performance.

There are many unanswered questions about the lack of transformation and the development of players in South African rugby. The structures that currently govern rugby at a youth level may be contributing to a lack of transformation. A key age spectrum that needs to be examined is between the ages of 13 and 18. In an attempt to contribute to knowledge so that the system can be improved, two studies were conducted which are described in chapters 3 and 4.

Chapter 3 examines the development pathway of rugby in South Africa by measuring how many players who attended U18 National Craven Week had attended U13 and U16 National youth tournaments. This chapter was prepared as a publication and published; "Durandt, J., Parker, Z., Masimla, H., & Lambert, M. (2011). Rugby-playing history at the national U13 level and subsequent participation at the national U16 and U18 rugby tournaments. *South African Journal of Sports Medicine*, *23*(4), 103–105". As a consequence there may be partial overlap with material presented in the literature review.

Chapter 4 examines the changes in body mass, stature and BMI in South African elite U18 rugby players from different racial groups (2002-2012). The data collection stopped at the tournament in 2012 and therefore the study could not continue beyond this date. This study was also prepared and published; "Durandt, J., Green, M., Masimla, H., & Lambert, M. (2017). Changes in body mass, stature and BMI in South African elite U18 Rugby players from different racial groups from 2002-2012. *Journal of Sports Sciences*, *36*(5), 477–484". As a consequence there may be partial overlap with material presented in chapters 2 and 3.

CHAPTER THREE

Rugby playing history at the U13 Level and subsequent participation at the national U16 and U18 rugby tournament

Introduction

The South African Rugby Union (SARU) hosts four national competition tournaments for junior players (13 - 18 years of age) each year. These tournaments are designed to be the pinnacle of SARU's talent identification and development programme. The national tournaments are divided into three age groups, U13 Craven Week, U16 Grant Khomo Week and U18 Craven Week and Academy week.

The reason for the first national schools tournament in July 1964 was to bring the top high school boys together to celebrate the 75th anniversary of the South African Rugby board. The tournament was named after the famous Springbok rugby player and coach Dr Danie Craven. The U18 tournament has been held annually since then and is currently rated as one of the top school-boy rugby tournaments in the world (Nienaber, 2013). The tournament has a reputation for identifying and developing talent in South Africa, supported by the fact that several Springboks played in the tournament as schoolboys (Colquhoun et al., 2009).

To understand the context of these age group tournaments in relation to talent identification, it is necessary to firstly define this term, as there is currently no consensus on the definition of either talent identification (TID) or talent development (TDE). Therefore for the purpose of this paper the definition used in a recent review of talent identification and development models in sport will be used (p. 403): Talent Identification (TDI) is 'the process of recognising current participants with the potential to excel in a particular sport' and TDE is described as 'providing the most appropriate learning environment to realise this potential' (Vaeyens et al., 2008).

The first systematic talent identification and development programmes were implemented by the communist countries in the 1960s and 70s (Pearson et al., 2006). Other countries, such as China and Australia, used substantial state resources to fund TID and TDE programmes in the 1980's and 1990s (Digel, 2002). These programmes have created the perception held by many parents, coaches and administrators that talented adolescent athletes can be detected or identified by measuring those characteristics that predict success in adult competition. This traditional view has been contradicted in the scientific literature where erroneous assumptions and problems have been identified (Pearson et al., 2006; Vaeyens et al., 2008). For example, the main problem with this model is that most talent identification programmes are directed at the adolescent age group (11 - 18 years), an age which is characterised by much variation as a result of different rates of development (Pearson et al., 2006). Furthermore, talent is not simply the measurement of innate abilities, but results from the interaction of these innate abilities with the environment within which the athlete develops (Vaeyens et al., 2008). For these reasons the traditional models, popularised in the 1980s and 1990s, are now being challenged. This has resulted in a general shift towards athlete development rather than talent identification. The models that best encapsulates this shift is the Long Term Athlete Development (LTAD) model (Balyi, 2012) and the Composite Youth Physical Development (CYD) Model (Lloyd et al., 2015). These models describe the different stages of physical, mental, emotional and cognitive development of children and adolescents. The main emphasis of these models is to provide more time and opportunities for athletes to develop, especially those athletes who mature at a later stage. In addition, these model provides guidelines on the types of activities related to talent identification and skill acquisition that are appropriate at the different age groups. The models provide a framework within which each sport discipline can create an athlete development pathway catering for the demands of that sport.

Early research on talent identification of young rugby players (8 - 13 years) in South Africa indicated that talented players could be identified at an early age (Pienaar & Spamer, 1998). However, this study and a subsequent follow-up study did not track whether these talented young players developed into older talented players, particularly after they had matured through puberty (13 - 18 years) (Spamer &

Hare, 2001). In a recent commentary we show how South Africa has 9.4 and 3.7 times as many pre-teen players compared with Australia and New Zealand respectively, yet at a senior level South Africa has only 3.1 and 2.3 times as many players as Australia and New Zealand (Lambert & Durandt, 2010). It may be argued that SARU has to place less emphasis on organised talent identification as there is such a large pool of pre-teen players (n=239 614) (Lambert & Durandt, 2010). With such a large pool of players, the precision and efficiency of the system becomes less important because the expectation is that the talented players will emerge as a result of the competition. It follows that SARU has adopted the approach of organised competition as its main source of talent identification and development. With this approach, and the strong competition between rugby-playing schools, the chances of talented players emerging are very good. However, this approach might also account for the large attrition of players from pre-teens to seniors observed in South Africa, but not in a country such as Australia which places less emphasis on competition at these young ages (ARU, 2015).

In contrast to the competitive model for young players, adopted by SARU, most experts agree that promoting participation should take precedence over competition at a young age (Way & Balyi, 2007). Particularly at the U13 level players have different maturation ages. Therefore there is a bias for the coaches to select the bigger boys who may be more mature, but not necessarily more talented. There have been discussions about changing the format of the National U13 tournament and to rather use the resources for activities aimed at player retention and participation (Personal communication: M Green, SARU Transformation Manager). One of the problems SARU has had in making these decisions is that there is no hard evidence supporting either side of the argument. Therefore the aim of the study was to provide objective data to determine how many boys who played at a U13 national tournament went on to play at the U16 Grant Khomo and U18 Craven Week tournaments. We hypothesised that the representation of the U13 players in the older groups would get progressively lower because the factors which determine performance in rugby at an U18 level are not evident at the U13 level and only partially developed by 16 years of age.

Methods

The study was conducted in the form of a survey (appendix A) and was retrospective in nature. The questionnaire was developed to gain insight into player history regarding previous representation and player profiles. The SARU player database was used to validate information provided from the survey. The 2005 U13 Craven Week list of players from the SARU database was used for analysis. The year 2005 was selected as this was the first year that all the names of all players attending the week were entered into an electronic database. These names were checked against all the names of all the players attending the U16 Grant Khomo or the U18 Craven Week tournaments between 2006 and 2010, using the SARU database. The names were manually sorted to determine representation of the players over the duration of the study. This manual process was checked using the '*vlookup*' and '*match*' functions in excel. Permission to use the data from the database was obtained from the Faculty of Health Sciences Research and Ethics committee of the University of Cape Town.

Results

Sixteen teams attended the 2005 U13 Craven Week. Each team was permitted to have 22 players (n=352). However, the actual number of players listed on the SARU database was n=349 as a result of three teams only having 21 players listed.

Figure 7 shows that one 2005 U13 player (0.3%) participated in the U16 Grant Khomo Tournament in 2006, five players (1.4%) participated in 2007 and 107 players (30.7%) participated in 2008. The results show that the players had a greater representation in the U16 tournament as their age increased from U14 to U16 over three successive years. Figure 8 shows that in total 110 (31.5%) players who played U13 Craven Week were selected for U16 Craven Week in 2006 - 2008. The totals in Figure 8 are less than the totals in Figure 7 because 3 players from 2007 also participated in 2008. As a result of them participating for 2 years in succession they were not counted as repeats in the total.

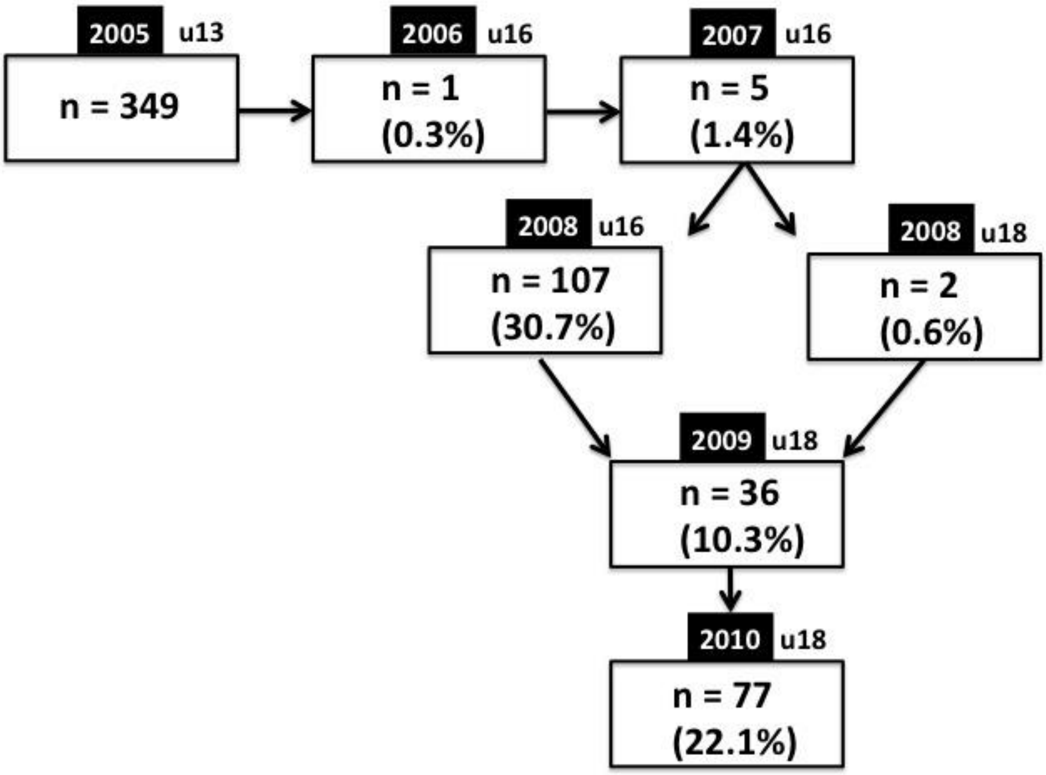


Figure 7: Number of players from the 2005 U13 tournament who played at subsequent U16 Grant Khomo and U 18 Craven Week Tournaments. The data are expressed as a percentage of the 2005 U13 tournament (n = 349). Reproduced from Durandt et al. (2011)*, with permission, https://journals.assaf.org.za/sajsm.*

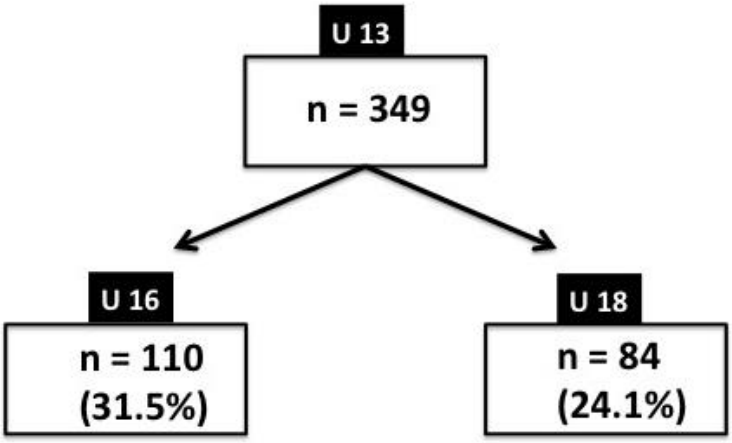


Figure 8: The total number (and percent) of the players from the 2005 U13 tournament who played at the U16 Grant Khomo and U18 Craven Week tournaments. Reproduced from Durandt et al. (2011)*, with permission, https://journals.assaf.org.za/sajsm*

Figure 7 also shows that two players (0.6%) from the U13 tournament participated in the U18 Craven Week in 2008, 36 players (10.3%) participated in 2009 and 77 players (22.1%) participated in 2010. As expected, the number of players participating increased as the players got older. Figure 8 shows that 84 players (24.1%) of the 2005 U13 Craven Week players played at the U18 tournament between 2008 and 2010. Only six of the U18 players who played in 2009 did not play in 2010 and only one of the two players who played U18 in 2008 also played in 2009. Therefore there were a total of 84 players if the non-repeats were added to the 2010 total. The representation decreased by 7.4% from U16 (31.5%) to U18 (24.1%).

Discussion

The main finding of this study was that the majority of players from the 2005 U13 Craven Week were not selected for either the U16 (69%) or the U18 Craven Week tournament (76%) a few years later. These results can be interpreted in one of two ways. Firstly, the attributes that determined success at the U13 level had changed at the U16 and U18 level. A number of studies have measured players of various ages to identify key physiological characteristics associated with performance in rugby (Deutsch et al., 1998; Durandt, Tee, Prim, & Lambert, 2006b; E. J. Spamer, 2009). These include body size, aerobic capacity, muscular strength and endurance, speed and muscle power. There is no evidence that the contribution to performance of these key physiological characteristics change with player age, and therefore this explanation cannot account for the poor conversion of success at the U13 level to success at the U16 and U18 levels.

An alternative interpretation is that the U13 players had characteristics associated with success in rugby, but these characteristics changed as the players got older. This is a more likely explanation, particularly since the span from 13 to 18 years encompasses puberty and maturation. It follows that more mature players of the same chronological age (U13) will have an older biological age. These players are more likely to be bigger, faster and stronger (Malina, 2004; 2014) and as a result of these characteristics will perform better than players who are less biologically mature. The late maturers who are talented will not be selected at this age (U13) and may only be selected at a high level after they have matured (U16 or U18). Some of these players may also choose to participate in another sport in which they can excel (Howard et al., 2016; Till et al., 2013b). The latter scenario could account for the major attrition that occurs in South African rugby (Lambert & Durandt, 2010).

These results support the current consensus in the scientific literature that describes the complexities in identifying talent in early adolescence (Pearson et al., 2006; Vaeyens et al., 2008). A recent editorial stated that "The prediction of long term success is extremely difficult and the later successful athletes are not necessarily the ones who performed best in youth competitions" (p.683) (Elferink-Gemser, Jordet, Coelho-E-Silva, & Visscher, 2011). This is especially true in sports, such as rugby, where body size is related to performance (Fontana et al., 2017; Gabbett et al., 2009; 2010; Howard et al., 2016; Sedeaud et al., 2013; Till et al., 2013b). A recent study by Till et al. (2016) in rugby league highlights the complexity of predicting talent at a young age and casts further doubt on the current SARU talent identification model.

What practical steps can be taken to address this problem? The first step is to acknowledge that talent identification is a complex process achieved by a combination of physical attributes, skills, attitudes and behaviours (MacNamara & Collins, 2011). The next step is to adopt a more pragmatic approach to develop talent from a young age. MacNamara and Colins (2011) highlight the fact that many talent identification programmes operate in resource-challenged environments and that this necessitates the need to establish sports policy against strong evidence-based research. This is true of the South African environment where any programme needs to increase general participation levels and the quality of this participation, while at the same time having clear pathways to elite participation.

In summary, these results suggest that talented young players (U13) do not necessarily become talented older players (U16 and U18). The emphasis placed on talent identification at the young level (U13) may be associated with the high attrition in participation from pre-teen to teens and then senior level in South African rugby (Lambert & Durandt, 2010). Changes need to be made to the LTAD programme of SARU considering these data in the revised plan.

CHAPTER FOUR

Changes in body mass, stature and BMI in South African elite U18 Rugby Players from different racial groups from 2002-2012

Introduction

Rugby union (rugby) is a team sport characterized by intermittent, short duration bouts of high intensity activity involving collisions between players. The players need to be strong and powerful to meet these demands (Cunniffe et al., 2009). A rugby team consists of 8 forwards and 7 backline players. In general, the forwards are required to compete for and retrieve the ball and are generally heavier, taller and slower than the backline players. The main function of the backline players is to gain field position and score points (Lombard et al., 2015; Smart et al., 2011).

Factors contributing to performance in rugby are multifaceted and include technical skills, tactical and psychological acumen (Sedeaud et al., 2012; Smart et al., 2011). Physical size of players is also positively associated with success (Barr et al., 2014; Olds, 2001; Sedeaud et al., 2012; 2013; Vaz et al., 2014; Vaz, Vasilica, Carreras, Kraak, & Nakamura, 2016)). For example, at recent World Cup events, teams that were more successful had the heaviest and tallest players (Barr et al., 2014; Sedeaud et al., 2012). In addition, the importance of size is emphasized by the study of Olds (2001), which showed that the body mass of international rugby players increased by 2.6 kg per decade between 1905 and 1999, well above the secular trend for body mass increases in young males over the same period. Also a study of elite level under 20 players showed that body mass increased by 20% over a 13 year period (1998–2010) (Lombard et al., 2015). Several studies have investigated the various reasons for this size increase, including the onset of professionalism, law changes, conditioning and improved nutritional strategies (Berthelot et al., 2015; Olds, 2001; Quarrie & Hopkins, 2007; Sedeaud et al., 2012; 2013; 2014).

South Africa has a rich tradition in rugby having won both the 1995 and 2007 senior as well as 2012 U20 International Rugby World Cups. Players from the three main racial groups play rugby in South Africa: black (those of African ancestry), white (those of Caucasian ancestry), and coloureds (those of mixed origin, a uniquely South African group). These racial groups are defined by the government of South Africa and national sporting bodies to track the progress of transformation in sport (SRSA, 2012). Transformation in sport is seen as a national priority in South Africa due to the legacy of apartheid (SRSA, 2011). During the Apartheid era, which ended in 1994, numerous discriminatory laws were implemented based on race. The vast majority of blacks and coloureds did not have equal access to sports, coaching, competitions or facilities (SRSA, 2011). The Apartheid era laws not only affected sport but also resulted in the general economic strata following racial lines with black and coloured racial groups generally being positioned in the lower socioeconomic categories and whites in the highest or most affluent category (Armstrong, Lambert, & Lambert, 2011).

Rugby at all senior professional levels in South Africa is still dominated by white players (DuToit et al., 2012). For example, a recent study showed there had been no change in the racial profile of professional rugby players from 2007 to 2011, despite the vast investments of the South African Rugby union (SARU) into development programs in an attempt to expedite transformation (DuToit et al., 2012).The SARU has for several years monitored the racial profiles of all its representative provincial teams. To understand the lack of change in these racial profiles over time SARU decided to monitor key indicators of performance over time in the various racial groups. National competitions provide an opportunity to monitor some of these key variables. The SARU hosts a national competition tournament for U18 players each year. This tournament is designed to be the pinnacle of SARU's youth talent identification and development program (Durandt et al., 2011). Trends in player demographics at this tournament will arguably be reflected at the adult level, a few years later and provide information about the extent of transformation in rugby. A number of studies have investigated how players from different ethnic groups in specific countries may have morphologies that could enhance their overall performance in rugby union (Cheng et al., 2014; Krause et al., 2015; Zemski et al., 2015).

Therefore the aim of this study was to determine whether there are differences between racial groups for body mass, stature and body mass index (BMI) in South African elite U18 rugby players and whether these measurements changed significantly between 2002-2012.

Methods

Participants

The study design was a retrospective survey. Questionnaires were completed by rugby players who attended the Craven Week U18 rugby tournament from 2002 to 2012 (n=4007) (Table 1). This tournament caters for the U18 rugby players who are selected by their provinces (Brown et al., 2012), and generally represents the best rugby talent in the country, with many of the players continuing to become professional rugby players (Durandt et al., 2011). The players selected for this tournament represent approximately 0.9 % of the U18 players in South Africa.

Procedures

The questionnaire was completed by the players at a workshop conducted by the High Performance Centre (HPC) of the Sports Science Institute of South Africa and the SARU. The questionnaire was developed by the HPC to gain insight into each player's history. Players were also asked to report their stature and body mass. Instructions were given and players were allowed to ask questions if anything was unclear. Teams were required to submit body mass and stature of each player before the tournament for the tournament program, therefore it was assumed that the players would know their own body mass and stature. To test the accuracy of this assumption we measured the actual body mass and stature of all players during one tournament (2010), and compared this to the self- reported data. Body mass was recorded to the nearest 0.1 kg on a calibrated scale (Seca model 708, Seca, Hamburg, Germany). The players were weighed in undergarments and without shoes. The stature of each player was recorded to the nearest millimeter using a stadiometer (Seca model 708, Seca Germany). BMI was calculated as the weight (kg) divided by the height squared (m^2) (Keys, Fidanza, Karvonen, Kimura, & Taylor, 1972).Race was self-reported as white, black or coloured. The authors are aware of the pitfalls of using racial terms as a grouping variable (Ncayiyana, 2007), however in the context of South Africa these are standard racial classification terms used to quantify racial transformation in society, particularly sport. Permission to use the data from the HPC database was obtained from the Faculty of Health Sciences Research and Ethics committee of the University of Cape Town.

Statistical analysis

The validation data (measured vs. self-reported body mass/stature) were analyzed with a Pearson's product moment correlation and Bland Altman limits of agreement (Bland & Altman, 2012). The Levene's test for homogeneity of variance was used before the data were analyzed using the one-way analysis of variance ($p<0.05$). The analysis included the main effects of time and race, and the interaction of time X race. Levene's test for homogeneity of variance was significant for racial groups. We analyzed the data using the non-parametric Kruskal Wallis test and got the same results as results from the analysis of variance. Therefore, we opted to just report the analysis of variance results. A Tukey HSD test was used for the *post-hoc* analyses ($p<0.05$). All data were analyzed using the StatSoft, Inc. (2012) STATISTICA (data analysis software).

Growth Charts were used to compare stature and body mass to the source population. In South Africa the US Centers for Disease Control (CDC) growth charts (2000) and the World Health Organisation (WHO) charts are used to monitor growth. The WHO charts do not provide weight to age charts for children over 10 years of age. It was therefore decided to use the CDC charts, which have also been used in other rugby union and rugby league studies (Cheng et al., 2014; Krause et al., 2015).

Results

The number of teams at the tournament, number of players surveyed and the compliance for each year is shown in Table 5. A total of 4007 players completed the questionnaire, out of a total of 4224 players at the tournaments (i.e. 95% compliance). Certain players from teams missed the survey due to injury or other commitments. Although 4007 players completed questionnaires, specific players omitted individual variables and there are therefore slight differences in the sample sizes for body mass, stature and BMI.

Table 5: The sample size of teams surveyed from 2002 to 2012. Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.

Year	Number of Teams at the tournament	Number of teams surveyed	Number of players at the tournament	Number of players Surveyed	Percentage surveyed
2002	20	20	440	427	97
2003	16	16	352	343	97
2004	16	16	352	343	97
2005	16	16	352	347	99
2006	16	16	352	323	92
2007	16	15	352	326	93
2008	18	18	396	380	96
2009	20	17	440	359	82
2010	18	18	396	387	98
2011	18	18	396	385	97
2012	18	18	396	387	98
Total	192	188	4224	4007	95

The validation of the self-reported vs. directly measured variables (body mass and stature) for the 2010 data is shown in Figure 9. The standard error of the estimate (SEE) for body mass and stature were 2.4 kg and 2.82 cm respectively. The correlation between self-reported and measured body mass and stature were r = 0.99 and r = 0.94 respectively. The limits of agreement (LOA) for body mass were -4.1 to 5.5 kg whereas the LOA for stature was -4.5 to 6.8 cm (Figure 10).

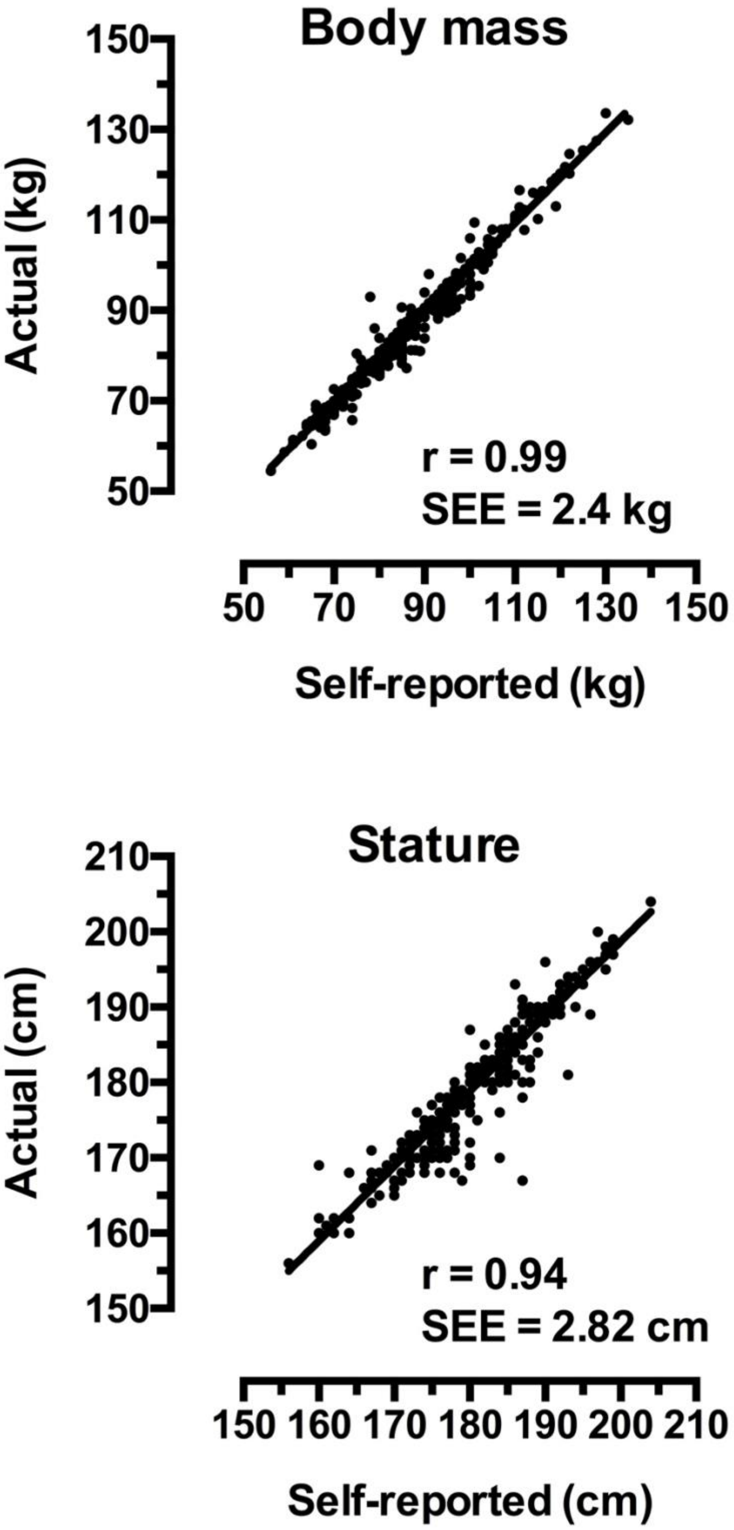
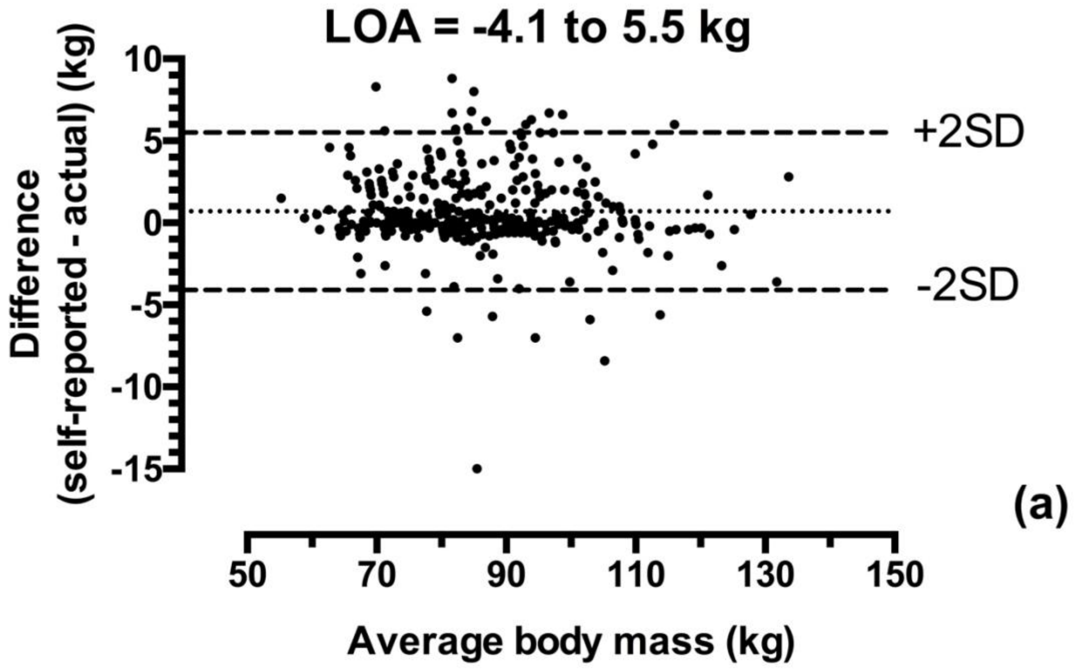


Figure 9: Correlation coefficient (r) and standard error of the estimate (SEE) for actual and self-reported body mass and stature. Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.



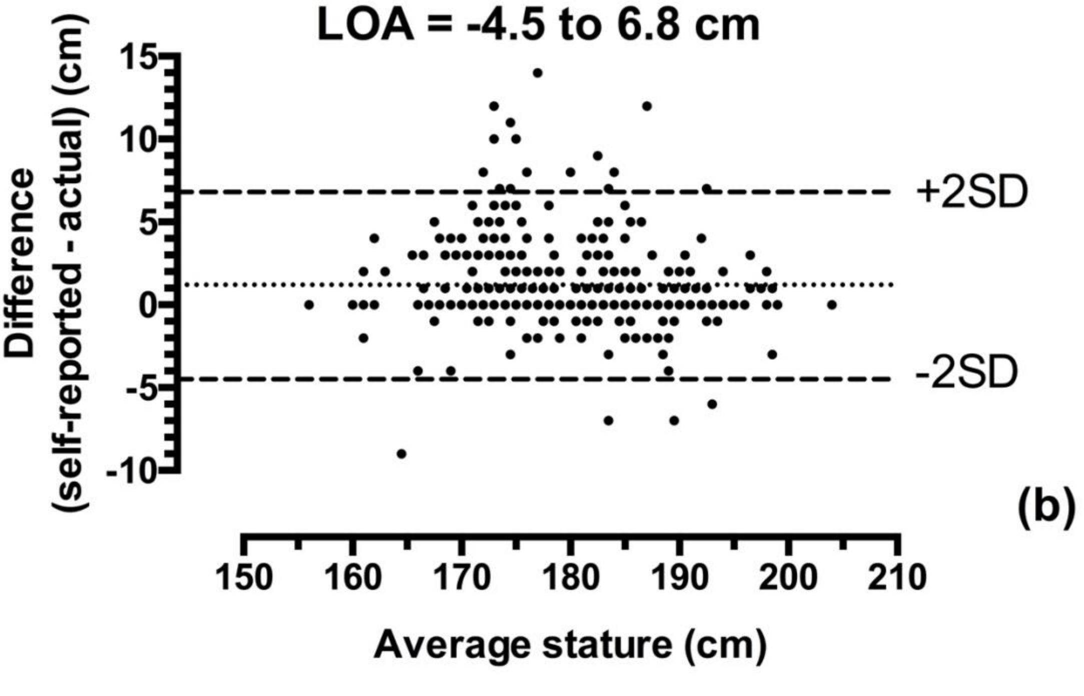


Figure 10: Limits of agreement (LOA) for body mass (a) and stature (b). Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.

The average age of the participants (4007) at the tournament was 17.7 ± 0.7 years. There were no significant differences in the age between white (17.8 ± 0.5 years), black (17.5 ± 0.7 years) and coloured players (17.6 ± 0.6 years).

There were significant differences in body mass between white, black and coloured players (P-value <0.0001) (Table 6), with the average body mass of white players being 9.8 kg heavier than the black players, who were on average 2.3 kg heavier than coloured players.

The body mass of all groups increased significantly from 2002-2012 (p < 0.0001). The interaction between group X time was not significant. The specific changes are shown in the legend beneath Table 6.

Table 6: Body mass (kg) of players from 2002 to 2012 (n = 3999). Values are expressed as mean ± SD. Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.

Year$^{\#}$	**White**	***n***	**Black**	***n***	**Coloured**	***n***	**Total***	***n***
2002	86.9 ± 11.7	272	79.1 ± 10,0	90	77.4 ± 11.7	65	83.8 ± 12.0	427
2003	89.5 ± 11.1	217	81.0 ± 11.9	85	76.3 ± 9.3	41	85.8 ± 12.2	343
2004	90.7 ± 11.2	209	79.8 ± 11.7	79	77.0 ± 10.8	55	86.0 ± 12.7	343
2005	90.8 ± 11.2	188	79.2 ± 10.7	92	76.6 ± 11.7	67	85.0 ± 12.9	347
2006	90.7 ± 11.9	181	79.9 ± 9.5	84	77.3 ± 11.2	58	85.5 ± 12.6	323
2007	91.5 ± 11.5	177	81.3 ± 9.6	81	78.9 ± 12.3	67	86.3 ± 12.6	325
2008	90.3 ± 11.0	217	81.3 ± 10.7	89	77.8 ± 11.2	73	85.8 ± 12.2	379
2009	90.8 ±12.3	199	80.0 ± 12.8	91	78.3 ± 11.0	67	85.7 ± 13.4	357
2010	91.0 ± 13.1	226	81.8 ± 12.5	85	79.8 ± 12.6	74	86.8 ± 13.8	385
2011	93.2 ± 12.1	225	83.0 ± 11.8	86	81.0 ± 12.9	72	88.6 ± 13.3	383
2012	93.4 ± 12.3	208	83.6 ± 11.9	98	81.9 ± 13.9	81	88.5 ± 13.6	387
Total	**90.7 ± 11.9**	**2319**	**80.9 ± 11.3**	**960**	**78.6 ± 12.0**	**720**	**86.2 ± 12.9**	**3999**

#Main effect of *time*	p < 0.0001	($F_{10, 3966} = 5.53$)
2002 vs. 2010, 2011, 2012	p < 0.012	
2003 vs. 2011	p < 0.043	
2005 vs. 2011, 2012	p < 0.002	
2006 vs. 2011, 2012	p < 0.031	
2008 vs. 2011	p < 0.033	
2009 vs. 2011, 2012	p < 0.040	
* Main effect of *group*	p < 0.0001	(($F_{2, 3966} = 430.31$)
White vs. Black	p < 0.00002	
White vs. Coloured	p < 0.00002	
Coloured vs. Black	p < 0.00002	
Interaction *group* X *time*	p = 0.946	($F_{20, 3966} = 0.550$)

The percentage change in body mass from 2002-2012 for white, black and coloured player groups are shown in Figure 11. The percentage changes are calculated using the body mass of white players in 2002 as the anchoring point (Figure 11). The overall percentage change for each racial group was: 7.5% (6.5kg) (white), 5.8% (4.5kg) (black) and 5.7% (4.5kg) (coloured). This equates to an increase of 0.65kg/year for white players, and 0.45kg/year for black and coloured players.

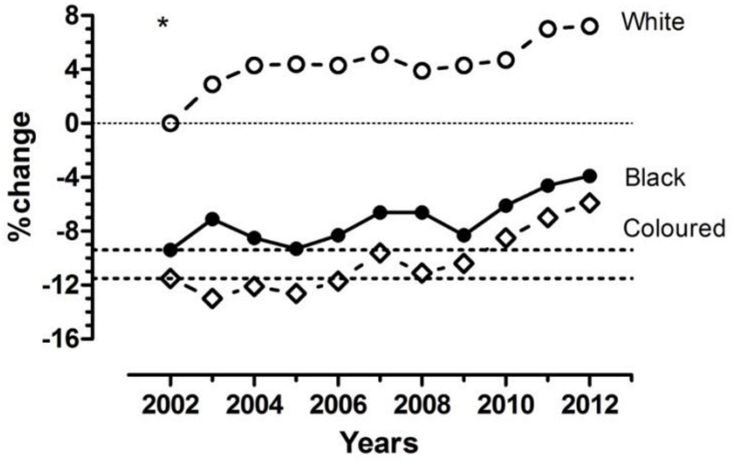


Figure 11: Percentage change in body mass for U18 white, coloured and black between 2002 and 2012. (The average range between the lower and upper 95 % confidence intervals for white, coloured and black players was 0.3, 0.6 and 0.1%, respectively). Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.
** The percentage changes are calculated using the body mass of white players in 2002 as the anchoring point.*

The body mass for the 50th to 75th, 90th to 97th percentiles and 97th and above percentile for 17.7 year olds from the CDC growth tables are as follows: 66.3–74.5 kg, 83.9–95.9 kg and >95.9 kg respectively for body mass (CDC, 2000).

When comparing the results to the CDC growth tables, the mean body mass for the group (86.2 ± 12.9 kg) was above the 90th percentile. White players' (90.7 ± 11.9 kg) mean body mass was above the 90th percentile. Black (80.9 ± 11.3 kg) and coloured players (78.6 ± 12.0 kg) were above the 75th percentile.

There were significant differences in stature between white, black and coloured players ($p < 0.0001$) (Table 7). On average white players were 7.0 cm taller than black players who were 0.5 cm taller than coloured players. Players' stature measurements did not change significantly during the study period (2002-2012).

Table 7: Stature (cm) of players from 2002 to 2012 (n = 4007). Values are expressed as mean ± SD. Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.

Year [a]	**White**	***n***	**Black**	***n***	**Coloured**	***n***	**Total** [b]	***n***
2002	182.9 ± 7.6	272	177.8 ± 8.0	90	176.8 ± 7.5	65	180.9 ± 8.1	427
2003	184.3 ± 7.3	217	177.4 ± 10.1	85	176.1 ± 8.7	41	181.6 ± 8.9	343
2004	185.1 ± 7.1	209	176.5 ± 9.3	79	175.8 ± 7.3	55	181.6 ± 8.8	343
2005	184.6 ± 6.4	188	176.7 ± 9.0	92	176.7 ± 9.1	67	181.0 ± 8.6	347
2006	184.7 ± 6.9	181	177.4 ± 8.7	84	176.3 ± 7.6	58	181.3 ± 8.4	323
2007	184.5 ± 6.8	178	177.5 ± 9.8	81	178.1 ± 9.2	67	181.4 ± 8.8	326
2008	183.5 ± 6.9	217	178.3 ± 8.5	90	175.9 ± 7.6	73	180.8 ± 8.1	380
2009	183.8 ± 6.9	199	175.9 ± 8.0	93	176.2 ± 7.5	67	180.4 ± 8.2	359
2010	184.1 ± 6.9	226	175.9 ± 6.9	87	176.7 ± 8.3	74	180.9 ± 8.2	387
2011	184.6 ± 6.3	225	178.2 ± 8.4	87	176.5 ± 7.6	73	181.6 ± 7.9	385
2012	184.8 ± 7.2	208	177.8 ± 8.2	98	178.0 ± 7.6	81	181.6 ± 8.3	387
Total	**184.2 ± 7.0**	**2320**	**177.2 ± 8.6**	**966**	**176.7 ± 8.0**	**721**	**181.2 ± 8.4**	**4007**

[a] Main effect of *time* $p = 0.356$ ($F_{10, 3958} = 1.10$)

[b] Main effect of *group* $p < 0.0001$ ($F_{2, 3958} = 441.4$)
White vs. Black $p < 0.00002$
White vs. Coloured $p < 0.00002$

Interaction *group* X *time* $p = 0.473$ ($F_{20, 3958} = 0.99$)

The percentage change in stature for each racial group is shown in Figure 12.

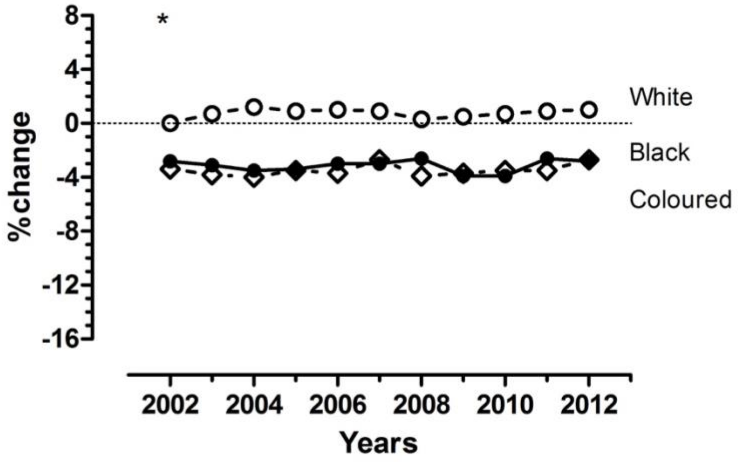


Figure 12: Percentage change in stature for U18 white, coloured and black players between 2002 and 2012. (The average range between the lower and upper 95 % confidence intervals for white, coloured and black players was 0%, 0.2% and 0.4% respectively). Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.
** The percentage changes are calculated using the stature of white players in 2002 as the anchoring point.*

The stature for the 50th to 75th, 90th to 97th percentiles and for the 97th and above percentiles for 17.7 year olds from the CDC growth tables are as follows: 175.9–180.7 cm, 184.9–189.1 cm and >189.1 cm respectively (CDC, 2000).

The mean stature of the group (181.2 ± 8.4 cm) was above the 75th percentile. White players (184.2 ± 7.0 cm) were above the 75th percentile. Black players (177.2 ± 8.6 cm) and coloured players (176.7 ± 8 cm) were above the 50th percentile.

The body mass index of the players is shown in Table 8. There were significant differences between groups ($p < 0.0001$). The average BMI of white players was 0.9 kg.m^{-2} greater than black players who in turn were on average 0.7 kg.m^{-2} greater than coloured players. The interaction (group X time) were not significant, suggesting all groups changed similarly over time. The specific differences are shown beneath Table 4. The overall percentage change for BMI (figure 5) from 2002-2012 was 5.4% (1.4 kg.m^{-2}) for white players, 4.9% (1.2 kg.m^{-2}) for coloured players and 5.6% (1.4 kg.m^{-2}) for black players.

Table 8: Body mass index of players from 2002 to 2012 (n = 3988). Values are expressed as mean ± SD. Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.

Year[#]	**White**	***n***	**Black**	***n***	**Coloured**	***n***	**Total**[*]	***n***
2002	25.9 ± 2.8	272	25.0 ± 2.8	90	24.7 ± 3.0	65	25,6 ± 2.9	427
2003	26.3 ± 3.0	217	25.8 ± 3.5	85	24.5 ± 1.7	41	26,0 ± 3.1	343
2004	26.5 ± 2.9	209	25.6 ± 3.5	79	24.8 ± 2.6	55	26,0 ± 3.1	343
2005	26.6 ± 2.9	188	25.3 ± 3.0	91	24.5 ± 2.9	67	25,9 ± 3.0	346
2006	26.6 ± 2.9	181	25.5 ± 2.8	82	24.8 ± 3.0	58	26,0 ± 3.0	321
2007	26.9 ± 3.1	177	26.0 ± 3.9	81	24.8 ± 3.0	67	26,2 ± 3.4	325
2008	26.8 ± 2.9	217	25.7 ± 3.4	88	25.0 ± 2.7	71	26,2 ± 3.1	376
2009	26.8 ± 3.1	199	25.9 ± 3.6	89	25.2 ± 3.5	67	26,3 ± 3.4	355
2010	26.8 ± 3.2	226	26.4 ± 3.7	85	25.5 ± 3.2	73	26,5 ± 3.3	384
2011	27.3 ± 3.1	225	26.2 ± 3.4	86	26.0 ± 3.2	71	26,8 ± 3.3	382
2012	27.3 ± 3.0	208	26.4 ± 3.7	98	25.9 ± 3.5	80	26,8 ± 3.3	386
Total	**26.7 ± 3.0**	**2319**	**25.8 ± 3.4**	**954**	**25.1 ± 3.1**	**715**	**26,2 ± 3.2**	**3988**

#Main effect of *time*	$p < 0.000001$	($F_{10, 3958} = 4.50$)
2002 vs. 2010, 2011, 2012	$p < 0.022$	
2003 vs. 2012	$p < 0.031$	
2004 vs. 2012	$p < 0.045$	
2005 vs. 2011, 2012	$p < 0.020$	
2006 vs. 2012	$p < 0.032$	
2009 vs. 2011, 2012	$p < 0.040$	
* Main effect of *group*	$p < 0.00001$	($F_{2, 3958} = 82.60$)
White vs. Black	$p < 0.00002$	
White vs. Coloured	$p < 0.00002$	
Coloured vs. Black	$p < 0.00007$	
Interaction *group* X *time*	$p = 0.990$	($F_{20, 3958} = 0.44$)

The percentage change in BMI from 2002 to 2012 is shown in Figure 13.

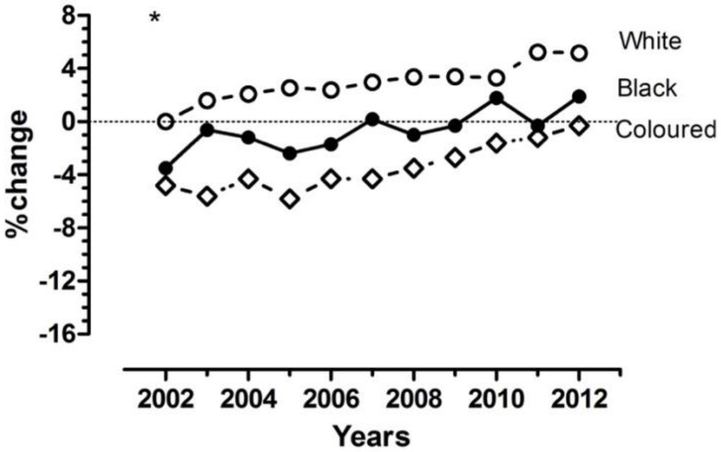


Figure 13: Percentage change in BMI for U18 white, coloured and black rugby players between 2002 and 2012. (The average range between the lower and upper 95 % confidence intervals for white, coloured and black players was 0.5%, 0.1% and 1.0% respectively). Reproduced from Durandt et al. (2017), with permission, Taylor and Francis group, http://www.tandfonline.com.
** The percentage changes are calculated using the BMI of white players in 2002 as the anchoring point.*

Discussion

The first main finding of this study was that there were significant differences in body mass, stature and BMI between white, black and coloured U18 elite rugby players. In particular white players were on average 9.8 kg heavier than black players who were on average 2.3 kg heavier than coloured players. The white players were also about 7.0 cm taller than black and coloured players. These differences were reflected in BMI results where white players had higher values than black players, who also obtained higher values that the coloured players.

The differences in stature and body mass between the racial groups are in accordance with previous research on the general population in South Africa (Armstrong et al., 2011; Chaning-Pearce & Solomon, 1986; DOH, 2007; Hawley et al., 2009; Henneberg & van den Berg, 1990; Tobias, 1990). However, this study is the first to examine race differences at an elite sports level in South Africa.

The mean body mass of the entire group of players was above the 90th percentile when compared to the CDC growth tables used in South Africa, whereas stature was above the 75th percentile (CDC, 2000). However, when the data were analysed according to race, white players as a group were at the 90th and 75th percentile for body mass and stature compared to black and coloured players who were just above the 75th percentile for body mass and the 50th percentile for stature. This confirms previous research showing that elite level rugby players are much heavier and taller than the age matched general population (Darrall-Jones, Jones, & Till, 2015; Delahunt et al., 2013; Olds, 2001; Sedeaud et al., 2012; Zemski et al., 2015).

In the general population BMI may serve as an estimate of adiposity, however in the athlete population it does not necessarily represent excess body fat (Zhao et al., 2014), but may rather provide an indication of lean body mass (LBM) (Sedeaud et al., 2014). Increasing LBM in rugby, within limits, is regarded as advantageous to the development of strength, speed and power (Sedeaud et al., 2012;

2014). Although LBM was not directly measured in this study, the body mass and stature differences in this study alone, would give the white players a distinct physical advantage in the contact phases of the game (Sedeaud et al., 2013). The size differences in this study are so significant that they equate to black and coloured players having to play in effect an age level above their actual age (Durandt et al., 2006a).

Comparatively, black and coloured players of this study were shorter (177.2 cm, 176.7 cm) and lighter (80.9 kg, 78.6 kg) than U18 players of the English Rugby Union (183.5 cm, 88.3 kg) (Darrall-Jones et al., 2015). They were shorter but similar in body mass compared to school level players from Ireland (180.0 cm, 78.6 kg) who were a year younger than this group (Delahunt et al., 2013). They were shorter and lighter compared to national level Portuguese players (179.1 cm, 82.9 kg) of the same age (Vaz et al., 2016). However, white South African players had similar stature and body mass compared to the English players (183.5 cm, 88.3 kg) who also happened to be white (Darrall-Jones *personal communication*).

These significant differences in body mass, stature and BMI for the various racial groups in South Africa may have important implications for transformation in rugby. For example, the population in the country comprises 80% black, 9% coloured and 8% white (STATS, 2014). However, twenty years after the policy of apartheid was terminated, the national team was still predominantly white (72% white, 19% coloured and 9% black) (DuToit et al., 2012). While the differences in size of the players from different racial groups persist at the junior level, the ability to have a team at the senior level that is representative of the general population is rather limited. In rugby, and other contact sports, coaches have a tendency to select bigger players (Sedeaud et al., 2013). This makes it more difficult for smaller players to progress through the ranks to the high level teams. The trend of choosing bigger players is already evident at the U15 level (Sedeaud et al., 2013).

The source population of a country may have anthropometric variations in specific regions (Olds, 2001). These variations are at times also associated with certain racial groups (Malina, 2009). Several studies have examined the impact of morphology on performance in rugby union, particularly the impact of racial groups (Cheng et al., 2014; Krause et al., 2015; Zemski et al., 2015). These studies are descriptive and do not investigate the causes of these differences. These racial differences should not be explained as “genetic traits” (Hughey & Goss, 2015). Humans share 99.9 % of their DNA and there are often more genetic variations among the same racial groups as opposed to differing groups (Ncayiyana, 2007). Racial groups are therefore not biologically distinct races, but they may have been specifically affected by historical events which result in higher frequencies and formations of relevant genes (Ncayiyana, 2007). It is now accepted in the literature that modifications in the social, economic and political environment are the principle causes of secular changes in growth status (Bogin, 2013; Burgard, 2002). It is for this reason that the differences in anthropometric profiles of the elite rugby players and the general population in the South African should be viewed within a specific historical context.

The second finding of this study was that stature remained similar in all three groups over the study period. A study by Hawley et al (2009), examined a cohort of South African black and white urban children at 1962 and at 2001. They showed significant increases in skeletal maturity and stature of urban black children compared to no significant increases in white children. This shows that there may be a positive trend developing in the general black population, particularly in those people who move to urban areas (Cole et al., 2014; Hawley et al., 2009). As a result of the finding that skeletal maturity and stature of urban black children increased significantly over time, we expected that the body mass of black and coloured players would increase at a faster rate than that of white players. The similar change in body mass may be attributed to the possibility that the factors that affect body mass in athletes in the short term (resistance training, training volume, nutrition) may have exerted a greater effect than the effect of a change in socioeconomic status. In contrast changes in stature take much longer to manifest once the socioeconomic environment improves (Bogin, 2013). We did not measure the maturational status of black and coloured players as compared to white players but this may also play a role in the ability of the different racial groups to compete on an equal footing (Malina et al., 2015).

Tobias (1990) observed a negative or stagnant secular trend in stature from the early 20th century to 1970 for South African black adult males. The stature of white adults over a similar period increased 0.5cm per decade (Henneberg & van den Berg, 1990). These negative or stagnant trends in growth have resulted in South Africa being used as a model to prove the effect of socioeconomic environment on secular trends for growth (Bogin, 2013; Burgard, 2002). Although players' socioeconomic status was not measured in this study, white players will generally have a higher socioeconomic status than black and coloured players. The socioeconomic factors can also effect general motor and sport specific motor performance (Armstrong et al., 2011; Klein et al., 2016). The differences can be pronounced and manifest at an early age. This was shown in a study of 10 295 South African children between the ages of 6 and 13 years who did the EUROFIT test battery (Armstrong et al., 2011). The white male children were significantly heavier and taller than their coloured and black counterparts. The black boys were on average 10 cm shorter and 6 kg lighter than the white boys. Furthermore, white boys outperformed black and coloured children on most of the tests of physical ability except for flexibility. When the results were adjusted for socioeconomic status the anthropometrical and performance differences were greatly reduced. This shows the importance of socioeconomic factors on physical development (Armstrong et al., 2011). No studies, have examined the time it takes to reverse the socioeconomic induced effects on general and sports specific motor control after the socioeconomic conditions have been improved. This is an important question, because it impacts on the ability to provide equal opportunities for everyone, particularly in a contact sport such as rugby where size is an important prerequisite for performance.

The issue of size in rugby players is not only restricted to South Africa. In France the number of foreign-based rugby players at an elite level has increased from 1.8% in 1988 to 36.2% in 2013. The foreign-based players are significantly taller and heavier than the local French players (Sedeaud et al., 2013). Sedeaud et al. (2013) describes how this process has come about as a result of the natural process of teams seeking bigger and stronger players until the native group of players was depleted. The teams were then forced to start buying bigger players from around the world. In the South African context, this process of natural selection favours the white players who have an advantage over their black and coloured counterparts based on size. To counter this the SARU have been running developmental and high performance programs for the past 20 years. The goal of these programs has been to accelerate the development of black and coloured players through to an elite level (DuToit et al., 2012). The lack of major changes in the composition of elite adult teams suggests that the programs have either been ineffective, not sufficiently aggressive or that the transformation of rugby in South Africa will take much longer and be dependent on the changes in the socioeconomic conditions.

Conclusion

This study shows there are significant size differences between racial groups at an elite under 18 level in South Africa. These differences in body mass, stature and BMI, which are associated with success in rugby, have not changed over the 10-year study period. These size differences may have a major effect on black and coloured players, and prevent them from progressing through the ranks of junior to senior rugby. These racial differences in size may be having a similar effect as seen with the relative age effect in rugby union (where older players are favoured for selection because of their size) (Grobler et al., 2016). This study raises important questions. Administrators, sport scientists, conditioning coaches and coaches are generally aware of issues related to maturation and their effects on performance and selection of teams, but how aware are they of these racial differences? Are the rugby development pathways in South Africa set up in such a way to make allowance for these differences? These results may have implications for the pace of transformation in rugby in South Africa. Until the differences in size at the youth level are negated or accounted for in the various programmes and structures, the smaller black and coloured players will be at a disadvantage compared to their white counterparts. Future research should focus on quantifying what effect these size differences have on players progressing to an elite level. This research should also measure socioeconomic status rather than using the indirect measures we used in this study.

CHAPTER FIVE

General discussion

Thesis summary

The aim of this thesis is to examine the player history and profiles of U18 players attending the national U18 Craven Week to gain insight in to the player pathway and the physical profiles of white, black and coloured players over time. With this in mind the first objective of the thesis was to examine the profiles of U18 Craven Week rugby players to gain insight into the development pathway from U13 to U18. A second objective was to understand factors influencing transformation by measuring the physical profiles of the various racial groups over time. A set of questions were provided in the introductory chapter, which will now be summarised, followed by a conclusion, practical applications and suggestions on future research.

1. *How many players who attended U13 Craven Week go on to attend U16 and U18 Craven Week?*

The first study showed that the majority of players who attended the U13 Craven Week in 2005 were not selected for either the U16 or U18 Craven Week tournament a few years later. Only 31.5% of the players who played in the U13 Craven Week were again selected for the U16 Craven Week and 24.1% were selected for the U18 Craven Week tournament.

2. *What are the physical profiles of the U18 players from various racial groups at Craven week between 2002-2012?*

Self-reported body mass, stature and body mass index (BMI) were analysed for all players (n = 4007) who attended the U18 Craven Week between 2002-2012. The average age of players at the tournament was 17.7 ± 0.7 years. There were no significant differences in age between white (17.8 ± 0.5 years), black (17.5 ± 0.7 years) and coloured players (17.6 ± 0.6 years). There was a significant difference in body mass between white, black and coloured players, with the average body mass of white players being 9.8 kg heavier than the black players, who were on average 2.3 kg heavier than coloured players. There were also significant differences in stature between white, black and coloured players. On average white players were 7.0 cm taller than black players who were 0.5 cm taller than coloured players. The BMI being a function of body mass and stature also showed significant differences between groups. The average BMI of white players was 0.9 kg.m^{-2} greater than black players who in turn were on average 0.7 kg.m^{-2} greater than coloured players.

3. *Have these profiles change over time?*

The body mass of all groups increased significantly from 2002-2012. All groups changed similarly over time with the overall percentage change for each racial group was: 7.5% (6.5 kg) (white), 5.8% (4.5 kg) (black) and 5.7% (4.5 kg) (coloured). This equates to an increase of 0.65 kg/year for white players, and 0.45kg/year for black and coloured players. Players' stature measurements did not change significantly during the study period (2002-2012). All groups changed similarly over time with the overall percentage change for BMI from 2002-2012 being 5.4% (1.4 kg.m^{-2}) for white players, 4.9% (1.2 kg.m^{-2}) for coloured players and 5.6% (1.4 kg.m^{-2}) for black players.

4. *How do these various profiles compare to the general population?*

The Centres for Disease Control and prevention (CDC) growth charts were used to compare the players to the general population. The results confirmed previous research showing that elite level rugby players were much heavier and taller than their age matched general population. When comparing the results to the CDC growth tables, the mean body mass for the group (86.2 ± 12.9 kg) was above the 90th percentile. White players' (90.7 ± 11.9 kg) mean body mass was above the 90th percentile.

Black (80.9 ± 11.3 kg) and coloured players (78.6 ± 12.0 kg) were above the 75th percentile. The mean stature of the group (181.2 ± 8.4 cm) was above the 75th percentile. White players (184.2 ± 7.0 cm) were above the 75th percentile. Black players (177.2 ± 8.6 cm) and coloured players (176.7 ± 8 cm) were above the 50th percentile.

5. How do these various profiles compare to other international rugby players of the same age?

The data showed that the black and coloured players were shorter and lighter compared to their overseas counterparts whereas the white players were similar. The black and coloured players of were shorter (177.2 cm, 176.7 cm) and lighter (80.9 kg, 78.6 kg) than U18 players of the English Rugby Union (183.5 cm, 88.3 kg). They were shorter but similar in body mass compared to school level players from Ireland (180.0 cm, 78.6 kg) who were a year younger than this group. They were shorter and lighter compared to national level Portuguese players (179.1 cm, 82.9 kg) of the same age. However, white South African players had similar stature and body mass compared to the English players (183.5 cm, 88.3 kg), who also happened to be white.

Conclusion and practical application

Study one showed how only a minority of players who are selected for U13 Craven Week go on to play U18 Craven Week. This finding confirms previous talent identification research which highlights the complexity of talent selection in early adolescence (Güllich & Emrich, 2014; Moesch et al., 2011; Pearson et al., 2006). The SARU currently uses a pyramid model of sports participation for its talent identification and development programmes. This model uses competition as a primary source identifying and developing talent (Bailey & Collins, 2013). The model has been criticised for forcing players to move up or out of the system (Lloyd et al., 2015). This model may have contributed to the high levels of drop out seen from pre-teen to teen level in South African rugby (Lambert & Durandt, 2010). In addition to the use of this problematic model, there is also a growing trend of early specialisation and increasing levels of the amount and intensity of competition (Durandt et al., 2015).

Junior rugby forms the base of your player pathway and needs to be healthy in order to provide sustained growth over time. An independent survey commissioned by SARU showed that there are decreasing levels of participation at a junior level (Durandt et al., 2013). The decreasing levels of junior participation and the high dropout rates between pre-teen and teen may require a change in approach. The new talent identification and development models such as the LTPD and CYD advocated player pathways that create opportunity to remain or re-enter the player pathway at multiple points over time. The current SARU development platform operates on the principle of "survival of the fittest". This is evident in the data showing a RAE for both junior and senior players in South Africa (Grobler et al., 2016; Kearney, 2017). Kearney (Kearney, 2017) states that the under representation of players born in the final quarter of the year in South African rugby suggests an inherent inefficiencies within the current talent development system. Players are accessing support and opportunities based on current maturation status rather than future potential.

Study two showed significant differences between racial groups for body mass, stature and BMI. These findings are very significant in the south African context. South Africa has a history of institutionalised racism which came to an end with the election of the first black president in 1994. These positive changes resulted in an urgency for transformation in all areas of society including sport. This transformation has been slow in South Africa rugby with the majority of professional teams still predominately white and therefore not representing the actual demographics of the country (DuToit et al., 2012). This study may provide some insight as to why this process of transformation in rugby is so slow.

Rugby is a contact sport and the literature shows that size plays a considerable role in rugby success (Barr et al., 2014; Olds, 2001; Sedeaud et al., 2012). There is a tendency for coaches to pick bigger and early maturing players at a junior level. This makes the significant size differences between racial groups very significant. These size differences may be creating a "racial effect" which is similar to the RAE which has been well documented. The size differences are so big that they equate to black and coloured players having to play in effect an age level above their actual age (Durandt et al., 2006a). In specific European countries like England and Italy where they monitored the progression of elite versus sub elites there was no difference in size between the groups (Fontana et al., 2017; Till et al., 2015). The authors suggest that these groups had already become relatively homogeneous as a results of the performance demands of the sport. This is not the case in South Africa where our black and coloured players are smaller than the white players and their international counterparts of the same age.

The South Africa black and coloured source population is shorter and lighter than the source white population (Cole et al., 2014; Hawley et al., 2009). This is related to specific regional genetic traits and socioeconomic factors which have been well document in South Africa (Bogin, 2013; Burgard, 2002). The negative or stagnant growth trend in South Africa in the black population for most of the 19th century has been associated with the negative socioeconomic environment this group was forced to endure. The time it takes to reverse these types of socioeconomic environments is not clear. There have been some positive growth signs in the black source populations and we therefore expected this to transfer into the black players to be getting taller or bigger at a faster rate than the white players (Hawley et al., 2009). The data in the current study showed that all players were not growing taller and that they were all getting heavier at a similar rate, indicating that the size difference in youth rugby players from different racial groups have remained constant over the last decade. In addition to the effects that the socioeconomic environment can have on size in the South African context it has also been shown to affect sports performance in youth (Armstrong et al., 2011).

These two studies highlight the need for SARU to re-evaluate their current talent identification and development system. How can a system be created where black and coloured players are supported to remain or re-enter the player pathway at multiple levels ? South Africa has a rich rugby tradition and has relied on its school system to develop quality players through a high level of coaching and competition. The problem with the school rugby system from a transformation perspective is that the top rugby schools are predominantly white (Parker, 2013). The majority of the black and coloured schools do not have the resources (coaching, facilities, nutrition and parental support) to produce quality players or to compete with traditional rugby schools. The traditional white rugby schools are transforming but not at the rate that is required to change the demographic of professional rugby in South Africa.

Recommendations

- The SARU recently established a national academy for U19 & U20 black and coloured players in an attempt to provide these players with expert coaching, conditioning and medical support required to prepare them to make it in professional senior rugby. This programme will only succeed if it manages to attract the best players and if it is supported by the various provincial unions that make up and effectively control the SARU.
- Development of a junior player pathway within South Africa rugby. SARU currently does not have a standardized junior player pathway (primary schools). Each provincial union has different rules and structures for youth rugby. Creating clear guidelines and materials (including a junior coaching resource) would possibly help in increasing

numbers at a junior level and make it easier for poorly resourced schools to get into the game. Coaches need to be educated on how issues around maturation and race differences effect talent selection.

- Elite schools assistance programme. SARU has a well-developed high school rugby system . There are strong rugby schools that produce high quality players. The problem is that these traditional rugby schools have remained predominately white. SARU has previously tried to uplift rugby schools from a traditionally disadvantaged backgrounds but these programmes were expensive to run and the programmes were not always well coordinated. A dual strategy may be required where national/provincial government and SARU partner to support placing top players of colour in traditional rugby schools and uplifting specific schools in disadvantaged areas.
- Restructuring U13 Craven Week. This research has shown the U13 tournament is not an effective talent identification tool. SARU may need to look at reshaping the tournament to be more inclusive. Can it be structured in such a way that it becomes a driver for participation and not deselection ?

South African rugby has traditionally had an abundance of talent and therefore it could get away with an inefficient talent identification and development model. This model may no longer be appropriate with the current transformation imperative. The SARU must urgently look at creating a system that takes the South African specific environment into account and provides sufficient support to allows sufficient number of black and coloured players to enter and remain in the player pathway.

Limitations

The limitations of these studies were that they did not measure maturation or look at relative age effect. The second study relied on self-reported data.

Future research

Future research should focus on the effect that these size differences between racial groups are having on player selection and progression from pre-teen to teen and on to professional rugby. The research should consider the socioeconomic status of players and determine what effect this is having on player progression through the player pathway. Future studies should also attempt to include other factors which may be affecting career progression such a technical, tactical and psychological development. Is it time for SARU to investigate weight grade rugby in South Africa? We have now established that there are large size difference between the various racial group in junior rugby. How do we resolve these differences from a developmental perspective ? It may be prudent to establish a research project to evaluate the effectiveness of running a version of weight grade rugby in a South African rugby specific context.

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Appendix A - Questionnaire for study 1 and 2

Craven Week Questionnaire

A. Personal

Please print

Last Name

First Name

Identification Number

Please check the correct box like this:

a	[✓ b]	c	d

Racial group: What is your home language?

Xhosa	Zulu	English	Afrikaans	Other*

Black	White	Coloured	Other*

*List Other: ____________________ *List Other: __________________________

Date of Birth: Place of Birth: ______________________________

Day		Month		Year	

Height: (cm)

Weight: (kg)

Your current postal address		Parents Address
Post Code:	m	Post Code:
Telephone:	0	Telephone:

2. How many rooms (excluding bathroom and kitchen) do your parents have in their home?

1	2	3	4	5	6	7	8	9	10	11	12 or more

3. Have any members of your family ever played rugby before?

	Yes	No	Team
Father			
Brother 1			
Brother 2			
Brother 3			
Brother 4			

B. School

1. What school do you go to?

Name:
City:
Province:

C. Sport

1a. What age did you start playing rugby?

2. How many years have you been playing rugby for?

3. What position do you play?

Full back	Wing	Center	Fly half	Scrumhalf	8th man	Flank	Lock	Prop	Hooker

4. How often do you practice during the rugby season?

Once a week	Twice a week	Three times a week	Four or more times a week

5. Have you attended Craven week before?

Yes	No

If yes, which years did you attend?

6. Do you play other sports?

Yes	No

If yes, which other sports do you play?

Athletics	Cricket	Soccer	Hockey	Swimming	Cycling	Other

List other: ____

D. Injuries

Have you ever had an injury that stopped you from playing rugby for more than one week?

Yes	No

If yes, how many times have you had to stop playing rugby for more than a week?

E. Weight training

Do you participate in weight/strength training?

Yes	No

If yes, skip to question 3

2. If no, why? (please tick the appropriate answer

	No facilities
	Have facilities but no training programme
	Have facilities, choose not to train with weights

(Please go to section F)

For how many years have you been training in the gym?

6 months	1 yr	2 yr	3 yr	4 yr	5 yr

How often do you train with weights? (one, two, three, four or more times a week?

	1X	2X	3X	4X	>4X
During rugby season					
Off season					

What type of gym do you use?

Home gym	School gym	Commercial gym (eg. Virgin Active)	Other

Do you follow a prepared weight training programme?

Yes	No

If no, skip to section F

If yes, who prescribed the programme?

Yourself	Gym instructor	Coach	Biokineticist	Other (list):

F. What are your views on the following?

1. There is pressure from my parents for me to do well in rugby.

Strong pressure	Moderate pressure	No pressure	They don’t want me to play rugby

2. Do you see rugby as your future career?

Definitely yes	Yes	Maybe	No	Definitely no

3. Are you worried about getting a serious injury while playing rugby?

Definitely yes	Yes	Maybe	No	Definitely no

4. Rate the following 4 points in order of priority in your life at present (Rate from 1-4)

Low High priority

School work or passing matric	1	2	3	4
Excelling in rugby	1	2	3	4
Earning money	1	2	3	4
Friends and socialising	1	2	3	4

G. Finances

1. Who pays for your transport to school rugby games?

Yourself	Parents	Relatives	School	Province	Sponsor

2. Do you have enough money for your rugby kit? (such as boots and shorts)

Yes	No

3. Who pays for your rugby kit?

Yourself	Parents	Relatives	School	Province	Sponsor

H. Work

1. Do you do any work outside school at present?

Yes	No

If No, skip to section J, if Yes, what type of work?

2. How many hours do you work outside school per week?

5	10	15	20	>20

3. What is the pay per hour?

R10	R12	R14	R16	R18	R20	R25	R30	>R30

I. Future Plans

What do you plan to do when you leave school?

Go to university	Go to technikon	Professional rugby	Go overseas	Find a job

2. If you plan to go to university or technikon, what degree or diploma do you want to study?

3. At which university/technikon do you plan to study?

4. Which job would you prefer?

1st choice	2nd	3rd

Thank you very much for your co-operation!