STRENGTH AND CONDITIONING PRACTICES OF HIGH SCHOOL RUGBY COACHES: A SOUTH AFRICAN CONTEXT

BY

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ABSTRACT

Although the sport of rugby union is well established, the strength and conditioning practices of high school level players are not well known. Therefore, the purpose of this study was to examine the current strength and conditioning practices that coaches implement at South African high school level rugby. A secondary purpose was to compare practices between different types of schooling systems available in South Africa. An online survey or in person interview (depending on the school), adapted from previous strength and conditioning questionnaires, was conducted with 43 responses; including 28 schools among the top 100 rugby schools in South Africa for 2016 and 15 no-fee paying public schools in the Eastern Cape Province of South Africa. Results indicated that the top 100 rugby schools implement conditioning practices similar to the best-known international practices compared to no-fee paying schools who lacked the knowledge and skills in various strength and conditioning principles. It was found that all no-fee paying school coaches had insufficient qualifications to administer the correct training techniques. Coaches at all schools lacked the appropriate knowledge on injury prevention and scientifically based training programmes. It was concluded that education and skills around the best strength and conditioning practices for school level coaches needs to be improved and particularly in less privileged schools. The main goal being to reduce the risk of injury and improve performance across all sectors of the rugby playing population within the country. This was deemed crucial to the transformation goals set out by the South African Rugby Union, which would benefit from player development in lower socioeconomic schools.

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CHAPTER I

INTRODUCTION

BACKGROUND TO THE STUDY

Rugby Union (further referred to as rugby) is a popular sport around the world, with over 8.5 million players worldwide as of 2016 (World Rugby, 2017). Due to the increasing popularity and high profile nature of elite rugby, related research has grown substantially over recent years, attempting to optimise performance (Duthie, 2006; Sedeaud et al., 2012; Phibbs et al., 2017) and reduce injury (Faigenbaum and Shram, 2004; Lloyd et al., 2014; Brown, 2014). As a consequence, there is an increasing importance held on developing the physical characteristics of modern players.

Strength and conditioning in rugby is becoming increasingly important with the rise of professionalism and the modern game becoming faster with players developing more physically (Arkell, 2015; Lambert and Durant, 2010; Olds, 2001). Physical characteristics such as strength, power, speed, cardiovascular fitness and body composition can contribute towards the success of a player and a team (Posthumus, 2009; Lambert, 2009). Developing such attributes has thus become a crucial part of competitive preparation and has become a highly investigated aspect of rugby specific literature. Understanding the techniques to implementing an effective physical conditioning program can give players and teams the competitive edge (Garraway et al., 2000). Furthermore, rugby has a high incidence of injury due to the physical nature of the game (Quarrie and Hopkins, 2007; Brooks and Kemp, 2008) and in South Africa it presents an above-average overall injury risk (69 injuries in 1000 hours exposure) compared to other popular sports such as cricket (2 injuries in 1000 hours exposure) (Fuller and Drawer, 2004). The physiological and morphological adaptations of strength and conditioning do not only benefit rugby performance, but also reduce the risk of injury (Faigenbaum and Shram, 2004; Lloyd et al., 2014). An important aspect of an effective strength and conditioning program is ensuring it is best suited towards the athletes in which it serves. Further, if not done correctly, strength and conditioning programmes may also cause injury.

In South Africa, rugby is the second most popular sport, following soccer, with over 10 million followers and half a million players in 2016 (World Rugby, 2017). Many players commence with their rugby career from as young as seven or eight years and are exposed to 12 years of playing rugby for their schools. South African high school rugby is fiercely competitive and reflects the modern professionalism of the sport at an elite level (Brown, 2014). Sponsorships, televised matches and bursaries have all increased rugby competition in high schools and have seen major investments by schools to improve their rugby results (Hunter, 2016). Such investments include hiring professional coaches and specialist coaches to improve the level of rugby, with strength and conditioning specialist becoming more frequent in top rugby playing schools. The expertise provided by such specialists is paramount in developing the physical characteristics of young players into competitive athletes. Therefore, researchers are increasingly interested in understanding youth athletic development to continuously improve performance and injury prevention techniques. However, the costs involved with such investments at a high school level need to be justified by the end results. Thus, describing the training habits and player development could provide insight as to what makes certain schools more successful than others in high school rugby.

Despite the increasing popularity of rugby in South Africa, the sport is plagued with political interference and racial division (du Toit, 2014). Interventions such as racial quotas have been introduced to reverse the apartheid policies of racial division and systemic disadvantage (du Toit et al., 2012). However, despite such interventions, the previously disadvantaged people of colour, representing 90% of the South African population, remain the minority in the elite level rugby teams (du Toit, 2014). There is a distinct lack of black players that fulfil their potential and reach an elite level of rugby. Development of players needs to start from grassroots levels such as schools where the majority of players are Black Africans (Department of Sports and Recreation South Africa, 2012). However, the South African schooling system is steeped in inequalities that favour the minority white wealthy population and such inequalities are reflected in the rugby structures, where they thrive (Arkell, 2015; Hunter, 2016). The vast majority of schools, pre-dominantly black, face damning socioeconomic circumstances at home and have to strive to overcome similar circumstances in school as well. These schools catering for poverty struck communities battle for educators, resources and facilities (Klein *et al.*, 2016). As a result these schools lack the structures and knowledge to develop their students into competitive athletes that could pursue sports as a career. Combining, the principles of strength and conditioning together with nutrition could assist these players in the physical development required to reach an elite level of rugby performance (Weakley *et al.*, 2017). However, the extent to which strength and conditioning has been adopted in a South African high school context is yet to be investigated.

The lack of research into physical development in a South African high school context has prompted the current study. If effective transformation is to be achieved, the nation cannot rely on the few top rugby playing schools in the country to provide the players, especially since these teams are represented pre-dominantly by white players (Arkell, 2015). However, there is a lot to be learned by the success of the top rugby playing schools. Their expertise can lead adolescent development across the country. Therefore, the practices of these schools can form a fundamental starting point from which research can expand.

STATEMENT OF THE PROBLEM

While there is a growing interest in research to improve strength and conditioning practices at an elite level of rugby, little is known about the practices implemented in the earlier stages of an athlete's development, including their school years. There is a need to understand the strength and conditioning practices implemented at a high school level, and in a unique South African context. This study originated in response to a research gap in the literature concerning the principles of strength and conditioning prescribed by high school coaches, and if these principles vary according to types of schools (i.e. privileged compared to less privileged schools). Understanding these principles can go a long way in developing a framework for future researchers to develop an appropriate strength and conditioning program designed specifically for the South African high school athlete.

AIMS AND OBJECTIVES

The primary aim of the study was to profile the practices of coaches and/or strength and conditioning specialists in the top high school rugby teams in South Africa. A specific objective was to compare the practices of strength and conditioning coaches in the different schooling systems in the Eastern Province, South Africa (independent private schools, fee paying public schools and no-fee paying public schools).

RESEARCH HYPOTHESIS

It is expected that differences exist between the strength and conditioning practices employed in different schooling systems in South Africa. It is further expected that the principles employed at the wealthier schools would be superior due to access to education, training and facilities.

RESEARCH DESIGN

The current literature available in rugby provides a rich foundation of physical requirements and strength and conditioning principles adopted to achieve success at an elite level. Additionally, research in youth development is becoming widely available to the public. There is however very little empirical research on the practices adopted, or that should be adopted, at a high school level to maximise a team's potential and the potential for player development. Furthermore, there is little research to this effect that focuses on the unique population of South Africa.

This study therefore proposed to utilise qualitative methodology to gather in-depth data on an area that is yet to be investigated. It is hoped that discovering more about the strength and conditioning tools employed by top South African high school coaches, can promote the development of such principles across South Africa. Furthermore, by understanding the tools employed by less prominent rugby schools, recommendations can be made to minimise the gap in knowledge and lead South Africa to a better future in rugby.

CHAPTER II

REVIEW OF LITERATURE

HISTORY OF RUGBY

The development and growth of rugby union

Little scientific evidence has tracked the history of rugby and in most cases, the history is referenced to a website, namely rugbyfootballhistory.com (Trueman, 2013; Van Aarde, 2014). Rugby football originated in 1823 with a story of a young boy, William Webb Ellis, who picked up a football and ran with it in his arms (Trueman, 2013). Despite little evidence to substantiate the story, the Rugby World Cup bears the boys name in his honour. Despite the contested origins of rugby, it evidently evolved from the traditional European football game. A variety of ball games developed from football, including at the Rugby School, where Webb-Ellis attended. The first set of rugby rules were introduced in 1845, written by a group of scholars from the Rugby School (Trueman, 2013). The formation of the Rugby Football Union occurred in 1871, where 21 clubs and schools met to establish a set of laws, drawn up by lawyers and alumni of Rugby School (Trueman, 2013).

In 1871, the first international match was played between England and Scotland and soon thereafter, rugby had spread to several countries. In 1886, the International Rugby Football Board (IRFB) became the world governing and law-making body of rugby. The Rugby Football Unions across the globe recognised the IRFB in 1890 and changed its name to World Rugby in 2014 (Trueman, 2013).

According to World Rugby (2017), rugby participation is growing at an unprecedented rate, reaching 8.5 million players across 121 countries by the end of 2016 and expected to reach 11 million by 2020. Rugby only became a professional sport in August 1995, which resulted in major changes to governance, international competitions and player remuneration (Quarrie and Hopkins, 2007).

The laws of rugby have changed considerably over time and more frequently than those of comparable sports, with certain amendments coming during the era of professionalism (Quarrie and Hopkins, 2007; World Rugby, 2016). More recently, law changes have been implemented to improve the viewers' appreciation of the game and, most importantly, to reduce serious injuries (Fuller *et al.*, 2007a). Such law changes include those discouraging dangerous play and improving technique in contact situations which were previously causes for concern, such as the tackle, ruck, maul and the scrum (Murray *et al.*, 2017).

History of rugby union in South Africa

Rugby came to South Africa in the 1880s through the settlement of the British settlers in the Cape area (Gustafsson and Gjörloff, 2013). The game was solely for the British and was only played in elite schools and social clubs. In many ways, rugby union optimised British colonial rule and was dominated by the 'civilised' whites. Afrikaners first began playing rugby during the Anglo-Boer war, where it became a way to get back at the English by stealing their beloved sport (Gustafsson and Gjörloff, 2013; Bolligelo, 2006). Rugby became extremely popular in the Afrikaans-speaking community and was adopted amongst Afrikaans schools.

Sports hold an important place in the Afrikaans South African culture. However, since rugby was embraced before the 1990s, it became connected to certain social structures including class and race (Bolligelo, 2006). In no other country was sport so divided by class and race. Rugby was considered a higher status sport, as was cricket, whilst soccer was played and supported by the lower class. Despite the exclusion of the non-white populations in rugby, certain black communities took fondly to the sport where it flourished. However, racial division remained an underlying issue in South African rugby. The South African rugby team (The Springboks) became a symbol for racial division within South Africa even before Apartheid laws restricted black players from representing South Africa (Gustafsson and Gjörloff, 2013). The Apartheid regime gathered global criticism between the 1960s and

1970s and as a consequence of racial division, the Springboks (the national team) received international backlash (Bolligelo, 2006). Opposition countries refused to play the Springboks despite efforts by the president of the South African Rugby Board to allow black players in the national team (Bolligelo, 2006). Eventually with the abolishment of apartheid, South Africa was re-admitted to international rugby in 1992 (Bolligelo, 2006).

Rugby continues to grow in popularity around South Africa as the racial divide is broken down. South Africa boasts over 600,000 registered rugby players from all corners of the country (Gustafsson and Gjörloff, 2013). The 1995 Rugby World Cup victory for South Africa was widely seen as a major step towards reconciliation of white and black South Africans. The second World Cup victory in 2007 cemented the already established belief that South Africa is one of the powerhouses of rugby union.

Rugby's role in early South African history was ambiguous and at times seemed to unite previously unequal South Africans together. At other times it only served to strengthen the barriers between South Africans. One thing can be said with certainty is that rugby is an important part of South African history and continues to play a role in many South African lives today.

HIGH SCHOOL RUGBY IN SOUTH AFRICA

Professionalism in high school rugby

Rugby at a school level in South Africa is male dominated with very few girls' schools offering rugby as a sport, and therefore much lower participation levels (Posthumus, 2013). In traditional boys' schools in South Africa, rugby plays a major role in establishing a 'school's identity' as well as a learners' identity (Ellis, 2016). Considering the history of rugby in South Africa and its influence on factors such as national pride, it becomes clear that many schools derive meaning from their identity as a rugby school. Since the dawn of professionalism in 1995 high school rugby has grown throughout South Africa and schools can often develop an unhealthy obsession for "*winning-at-all-costs*" (Noakes and Vlismas, 2011). Playing for a schools' 1st team is widely regarded as a significant achievement, where players are admired by their peers and school alumni (Noakes and Vlismas, 2011). Certain interschool matches can attract up to 25,000 spectators in a single day, while also being televised by major sports broadcasters across the country (Ellis, 2016). Such interschool matches provide players an opportunity to display their skills and characteristics in an attempt to improve their likelihood of a future career in rugby. Provincial competitions start from as young as under 13, where the best players in each province are already putting their skills on display for prospective recruitment by clubs, unions and academies (Van Reenen, 2012). The South African Rugby Union (SARU) hosts four national tournaments ranging from under 13 through to under 16 and under 18 competitions (Durandt *et al.*, 2011). Therefore, the level of professionalism in youth rugby is pushed from an early age and taken seriously by players, coaches and spectators alike.

A high level of professionalism at an early age can jeopardize potential late bloomers' opportunities to be noticed, thereby hindering their chances of developing to their full potential (Bayli and Hamilton, 2004). Underprivileged communities (majority black) with less resources and fewer opportunities tend to be under-represented in the top tier South African rugby playing schools (Department of Sports and Recreation South Africa, 2012). These top schools are where the majority of provincial players are chosen from, from as early as the under 13 Craven Week competition[1]. There exists a gap between the players being pushed through a competitive rugby school with better access to facilities and coaches, compared to those who do no receive the same privileges (Department of Sports and Recreation South Africa, 2012).

The South African school system

The South African schooling system is unique in that it is characterized by deep inequalities which mirrors the stark reality of two education systems that exist in the country (Wilmot and Dube, 2015). One such system being for the middle-class (minority) population which is functional, well-resourced and comparative to developed countries; and the other for the

[1] Craven Week: An annual u13 and u18 rugby tournament where the best South African youth rugby players represent their province. A similar u16 tournament is named the Grant Khomo Week.

majority (mostly black) learners from economically disadvantaged backgrounds, which is often dysfunctional and under-resourced (Wilmot and Dube, 2015). The South African high school education system is divided into two broad types of ordinary (not special needs) schools; private independent schools and public schools.

Private independent schools serve the upper class population of South Africa, catering for 4.1% of the enrolled student population in 2014 (Department of Basic Education South Africa, 2016). These schools have the autonomy to choose the best education system and appropriate allocation of resources at their disposal. Whilst only 4.1% of learners are enrolled in independent schools across South Africa, they enjoy 15 spots in the top 100 (15%) high school rugby rankings for 2016 (www.saschoolsports.co.za: Appendix A).

Public schools in South Africa are characterized by deep inequalities that reveal a reality whereby two systems exist; one for the middle class population and one for the majority (mostly black) population (Wilmot and Dube, 2015). The minority catering public schools benefit from better resources and private funding through a governing body system of parents and alumni. Whereas the majority catering, predominantly black, public schools are shroud with inefficiency, lack of resources and a low quality of education (Wilmot and Dube, 2015). Public schools in South Africa are categorized by a poverty ranking system that describes the community in which they serve. The rankings are separated into quintiles from 1-5, quintile 1 being the 'poorest' and quintile 5 being the 'least poor' (Grant, 2013). In 2014, the quintiles 1-3 were declared no-fee paying schools and quintiles 4 and 5 are fee-paying schools (Wilmot and Dube, 2015). The gulf between fee-paying schools and non-fee paying schools can be large; with the dysfunctional non-fee paying schools catering for the economically disadvantaged students (Wilmot and Dube, 2015). The no-fee paying schools often lack resources such as textbooks and adequate numbers of teachers, demonstrating an overall theme of mismanagement (Case and Deaton, 1999).

The top 100 high school rugby rankings list for 2016 consists of 85 public schools, none of which are non-fee paying schools. The number of professional rugby players coming from non-fee paying school is far lower than the more successful independent schools and fee-paying public schools. A timeline of 1st XV rugby rankings highlights the dominance of certain schools in the South African high school rugby circuit (Rugby15.co.za, 2017). Schools such as Paarl Boys High, a quintile 5 public school catering for the 'least poor' populations of South Africa, have finished three consecutive seasons (2015-2017) at the top of the high school rugby rankings (Rugby15.co.za, 2017). Other rugby powerhouse schools in South Africa include Grey College from Bloemfontein, Hoërskool Monument in Gauteng, Paarl Gimnasium and Paul Roos Gymnasium both from the Western Cape. All of these schools are quintile 5 public schools and predominantly Afrikaans. The top 100 rugby schools list for 2016 consists exclusively of independent private schools and quintile 5 public schools, suggesting a correlation between financial wellbeing and the schools' rugby performance. Hunter (2016) quoted an interviewed school parent; "*you judge a school by the performance of its rugby team*". Such a mentality in South Africa, where it is win-at-all-costs, can contribute to an increased level of professionalism in high school rugby. As talent players are attracted to traditional rugby schools, it erodes the competitiveness of schools not considered top tier rugby institutions. Furthermore, successful rugby schools are more likely to receive significant financial backing due to their success, further widening the gap between other schools. Scholarships and other inducements are frequently used to lure top players, further exacerbating an already skewed player profile among South African schools. Whilst these factors can contribute to success in rugby, it is important to consider the unique perspective of South African athletes and the socioeconomic status in which they live.

The South African perspective

South Africa is a unique country in terms of socioeconomic stresses, since it falls under the category of a low-to-middle-income country, but possesses aspects of a more developed western world. This is the case socially, economically and within the bounds of education (Bradshaw *et al.*, 2003). The socioeconomic status refers to the relative standing of an individual within hierarchical social structure determined by their wealth, power and prestige (Arkell, 2015). Parental education levels and the type of school attended play a major role in determining socioeconomic status (Caro, 2010). Due to South Africa's' apartheid past, children from lower socioeconomic backgrounds are primarily black, whilst the higher socioeconomic standing are predominantly white children (Armstrong *et al.*, 2011). There is a link between the socioeconomic status of the community and the quintile system used to rank public schools (Wilmot and Dube, 2015). The socioeconomic statuses of scholars in lower level quintile schools can be assumed to be lower than that of higher quintile rated schools. Therefore, the setbacks experienced in lower economic status families can often reflect the similar obstacles experienced at the low quintile rated schools.

Higher participation and access to facilities explains the improved sports performances in people with higher socioeconomic status (Klein *et al.*, 2016). Access to facilities is a fundamental problem facing a poverty stricken country such as South Africa. The inability to access the required facilities inhibits the capacity of an athlete to optimize performance, placing the athlete in a disadvantaged position (Van Aarde, 2014). Furthermore, training, education and talent identification is minimal for players from lower socioeconomic backgrounds, causing significant challenges for aspiring rugby players.

A large gap exists in academic achievement between schools in low socioeconomic regions compared to a more advantaged backgrounds. This is evidenced where private schools have some of the highest high school pass rates in the country (Caro, 2010). Further gaps exist in the success of rugby playing level, and consequently the success of players coming from such a background. It is difficult for children to escape the disadvantaged background with lower education levels, meaning these children are likely to have a low socioeconomic status as adults (Arkell, 2015). The multitude of factors stemming from a low socioeconomic background plays a vital role in the physical development of children and thus the potential for rugby union success (Klein *et al.*, 2016).

The impact of socioeconomic status on physical development

Motor development and body composition characteristics have been shown to reflect the socioeconomic status of a family in which a child is raised, and can have an impact on sports performance (Arkell, 2015; Klein *et al.*, 2016). In South Africa, children from a low socioeconomic background tend to be smaller and less powerful than more advantaged children (Lambert and Durandt, 2010). Armstrong and colleagues (2011) showed that in South Africa, white children are generally taller and heavier than their black counterparts and they performed better in physical tests including the sit-up test, standing long jump and cricket ball throw test. Socioeconomic status amongst the South African population doesn't only influence participation in rugby but also the physical development required to compete at a high level.

Health organizations refer to the triple burden of disease facing developing countries, which explains the health problems facing a country including non-communicable diseases, communicable diseases and violence (Bradshaw *et al.*, 2003). South Africa is unique in that the status quo regarding HIV/AIDS has placed a higher load on the population, resulting in the existence of a quadruple burden of disease (Mayosi *et al.*, 2009). Such health risks placed on a country can have an influence on the physical development of the population (Ryan, 2015). Communicable diseases have direct implications for quality of life experienced by South Africans, particularly amongst lower income bracket populations. Poverty factors such as poor nutrition and income play a large role in strength status of athletes as well as access to facilities and proper training education (Ryan, 2015). Ryan (2015) identified nutrition as possibly the most prominent socioeconomic issue facing South African football players. Poor nutrition can have a direct influence on health risk, injury risk and physical capabilities of the South African population (Kirkendall, 1993). Additionally, HIV/AIDS has an impact on strength profiles of African athletes with the majority of affected athletes coming from a lower socioeconomic background (Mayosi *et al.*, 2009).

The unique socioeconomic situation of South Africans must be considered when developing an appropriate strength and conditioning program. The BokSmart initiative provides an "underground strength training" program which is designed for players without access to facilities (Posthumus, 2010a). To become a coach or referee involved at any level in South African rugby, one is required to participate in a BokSmart course. The main focus of the course is to instil proper coaching and referee protocols to reduce and manage serious head, neck and spine injuries in rugby (Brown, 2014). Additionally, coaches are provided with information packs, which include details about the "underground" strength and conditioning program. The “underground” program provides an in-depth explanation of strength and conditioning practices required to optimise performance without the use of traditional gym equipment (Posthumus, 2010a). The “underground” program provides evidence-based guidelines similar to that of gym-based programs however it provides alternative exercises using bodyweight, partners, and basic items such as concrete blocks and water containers (Posthumus, 2010a). Program design is limited due to natural constraints in variation and resistance compared to gym-based programs. Therefore, only two programs are provided, one for the youth ages 14 to 16 years and one for senior players aged 16 years and older (Posthumus, 2010a). Initiatives such as this are taking crucial steps to improving the level of strength and conditioning in the South African rugby playing population.

Despite the wealth of athletic potential that could be hidden in South Africa, the socioeconomic stressors of living in poverty reduce the development of such athletes (Pelak, 2005). Access to clean drinking water, improper nutrition and exposure to high physical loads simply by walking long distances to school are hurdles needing to be overcome by some scholars. Additionally, once at school these students bear the burden of mismanaged public resources that leads to no available textbooks, improper teacher to student ratios and even a lack of hygienic ablution facilities (Fleisch and Christie, 2004). All the external stressors created by being in a low socioeconomic situation play a crucial role in the development of a child, nonetheless as a potential elite athlete.

Understanding the impact of socioeconomic status on physical development is critical in the context of this study. The inequalities between schooling systems and their involvement in rugby is linked to the socioeconomic status of the school’s community to which it caters. However, with rugby involvement and access to facilities aside, it must be understood that South African athletes cannot be lumped into one category. Coming from a disadvantaged background and having hindered physical development from a young age can influence participation and performance in rugby. A thought must be spared as to how many potential world-class players remain unidentified due to their socioeconomic status and underdeveloped physical capabilities.

DEMANDS OF RUGBY

Rugby is an intermittent high intensity collision sport (Gamble, 2004). An elite level match lasts for 80 minutes with two halves of 40 minutes each, separated by a 10-minute interval. Whilst an under 19 (1st team school level) rugby match lasts for 70 minutes, divided into two halves of 35 minutes each, and is contested between two teams of 15 players each (Hendricks, 2012). The players are divided into two main categories namely forwards and backs. The forwards are further divided into the front row, second row and back row. The backs are divided into playing positions; halfbacks, centres and outside backs (World Rugby, 2016). The division of players on the field is determined by their role in the team and several unique aspects to the game can be attributed to that role (Quarrie and Williams, 2002).

Physical demands of rugby union

Rugby involves frequent bouts of intense physical exertion and physical contact between two teams of fifteen players attempting to outscore each other. Initial investigations into the physiological demands of rugby began with the use of time motion analysis (Duthie *et al.*, 2005; Deutsch *et al.*, 2007). Time motion analysis made use of video footage whereby movement patterns could be quantified. These studies quantify specific movements such as distance, speed and duration of various locomotor patterns throughout the match (Dobson and Keogh, 2007).

Duthie *et al.* (2005) found that high intensity bouts of exercise attributed to 14% of a forwards gameplay and 6% of that of a backline player. Studies have consistently shown differences between playing positions with respect to the frequency and duration of work and recovery periods (Duthie *et al.*, 2005; Deutsch *et al.*, 2007). It has also been identified that movements in rugby can vary between high force-low velocity (e.g. scrummaging), high velocity-low force (e.g. sprinting) and high force-high velocity movements (e.g. tackling) (Dodge, 2016).

More recently global positioning system (GPS) units have been introduced as a means of measuring physical demands and physiological loads placed upon players in specific situations (Cunniffe *et al*., 2009; Coughlan *et al*., 2011; Cahill *et al*., 2013). Time-motion analysis proved more time consuming, unreliable and subjective in defining the movement categories (Dobson and Keong, 2007).

A study by Cunniffe *et al*. (2009) tracked one backline player (fly half) and one forward (back row) during a match using GPS software. The study identified that during a match, the players spent 37% of the time standing or walking, 27% jogging, 10% cruising, 14% striding, 5% high-intensity running and 6% sprinting; covering a total distance of 6,953m on average. The back was found to perform a greater number of sprints exceeding $20km.h^{-1}$ compared to the forward. However, the back also spent a greater amount of time standing or walking, with the forwards entering slower speeds more frequently. Players were playing at 80-85% of VO_{2max} during the course of the match with a mean heart rate of 172 beats per minute.

Coughlan *et al*. (2011) took the previous study a step further by taking into account the number of contacts the two players were involved in. The forward was subjected to 838 impacts in a game and the back, 573. An accelerometer was used to measure the force of the impacts showing that the forward was subjected to higher "severe impacts" as opposed to the backs (174 vs 30). Coughlan *et al*. (2011) found similar results to that of Cunniffe *et al*. (2009). Both studies also highlighted a greater distance covered by both players in the second half as compared to the first half.

Cahill *et al*. (2013) set out to validate the findings of Cunniffe *et al*. (2009) and Coughlan *et al*. (2011) by increasing the sample size to 98 elite players from English Premiership Clubs. Cahill *et al*. (2013) identified that rugby was played predominantly at slow speeds with little distance covered by sprinting. The backs travelled a greater distance than forwards in total and a larger distance in sprints (50±76m). The forwards covered 36±64m in sprints and the front row players were shown to cover the least amount of total distance (5158±200m). The scrumhalf covered the greatest total distance during the match, covering 7098±778m.

Quarrie *et al*. (2013) conducted a time-motion analysis on 763 players from New Zealand between 2004 and 2010. The authors found similar results to those previously mentioned, highlighting higher contact loads per match for forwards due to the nature of the positions. Additionally, the study found that international players cover greater distances, in excess of 5m/s, when compared to players competing at lower levels of the professional game.

Limited research has been conducted on the demands of adolescent players in rugby union. Hartwig *et al*. (2011) showed young players in the u16 age group covered an average of 4000m during a game, with no significant difference identified between forwards and backs. Each player performed on average of 22 sprints lasting 2 seconds, considerably less than the elite players. Venter *et al.* (2011) studied u19 age group players, highlighting average distances covered of 4470m per game with 72% of the total time spent standing or walking. Both studies indicate physiological disparities between youth level rugby and elite level. The total distance covered in both studies was less than that of studies on elite players, however it must be noted that elite games last for 80 minutes whereas high school games last 60 minutes (Venter *et al.,* 2011). Similar distributions between the amounts for time spent standing, walking, jogging and running were observed in high school matches compared to elite matches (Cunniffe *et al*., 2009; Venter *et al.,* 2011; Hartwig *et al*., 2011). Whilst variances can occur due to ground conditions, weather and the tactic employed by the teams, the key roles of players remain similar throughout (Quarrie and Hopkins, 2007).

Dodge (2016) uses the classic Hill (1938) force velocity curve (Figure I) to demonstrate the diverse movements required in rugby union. The force velocity curve describes the occurrence of a decrease in force as velocity increases from zero concentrically (Kraemer and Looney, 2012). Since a rugby player is required to produce a diverse range of movements along the force velocity curve, development of such potential along the curve would optimize performance. For example, a front row forward is required to scrum, which is an activity that requires large amounts of force at low velocities (Bevan *et al*., 2010). However, the same front row player would be required to sprint at high velocities, over varying distances, throughout a rugby match (Cahill *et al*., 2013). Additionally, the same player would be subjected to several high impact collisions involving large forces at high velocities (Coughlan *et al*, 2011). Similar truths are apparent throughout all the playing positions on the rugby field, where each position requires unique physical capabilities at varying degrees. The overall success and performance of the player would then fall upon that player's ability to perform activities across the strength and power continuum, including maximal strength, power and high velocity movements (Dodge, 2016).

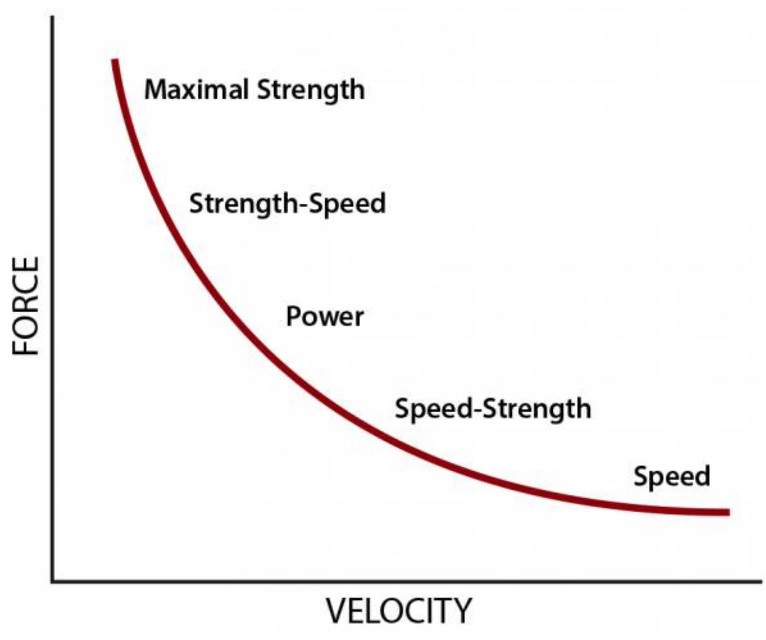

Figure 1: The Force Velocity Curve [Adapted from Dodge, (2016)].

Rugby being intermittent in nature requires input from both the anaerobic and aerobic metabolic pathways to meet the bioenergetics demands of the game (Cunniffe *et al*., 2009; Coughlan *et al*., 2011; Cahill *et al*., 2013). The varying physical stressors on the body and the intermittent nature of rugby means training must physically prepare players to cater for these demands (Duthie, 2006; Smart *et al*., 2014). The ability to recover from periods of high exertions in a short period of time remains a key focus in physical development and training in rugby (Cahill *et al*., 2013; Smart el al., 2014).

Physical requirements of Rugby Union

Certain physical capabilities such as strength, power, speed and endurance are important attributes for the performance of a rugby player and are critical to competition (Deutsch *et al*., 1998; Duthie *et al*., 2003; Duthie *et al*., 2005). Additionally, body composition such as mass and body fat, play an important role in determining the success of a player as it influences speed, power and endurance capabilities (Withers *et al*., 1987). The physical capabilities required of rugby player have been shown to correlate with the level of play and competitive rankings (Baker, 1998; Pearson *et al*., 2000; Baker, 2001; Cronin and Hansen, 2005; Baker and Newton, 2008). It is fair to acknowledge these factors as important performance predictors and any improvements would constitute an improvement in playing proficiency (Posthumus, 2010b). Strength and conditioning programs are designed to develop such physical capacities of players to improve performance and reduce injuries (Faigenbaum *et al*., 1996).

Smart *et al*. (2014) indicates the importance of speed, repeated sprint ability and body composition in the development of physical conditioning programs. Improving body composition, force production and muscular power can be achieved through appropriate strength training (Ahtiainen *et al*., 2003; Ignjatovic *et al*., 2011). Other key predictors of performance in rugby are maximal strength, movement velocity and jumping ability (Smart *et al*., 2014). Studies suggest the most important physical characteristics related to performance in rugby are the ability to express high rates of force development and high peak power output (Haff and Nimphius, 2012; Kraemer and Looney, 2012). Peak power output measures have been found to be significantly higher in elite rugby players compared to junior players (Baker, 2001; Hansen *et al*., 2011).

Lombard *et al*. (2015) conducted a 13-year study to analyse the physical evolution of South African u20 players. The study found an increased height (~2.8%), weight (~14%), strength (~51%), muscular endurance (~50%) and improved speed times over 10m (~7%) and 40m (~4%), but there was no improved aerobic performance over the course of the study (Lombard *et al*., 2015). The evolution of youth players is often attributed to professionalism, improved training methods and the desire for larger players to dominate the opposition in the contact scenarios (Cunningham *et al*., 2016). Barr *et al*. (2014) and Hansen *et al*. (2011) both found significantly higher differences between elite senior and junior players for mass measures of strength and power, but not for speed times. A French study of u15 age group players in 1988 and in 2008 found that the 2008 players were significantly ($p<0.001$) taller and heavier than the 1988 players (Seadeaud *et al*., 2013). However, increases in body size of rugby players could also align with an increase in size of the general adolescent population (Olds, 2001).

Lombard *et al*. (2015) found that that modern youth players are heavier, stronger and taller with improved body muscular endurance over time. Furthermore, it was concluded that the changes in physical characteristics of players could be attributed to the adaptations to the changing demands of the game and the improvement of training methods (Lombard *et al*., 2015). A 4-year study on South African u16 players also identified that players selected to the national squad at a youth level were on average heavier and taller than players not selected (Arkell, 2015). A similar study on Italian u16 national selection squad deemed height and mass crucial, however the most accurate predictors of success were percent body fat and speed (Fontana *et al*., 2017). Whilst an Australian study found that dispensation solely based on body mass and height does not explain selection, the mean body mass of community rugby players was above the 75th percentile on normative growth charts (Krause *et al*., 2015).

The success and career prospects of a rugby player could be significantly influenced by physique from a young age. Whilst it may not fit into ideal talent identification models, certain physical characteristics have long been rewarded by selection in South African youth rugby. One such way to improve physique and certain physical capabilities that determine success in rugby is through an appropriately administered strength and conditioning program.

In summary, rugby union is played at varying intensities, with periods of high intensity running and collisions interspersed with periods of lower intensity aerobic activity. The frequency and duration of physiological exertions is shown to vary considerably between playing positions due to the specific nature of each position (Roberts *et al*., 2008). Rugby is unique in the physical demands required to succeed as well as the physiological demands placed on the body. Coaches from youth to elite level are interested in improving performances of players by developing physical capabilities of players. However, even before performance optimisation, special attention needs to be placed on ensuring that players are able of withstand the physiological stressors on the body thereby avoiding injury.

INJURIES IN RUGBY UNION

The unique characteristics of rugby match play and the associated physical demands pose significant injury risks (Gamble, 2004). A consensus statement on injury definitions in rugby refers to an injury as "any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training" (Fuller *et al*., 2007b). Injury surveillance studies in rugby have revealed the severe physical nature in which the game is played resulting in a high prevalence of musculoskeletal injuries (Bathgate *et al*., 2002; Best *et al.*, 2005). These studies indicate the incidence of new injuries per 1000 playing or player hours; where "player hours" refer to match play and "playing hours" includes training as well as match play (Fuller *et al*., 2007b; Nicol *et al*., 2010).

Rugby appears to have a higher risk of injury than many other team sports, which is commonly attributed to the contact nature of the game (Williams *et al*., 2013). It has been shown that more injuries occur during match play, approximately 80-90% of all injuries (Brooks and Kemp, 2008). Whereas training injuries typically contribute to 10-20% of all injuries in senior rugby (Brooks and Kemp, 2008). Furthermore, numerous studies have reported the increase in injury occurrence in the second-half of a rugby match due to player fatigue and match intensity (Bathgate *et al*., 2002; Brooks *et al*., 2005a).

Numerous studies investigate the injuries sustained in professional players as opposed to amateur or youth rugby players. Current evidence suggests the incidence of injury in the professional game is higher than that of high school, women's and men's amateur games (*Molloy*, and Wiley, 2008; Palmer-Green *et al*., 2013; Schick, Roberts *et al*., 2013). These differences in incidence can often be explained by the definition of injury used in the respective study, nonetheless, injury incidence is consistently reported to increase with competitive level and age (Brooks and Kemp, 2008).

Injuries in professional rugby union

A number of studies have investigated the epidemiology of injuries in professional rugby (Jakoet and Noakes, 1998; Best *et al.*, 2005; Brooks *et al*., 2005a; Brooks *et al*., 2005b; Fuller *et al*., 2007a; Brooks and Kemp, 2008; Fuller *et al*., 2008a; Kemp *et al*., 2008; Fuller *et al*., 2015). The 1995 Rugby World Cup was reported to have an injury rate of 30 injuries per 1000 player hours in the preliminary matches and that increased to 43 injuries per 1000 player hours in the last qualifying quarter final matches (Jakoet and Noakes, 1998). During the 2003 World Cup, an injury incidence of 97.9 injuries per 1000 playing hours was reported (Best *et al.*, 2005). The higher than usual injury rate in the 2003 World Cup was attributed to a mismatch of skills, fitness and resources available between the participating countries (Wall, 2011). In the 2007 Rugby World Cup, Fuller *et al*. (2008a) reported an injury incidence of 83.9 injuries per 1000 playing hours. Fuller *et al*. (2016) did injury surveillance on the latest Rugby World Cup to take place in 2015. The incidence of injury was 90.1 match injuries per 1000 playing hours, where backs had a higher incidence compared to forwards (100.4 vs 81.1).

A recent meta-analysis was conducted to summarise the relevant studies to determine the incidence, cause, and severity of injuries in professional rugby (Williams *et al*., 2013). The analysis showed an overall incidence of 81 injuries per 1000 hours in matches and 3 injuries per 1000 hours in training. The mean severity for injuries was reported to be 20 days for match injuries and 22 days for training injuries. Furthermore, lower limb injuries were the most common form of injury however upper limb injuries were reported to be the most severe (Williams *et al*., 2013).

Table I: Incidence of match injuries by playing level (Williams *et al*., 2013).

Playing level	Injury incidence rate (per 1000 player hours)	Number of studies
International	123 (85-177)	3
Level 1 clubs	89 (75-104)	4
Level 2 clubs	35 (27-45)	3

Ten studies included in the meta-analysis provided overall injury incidence rates for match and training combined and are summarised in Table I. According to level of play; international matches had the highest injury incidence at 123 (85-177) injuries per 1000 player hours. Level one clubs playing at the highest league in top ranked rugby nations had an injury incidence of 89 (75-104). Whereas level two clubs playing at the highest league in lower ranked nations or in second leagues in top ranked nations had an injury incidence of 35 (27-45). Williams *et al*. (2013) demonstrated through this comparison the difference in injury incidence according to playing level. However, analysis of school level rugby injuries was not included in the investigation.

Nature of rugby union injuries

The nature of a specific injury includes the type and location of the injury, the frequency of injury and the event that lead to the injury. Injuries can be differentiated by tackle-related injuries and non-contact injuries as well as traumatic and non-traumatic injuries.

Fuller *et al*. (2016) identified the nature of injuries in the latest 2015 Rugby World Cup. During matches, head/face (22.0%), knee (16.2%), muscle-strain (23.1%) and ligament-sprain (23.1%) were the most common locations and types of injuries. Being tackled (24.7%) was the most common incident event for injury during matches. Fuller *et al*. (2016) concluded that the injury incidence, nature and inciting events in the 2015 World Cup were similar to previous competitions, however there was an increasing trend in the severity of injury.

The tackle event is most often associated with a high rate of injury to both the tackler and the player being tackled (Fuller *et al*., 2007a; Quarrie and Hopkins, 2008; Fuller *et al*, 2010; Fuller *et al*., 2016). Nicol *et al*. (2010) identified the tackle event as the most likely cause of injury in high school rugby, causing 62.1% of all injuries. Other comparable events contributing to injuries included the ruck, causing 24.3% and scrums, causing 5.4% (Nicol *et al*., 2010). Several other studies confirm the danger of the rugby tackle and attribute the tackle event to cause 5 times more injuries than any other contact scenario in rugby union (Table II)(Fuller *et al.*, 2007a; Hendricks and Lambert, 2010).

Table II: Percentage of all injuries by phase of play or mechanism leading to the injury according to 11 studies of children and adolescent rugby players. [Adapted from Freitag *et al.*, (2015)]

Phase of play	Percentage of all injuries
All tackle	39.6 - 64.0
Active tackle	18.5 - 40.0
Recipient of tackle	16.5 - 65.0
Scrum	2.0 - 36.0
Ruck/maul	8.3 - 31.5

Tackle injuries also account for the bulk of soft tissue injuries, fractures and dislocations in rugby union (Table III). Brooks *et al*. (2005a) found in elite level rugby, the most common mechanism for injury in backline players was the tackle, whilst the ruck or maul situation proved most dangerous for forwards. The act of tackling (18.5 – 40.0%) generally accounted for fewer injuries than being the recipient of a tackle (16.5 – 65.0%) (Freitag *et al.*, 2015).

The tackle is responsible for a high proportion of upper body injuries in tacklers such as head/neck injuries and concussions whilst the player being tackled is more susceptible to lower body injuries such and knee and thigh injuries (Fuller *et al.*, 2007a; Quarrie and Hopkins, 2008; Palmer-Green *et al.*, 2013). The head and face are the most commonly injured body part in high school rugby, followed by the shoulder and knee (Durie, 2000; Nicol *et al.*, 2010).

Table III: Percentage of all injuries by nature of injury according to 19 studies of children and adolescent rugby players [Adapted from Freitag *et al*., (2015)]

Injury	**Percentage of all injuries**
Ligaments injuries, sprains and strains	15.7 - 47.2%
Laceration, contusion and haematoma	2.7 - 46.0%
Fracture	3.0 - 27.0%
Concussion	2.2 - 24.6%
Dislocation and subluxation	0.5 - 10.8%

Table III lists the most common type of injuries in children and adolescents from 19 studies described in a systematic review (Freitag *et al*., 2015). Soft tissue damages including sprains and ligament injuries have been found to be the most common type of injury at a school level (Nicol *et al*., 2010; Freitag *et al*., 2015). The least common types of injuries were dislocations and subluxations recording between 0.5% and 10.8% (Table III).

Concussions and head injuries, while relatively small as a percentage of all injuries remain a critical area of research due to the severity of such an injury (Table III). The tackle event is most commonly responsible for concussion injuries and is often caused by improper tackle technique. A general lack of skill from the tackler has been highlighted as a risk factor to concussions and a main cause of such injuries in high school rugby in South Africa (Clark *et al*., 1990). Catastrophic injuries are rare, however the impact on players and their families are severe. In South Africa, the incidence of catastrophic injuries was reported as 2.0 per 100 000 players, whereas spinal cord injuries accounted for 1.0 per 100 000 players (Brown et al., 2013).

There are certain common traits in the nature of injuries between elite level rugby and high school rugby. Further investigation into the specific injuries occurred in professional rugby and at a high school level can provide insight into the necessary interventions required.

Injuries in high school rugby union

According to Garraway *et al*. (2000) professionalism leads to a higher prevalence of injuries not only at a professional level but also at an amateur level. Comparable high school studies remain few and far between as studies use varying age ranges and definitions of injury. A study in New Zealand found injury rates as high as 65.8 injuries per 1000 playing hours in high school rugby players (Durie, 2000). The findings of Durie (2000) were based on injuries sustained by 1st team players in high school rugby in New Zealand. A significant decrease in injuries at 2nd team level to 35.0 injuries per 1000 playing hours was observed.

Burger *et al*. (2014) reported a tackle-related injury rate of 33.5 per 1000 playing hours in the 2012 South African U18 Craven Week rugby tournament. The study focused specifically on tackle-related injury rates as opposed to overall injury rates. It was noticeable that injuries were more prevalent in the later stages of the competition and the high injury incidence was attributed to player fatigue and match intensity as the competition progressed (Burger *et al*., 2014). A 1st team study conducted over a full season in a South African high school highlighted an increase in injury incidence when players were exposed to provincial as well as school level rugby (Tee *et al.*, 2017). Whilst the study was limited to one school over a single season, it suggests a high level of participation due to overlap in provincial and school rugby is a cause for concern in injury prevention (Tee *et al*., 2017).

Other high school studies found varying results ranging from 35-63 injuries per 1000 playing hours (Junge *et al*., 2004; McIntosh *et al*., 2010; Palmer Green *et al*., 2013). The varying results depend largely on the time scale of data recording, reporting by the schools involved, the age range of the youth teams involved and the definition of injury used for the study. Nonetheless, the incidence of injury at high school level is considerably high compared to that of other sports (Junge *et al*., 2004). Injury incidence is consistently reported to rise with age and competitive levels, however the observed injuries at high school level are high enough to cause concern (Roux *et al*., 1987; Lee and Garraway, 1996; Junge *et al*., 2004).

In summary, the level of play has a significant impact on the incidence of injuries in rugby. International level rugby has the highest incidence of injury amongst the reported studies however it is crucial to investigate the nature of rugby union injuries in an attempt to bring these figures down at all playing levels. Understanding the nature of rugby union injuries will contribute to the development and implementation of injury prevention strategies in youth rugby. Therefore, the current research and knowledge on injury prevention as well as athletic enhancement requires further exploration. One such technique in injury prevention and athletic performance improvements is the use of a structured strength and conditioning program.

STRENGTH AND CONDITIONING IN RUGBY

Strength and conditioning is an avenue in the realm of sports science that seeks to maximise an athlete's physical performance by improving physical characteristics and preventing injuries (Hunter and Harris, 2008; Dorgo, 2009). Strength and conditioning contributes to physical and physiological development of athletes encompassing all aspects of a holistic athletic development program (Hibbert, 2010). An effective strength and conditioning program has become paramount to optimal performance at an elite level of rugby and can differentiate a teams' success (Sedeaud *et al*., 2012). The importance in strength and conditioning has also grown amongst high school rugby with schools looking to improve wherever they can, as the game becomes more professional at such a young age.

Benefits to rugby performance

Rugby players should follow a planned and structured training program designed to bring the players to peak performance, promote long-term performance improvements and prevent injury (Haff, 2004a; Haff 2004b; Baker, 2007). This concept is the idea of periodisation, where structured variations in volume, intensity and training specificity have shown to yield greater results than non-periodical programs (Willoughby, 1993; Rhea *et al*., 2006). Developing strength, power, speed and endurance in such ways can benefit the individual and the team performance.

The benefits of an appropriate conditioning program on body composition can best be explained using Newton's second law ($a = F/m$) (Duthie, 2006). The amount of fat mass (m) with no change in muscle force (F) will cause a reduction in acceleration (a) (Duthie, 2006). Additionally, there is a larger amount of energy required to move excessive fat mass, increasing the relative physical cost of exercise (Duthie, 2006). A combination of appropriate training techniques and a specific dietary program can manipulate body composition to desired outcomes depending on positional demands (Vaz *et al.*, 2016). Specific training programs have shown to provide desirable effects on body composition in rugby players where the goal is to attain lean mass and reduce body fat (Duthie *et al.*, 2006a). Despite the desire for less body fat, researchers suggest body fat provides a crucial buffer against forceful impacts in contact situations (Gabbett and Domrow, 2005).

The contemporary approach to improving strength and power in rugby players involves a combination of gym- and field-based training. Training rugby-specific movements under resistance can develop strength and power in players. Functional training (**Functional training** attempts to adapt or develop exercises specific to the demands of their sport more easily and without injuries) within a resistance-training program, along with heavy-resistance training and plyometrics has proven to lead to substantial improvements in strength and power (Gambetta, 1998; Duthie, 2006). Strength and power qualities are crucial in improving the ability to change direction, running velocities and force production in scrums and tackles (Quarrie and Wilson, 2000). These abilities have proven to be critical in determining success in rugby union (Duthie, 2006).

Acceleration and speed is fundamental to success in rugby, with acceleration deemed most crucial since durations of sprints in game play are generally ~3 seconds (Faccioni, 1993; Deutsch *et al.*, 1998; Deutsch *et al.*, 2001; Duthie *et al.*, 2005). Improving speed and acceleration includes various methods such as resisted sprinting, unresisted sprinting, weight training and plyometrics (Faccioni, 1993). An appropriate speed program includes exercises that improve the strength characteristics specific to sprinting as well as enhancing sprinting technique (Duthie, 2006).

Previous research has demonstrated positive outcomes in developing essential physical qualities in rugby performance for both adults and adolescents (Beaven *et al.*, 2011; Argus *et* *al*., 2012; Smart and Gill, 2013; Weakley *et al.*, 2017). Therefore the implementation of strength and conditioning practices from adolescence can contribute to an improved performance in rugby.

Benefits of strength and conditioning in adolescents

Strength and conditioning in children and adolescents is shrouded in misconceptions, largely revolving around the use of resistance training techniques (Kraemer and Fleck, 2005). The most commonly heard myth is that resistance training will stunt the growth of children and adolescents participating in such types of training (Lloyd *et al.*, 2014). However, there is no scientific evidence to support such misconceptions and many institutions have published position statements supporting the use of resistance training in youth athletes (Lloyd *et al.*, 2014). The common trend throughout the position statements is that resistance training, when performed under strict supervision with proper technique, is a safe, effective and recommended training method for children and adolescents (McCambridge and Stricker, 2008; Lloyd *et al.*, 2014). Resistance training involves the use of any resistive load such as weights, machines or body weight to develop muscular strength and endurance (McCambridge and Stricker, 2008). Lloyd *et al*. (2014) highlight the importance of resistance training in children and adolescents in that muscular strength is an essential component of motor skill performance. Improvements in muscular strength, power, running velocity, general motor performance and change-of-direction speed through various forms of resistance training in youth (Stratton *et al.*, 2004; Mikkola *et al.*, 2007; Behringer *et al.*, 2010). The development of competency and confidence to perform safe and effective resistance training during growing years could provide long term benefits for health, fitness and sports performance (Lambert, 2010).

Resistance training in young individuals is receiving increased attention with the possible benefits to metabolic health, body composition and injury risk profiles of overweight children and adolescents (Lloyd *et al.*, 2014). While the treatment of overweight youth is complex, an appropriate training program that is inclusive of resistance training provides the opportunity to improve motor coordination and muscular strength (Schranz *et al.*, 2013).

However, an appropriately balanced strength and condition program does not only consist of resistance training. An effective program should also include aerobic and anaerobic conditioning, speed development, skill based conditioning, plyometrics, agility development and injury prevention exercises (Duthie, 2006).

Aerobic and anaerobic training are both implemented to improve fitness conditioning by modelling the requirements of match play (Rhea *et al.*, 2008). Rugby consisting of multiple consecutive phases of play requires a high level of metabolic conditioning (Gamble, 2004). Metabolic conditioning programs can improve a player's ability to exert themselves at such high energetic demands (Gamble, 2004). Additionally, conditioning drills that incorporate skills and rugby specific movements are more beneficial to create the adaptations required to meet the metabolic demands of rugby match play (Gamble, 2004).

Speed and agility development also plays a crucial role in developing young athletes' physical capacities. Whilst genetics play an important role in determining an athlete's speed, specialised speed and agility training has shown to effectively improve sports performance specifically in untrained youth athletes (Quarrie *et al*., 2001; Bloomfield *et al*., 2007). Speed and agility training is not only important in enhancing sports performance but also develops overall athleticism and reduces the risk of injury to the player (Noakes and Du Plessis, 1996). Strength and conditioning programs aimed at youth rugby players should therefore include all aspects of an effective program that enhances performance, improves physical development and reduces the risk of injury for the player.

Till *et al*. (2015) observed significant improvements in physical characteristics of adolescent rugby players between the age of 16 and 17 years, compared to older ages of 18 to 20 years, when performing a structured training program. The observation has been accredited to the age in which the players commenced structured training programs suggesting greater changes occur in younger individuals upon starting such a program (Till *et al*., 2015). Further work by Till *et al*. (2017) supports this claim demonstrating that players who commence training at a younger age tend to develop faster than their counterparts.

Studies observing changes in body composition in youth rugby players are numerous, but the focus tends to be towards identifying trends in team selection and body size. Few studies can specifically attribute changes in body size and composition due to training programs, as maturation could be the underlying factor (Till *et al*., 2014). Increases in mass could be due to improvements in lean body mass and fat mass content. However, considerable deviation around mean change in body mass (-3.7 – 13.9%) raises questions and individual responses vary widely (Gabbett, 2009; Till *et al*., 2014; Weakley *et al*., 2017).

Harries *et al*. (2016) demonstrated a 33.9 – 44.5% increase in absolute strength following a 12-week resistance-training program in sub-elite adolescent rugby players. While Weakley *et al*. (2017) showed lower levels of improvement (24.0 ± 16.9%) over a 12-week in-season program in sub-elite adolescent players. Smart and Gill (2013) identified strength improvement differences between supervised (72.5%) and unsupervised resistance training (16.8%), demonstrating the importance of supervision in maximizing adolescent rugby players physical characteristics. Improvements in measures of power correspond well with increases in lower body strength measures (Smart and Gill, 2013; Weakley *et al*., 2017). However, Weakley *et al*. (2017) were unable to show improvements in sprinting speed following the 12-week resistance training protocol. Trivial changes in sprint speed are most likely attributed to changes in body mass and maturation rather than large improvements in velocity (Barr *et al*., 2014).

A properly designed training program including all forms of training brings about muscle adaptations including fibre type composition and muscle hypertrophy (Folland and Williams, 2007). However, the influence in children and adolescents in not well characterized. Appropriate periodised training programs have shown to bring about improvements in strength beyond that of normal healthy growth and maturation, however hypertrophy is not evident (Posthumus, 2010c). With minimal evidence of the occurrence of hypertrophy, the proposed mechanism of strength gains in youth athletes due to adaptations to training is via neurological adaptation (Lloyd *et al*., 2014). Neurological adaptation to training refers to the changes in coordination, recruitment and activation of muscle fibres (Lloyd *et al*., 2014). Therefore, an overwhelming benefit of a combination of training methods for youth athletes is the neurological adaptations causing increases in strength (Payne *et al.*, 1997; Posthumus, 2010c; Lloyd *et al.*, 2014).

Apart from performance increments, a large reason why strength and conditioning plays a role in youth development is the reduced likelihood to incur injuries (Lloyd *et al.*, 2014). Hence, a crucial aspect to consider in designing a strength and conditioning program is developing an athlete capable of withstanding injury as much as possible.

Injury prevention or "prehabilitation"

The impact of injury can have a substantial influence on the success of a team and the players' career prospects by taking the player away from the playing field. Hence why injury prevention is possibly the most important reason for strength and conditioning as it benefits the player and the team. Furthermore, an injury during crucial development years in youth athletes could hamper long-term developmental goals. Strength and conditioning programs designed to increase physical capacities have shown to effectively reduce the risk of injury (Faigenbaum *et al.*, 1996; Faigenbaum and Shram, 2004). In the case of rugby, specific strengthening of sites of high impact forces during collisions can assist in providing the necessary injury prevention required (Gamble, 2008). Therefore, preventative rehabilitation (prehabilitation) should be an integral part of athletic training specifically in rugby with exposure to high impact forces (Beam, 2002).

Since an overwhelming proportion of injuries that occur in sports involve connective tissue, it is reasonable to believe that altering the size, density, or mechanical properties of the connective-tissue framework will help reduce the risk of injury (Stone, 1990). Five studies conducted on adolescents reviewed the impact of resistance training on injury prevention. The common trend in these studies showed that adolescent athletes suffered fewer injuries and recovered from injuries in less time when they participated in strength and conditioning programs as compared to those who did not (Hewett *et al.*, 1996; Wedderkopp *et al.*, 1999; Heidt *et al.*, 2000). Recent position statements have identified the importance of strength and conditioning in identifying deficits in young players and addressing individual limitations

(Lloyd *et al.*, 2014). The musculoskeletal system becomes more prepared for the demands of rugby and competition when the young player participates in a regular multifaceted strength and conditioning program (Faigenbaum and Myer, 2010).

Prehabilitation or injury prevention programs should focus on correcting imbalances or areas where the player might be lacking which could lead to injury (Cook, 2003). A multifaceted program that increases muscle endurance, strength, functional abilities and improved movement mechanics is the most effective approach for reducing sports-related injuries in young athletes (DiStefano *et al.*, 2010; Lloyd *et al.*, 2014). Furthermore, non-performance related elements should also be included in an injury prevention program such as posture, balance, mobility, stability and proprioception (Meir *et al.*, 2007).

There have been several prehabilitation programs created and introduced to rugby playing populations targeting vulnerable areas of the body in an effort to reduce the incidence of injury (Meir *et al.*, 2007). Such programs include the New Zealand RugbySmart program, World Rugby's Rugby Ready, and South Africas' BokSmart, which provide a framework for reducing injury in rugby players. These initiatives focus largely on investigating and avoiding catastrophic injuries. However, they do incorporate the use of strength and conditioning as a method for reducing the severity of injuries, and stress its importance.

The efficacy of different physical preparation programs as injury prevention techniques in youth athletes is becoming increasingly well established. The nature and responses to different forms of training on growth and maturation has also been examined, however further research is required to provide a clearer picture. Furthermore, program design needs to be evaluated according to injury data for the rugby specific demands and in each playing position. There is an increasing body of research that suggests an appropriate conditioning program can benefit not only adults but also youth athletes in reducing the risk of injury during sports (Lloyd *et al.*, 2014). Targeted strength and conditioning programs can therefore be effective in not only producing performance increments but also reducing the risk of injury in adolescent rugby union players.

Strength and conditioning education

Strength and conditioning education and certifications form a large distinguishing factor for the practices employed by coaches in multiple studies (Ebben and Blackard, 2001; Ebben *et al.*, 2004; Simenz *et al.*, 2005; Ebben *et al.*, 2005; Gee *et al.*, 2011; Pote and Christie, 2016; Jones *et al.*, 2016, Jones *et al.*, 2017). A recent study on high school and university level cricket in South Africa identified a lack of sufficient educational training to be a limiting factor in the conditioning techniques implemented (Pote and Christie, 2016). Thus, researchers have become interested in the relationship between coaching education and coaching efficacy (Sullivan *et al.*, 2012).

Strength and conditioning is a complex compilation of actions and techniques that draw on multiple sources of knowledge (Jeffreys, 2014). Therefore, education and certifications specific to strength and conditioning are highly valued in the industry as it demonstrates competence (Malek *et al.*, 2002). However that being said, it does bring in to question whether coaches need to be qualified to implement strength and conditioning principles? Stoszkowski and Collins (2016) revealed that coaches from a range of sports preferred acquiring knowledge through informal learning activities and social interactions. Based on those findings it was recommended that coaches' development and training should take place through social learning activities and mentoring schemes rather than formalised education (Stoszkowski and Collins, 2016). However, in the competitive and developing field of strength and conditioning formal education provides coaches with the knowledge required to implement effective practices (Tod *et al.*, 2012). Therefore, institutions with available resources are encouraged to invest in strength and conditioning expertise to bolster coaching staff credentials.

Despite scientific studies providing up-to-date information on the best strength and conditioning practices, it is unknown whether this translates to implementation. Since a well structured strength and conditioning program is evidenced to benefit youth athletes, implementation of best-known practices is important in rugby at a school level. The need for coaches to not only incorporate but actively learn the role of strength and conditioning is important to the development of South African rugby. However, issues arise when certain schools are able to employ a formally educated strength and conditioning expert where other schools do not have the means to do so. To negate this, becoming a rugby coach in a South African school requires participants to complete the BokSmart course. The goal of BokSmart is to educate coaches on the safety issues surrounding rugby, particularly with traumatic head, neck and spine injuries (Brown, 2014). Additionally, coaches are provided with the information necessary to adapt an effective strength and conditioning program even with a lack of access to facilities (Posthumus, 2010a). These avenues to enhance coaches learning are crucial in ensuring there is a single objective nationwide for the betterment of South African rugby.

Arguments are however put forward in preference of coaching experience over formal education (Tapley *et al.*, 2014). A previous study on strength and conditioning coaches revealed that a coach's practical knowledge was structured in several layers and was only partially built on the knowledge originating from formal education (Dorgo, 2009). A coach's knowledge was by in large developed through field experiences, life practices and interactions with other professionals (Dorgo, 2009). Therefore, there remains an argument of the importance of formal education in strength and conditioning. However, in the field of strength and conditioning certain scientific principles need to be understood and thus formal education in sports science is highly recommended. Davis (1994), found in a study of fitness professionals that ones with a formal background in sports science or physical education performed better that those without in questions on exercise physiology, program design and exercise nutrition. Malek *et al*. (2002) also demonstrated a higher level of competence among fitness professionals with a higher level of formal education than those without.

There remain conflicting views on the importance of formal education in coaching efficacy. Thus, strength and conditioning accreditation agencies such as the National Strength and Conditioning Association (NSCA) do not require a sport science degree or related field to become a member, although a bachelor's degree is required (NSCA, 2018). They do however expect coaches to become certified through an examination process that gains coaches credentials, however this are not legally required to administer strength and conditioning programs.

Determining strength and conditioning practices in athlete populations

The strength and conditioning practices of various sports including cricket (Pote and Christie, 2016), ice hockey (Ebben *et al.*, 2004), basketball (Simenz *et al.*, 2005), rowing (Gee *et al.*, 2011), strongman competitions (Winwood *et al.*, 2011) and baseball (Ebben *et al.*, 2005) have been established through questionnaires. The surveys have been adapted to their specific sporting codes from the original research of Ebben and Blackard (2001), on the National Football league strength and conditioning practices. Commonalities between the surveys include sections on the coaches' background information, physical testing, flexibility development, speed development, plyometrics, strength/power development and unique aspects for the specific sport. The questionnaires used a combination of quantitative and qualitative methods to cover the scope of the strength and conditioning practices.

To-date, two studies have researched the strength and conditioning practices in a rugby union population. Jones *et al*. (2016) set out to determine strength and conditioning practices in an elite rugby setting and to determine the relative importance of concurrent strength training and aerobic training held by coaches. While another study by Jones *et al*. (2017) examined the variances in strength and conditioning practices in elite rugby between Southern and Northern hemispheres.

Jones *et al*. (2016) adapted their survey from the previous work of Ebben and Blackard (2001). The objective of the study was to identify the specific conditioning prescribed and monitored in elite rugby union and to research a possible interference effect associated with concurrent strength training and aerobic training (Jones *et al*., 2016). The questionnaire sought out to examine how strength and conditioning coaches consider and manage such an interference effect. Forty-three coaches from elite rugby around the world responded to the questionnaire. A majority of the respondent were formally educated in Sports Science at an undergraduate level (79%) and had obtained a master's degree (61%). Twenty-four of the respondents had an accredited certification in strength and conditioning. All but one respondent indicated that physical testing was conducted on their players. Physical testing included acceleration (84%), agility (33%), anaerobic capacity (72%), body composition

(93%), cardiovascular endurance (81%), flexibility (63%), muscular endurance (40%), muscular power (86%), muscle strength (84%), speed (86%) and other (14%).

All 43 respondents indicated that their players were subjected to regular strength training sessions and believed that strength training is beneficial for rugby union performance. Furthermore 40 respondents indicated their athletes were subjected to speed development whilst 41 reported the use of speed development as well as flexibility development. Thirty-eight respondents (90%) indicated the use of a periodised conditioning programs, similar to other sports previously surveyed. The high reliance on periodised programs follows the best-known practices as it has been demonstrated to yield greater improvements in strength, power and body composition than linear training (Kelly and Chambers, 2016). Thirty-three respondents (77%) considered a possible interference effect associated with concurrent aerobic and strength training, whilst 47% believed it plays a crucial role in construction of a program. Hence the reason most coaches stressed the importance of periodisation in reducing possible negative interference effects.

Jones *et al*. (2017) conducted a survey to identify the variances in strength and conditioning practices in elite rugby union between the northern and southern hemispheres. Similarly to previous research, the survey was adapted from the original work of Ebben and Blackard (2001) on football. Forty coaches responded to the survey, 20 from the northern hemisphere and 20 from the southern hemisphere. The level of formal education as well as strength and conditioning certifications was similar between the hemispheres. Physical testing was conducted in 11 aspects of physical fitness similarly to Jones *et al*. (2016). Most physical abilities were tested equally in the southern and northern hemispheres apart from agility, which held more importance to coaches in the southern hemisphere (20% more respondents tested agility). Identically to Jones *et al*. (2016), all respondents indicated that their athletes partake in regular strength training. Whilst they all conducted strength training, Jones *et al*. (2017) found a greater importance was placed on strength and power training in the northern hemisphere. All the respondents prescribed speed development training and plyometric training to their respective athletes.

Both Jones *et al*. (2016) and Jones *et al*. (2017) excluded questions on injury and injury prevention methods. As strength and conditioning programs develop to enhance performance as far as possible, the inclusion of prehabilitation must play an important role in a sport where injuries are as frequent as in rugby union. These studies provide a good understanding of the strength and conditioning practices around the globe at an elite rugby union level. However, there is no research on the practices of high school level rugby union coaches and specifically how they deal with the unique aspects of the South African population.

SUMMARY AND RATIONALE

The current state of literature indicates that strength and conditioning plays an important role in optimising athletic performance and reducing injuries in youth rugby union. Additionally, the South African 'BokSmart' program requires coaches to expand on their knowledge and application of safety in rugby. For this reason, the quantification of strength and conditioning practices at a youth level holds important value. As physical characteristics and injuries are theorised to alter performance, strength and conditioning practices can be viewed as a crucial modifiable factor for rugby union performance. To date, only two-rugby union related studies have been conducted regarding the strength and conditioning practices adopted at an elite level. There are no studies of strength and conditioning at a high school level, or any applicable to a South African population.

Determining the practices can provide crucial insight into the current situation regarding South African coaches' knowledge on strength and conditioning and the degree to which the schools implement best-known practices. The level of strength and conditioning education varies from coach to coach, it is however in the best interests of South African rugby to ensure the best-known practices are utilised throughout the country. Understanding the common practices and disparities between schools can assist in developing an effective method for improving the current level of knowledge throughout the country. This, in turn, can result in improved dissemination of this knowledge.

A combination of a qualitative and quantitative survey is the most practical method for collecting data over large geographical areas. Establishing the current strength and conditioning practices of high school coaches is an important first line of research. Furthermore, identifying differences across strata groups must be established before appropriate interventions can take place. With these factors in mind, the methodology in the subsequent chapter was designed.

CHAPTER III

METHODS

RESEARCH DESIGN

The study was a cross-sectional descriptive study that requested participation in an electronically based survey questionnaire designed using www.kwiksurvey.com (Appendix D). The survey was used to investigate the current strength and conditioning practices of high school rugby coaches in South Africa.

There were **two components** to the research project:

1. Profiling the practices of coaches and/or strength and conditioning coaches in the top high school rugby teams in South Africa:

In order to identify strength and conditioning practices at a high school level, questionnaires were distributed to the top 100 high school rugby teams in South Africa in 2016 (Appendix A). A strength and conditioning profile of the top performing high school rugby teams in South Africa could thus be established. This provided insight into the second component of the present study, namely:

2. Comparing the practices of strength and conditioning coaches in the different schooling systems in South Africa (independent private schools, top 100 achieving public schools and quintile 1-3 public schools).

In order to identify the differences in strength and conditioning practices in different schooling systems, included in the questionnaire was information about the type of school.

Participants

The participants recruited were the head strength and conditioning specialists or coaches (in the case of no strength and conditioning specialist but who may be responsible for strength and conditioning of their players) at 12 private schools and 16 public schools and 15 no-fee paying schools. The high school teams chosen were the top 100 in the country in 2016 (Appendix A). Since the no-fee paying schools are of major interest for the growth and transformation of South African rugby it was decided that these schools would be approached in the Eastern Cape region surrounding Grahamstown where the researcher resided. The area of focus for no-fee paying schools was limited to the researches ability to travel to the schools. No-fee paying schools often lack access to computers and Internet making them easier to approach locally where the researcher was located.

INSTRUMENT

Questionnaire Design

The questionnaire for the study was designed following a literature review of previous strength and conditioning surveys. Questionnaires examining similar issues were given specific attention, particularly those regarding high school strength and conditioning such as Duehring *et al.* (2009) and Pote and Christie (2016). Most of the questions in the survey have previously been validated in similar team sports such as football, baseball and cricket, all of which were adjusted from Ebben and Blackard (2001). To date, two studies have been published with regards to rugby related strength and conditioning practices (Jones *et al.*, 2016; Jones *et al.*, 2017). Thus, the questionnaire in the current study was also based on these questionnaires. Owing to the limited literature available, however, with regards to rugby specific questionnaires, newly constructed questions were verified for construct validity through pilot testing with local strength and conditioning specialists as well as sports scientists.

Using a mixed-method quantitative and qualitative approach, the participants were asked to reflect upon their own strength and conditioning practices. The quantitative questions provided specific data that was transformed into useable statistics. These questions included a combination of nominal and interval levels of measurements that reflected the response frequencies. The qualitative questions provided the researcher with specific trends or opinions and ensured the participants were not limited in their answers. The survey is provided in Appendix D.

Justification of the survey

The current survey examined a variety of conditioning responsibilities and the collective knowledge of the top 100 South African high school level strength and conditioning coaches. The survey was adapted from Ebben and Blackard (2001) for application in a rugby context. Specific rugby related questions were pilot tested with an advisory group of strength and conditioning coaches and sports scientists in Grahamstown.

The survey itself consisted of four sections:

1. General section: This includes the background information of the coaches, degrees and qualifications obtained and general knowledge of strength and conditioning principles. There were seven sub-sections to this part of the survey. The first background information sought to gain a better understanding of the coach and the qualifications they possess. Additionally, questions around the coaches' use of physical testing, flexibility development, speed development, agility development, plyometric training, and strength and resistance training were asked.

2. Rugby specific section: This deals with rugby specific strength and conditioning questions that gives insight to position specific practices. The goal from this section was to differentiate any position specific practices. Additionally, information gathered in this section will highlight differences between practices in rugby and other similarly surveyed sports.

3. Injuries and injury prevention section: This section includes questions regarding the current injury status of players as well as methods implemented for injury prevention.

4. General comments: This section was included to allow coaches an opportunity to include any information they might deem useful to the study.

Pilot testing

Prior to testing, the survey was pilot tested with an advisory group of five strength and conditioning coaches and sports scientists in Grahamstown, South Africa. The strength and conditioning consultants in the advisory group were required to posses an accredited strength and conditioning certification (CSCS). The sports scientists involved in pilot testing the survey were from the Human Kinetics and Ergonomics department at Rhodes University and required at least a Masters in exercise science or related field. These respondents did not participate in the main study.

The survey was validated for content and face validity of the rugby specific questions that have yet to be validated in previous studies. The advisory group examined whether the survey covered all areas of current knowledge in the scientific literature, establishing content validity. Face validity was calculated by the group and was deemed valid.

Previous studies validated the non rugby-specific questions and have been used in sports such as basketball (Simenz *et al.*, 2005), American Football (Ebben and Blackard, 2001), ice hockey (Ebben *et al.*, 2004), cricket (Pote and Christie, 2016) and rowing (Gee *et al*., 2011). Jones *et al*. (2016) and Jones *et al*. (2017) validated rugby specific questions using a group of seven strength and conditioning coaches however some questions differ to the current study. The validity of the current study's survey was thus established by receiving feedback from the experienced advisory board.

EXPERIMENTAL PROCEDURE

The survey was emailed to the strength and conditioning specialist or the coach in charge of conditioning for the u19 1st team of the requested school. Email addresses were attained via the school's website or by forwarding through the schools administration. The email contained the information to the participant (Appendix B) and a link to the online website where the survey was completed (https://kwiksurveys.com/s/5Qn1NbPk). The email explained that they were under no obligation to complete the questionnaire and could choose to decline participation at any point.

In the case where the coach was unreachable by email, a face-to-face interview was arranged where possible. Due to the multi-lingual nature of the South African education system, it was expected that there would be some language barriers. Thus, face-to-face interviews were deemed necessary in assisting with the understanding of certain concepts and questions. During the interviews the participants were not influenced in any way but explanations were provided for some terms where necessary.

ETHICAL CONSIDERATIONS

Prior approval from the Department of Human Kinetics and Ergonomics, Ethics Committee at Rhodes University, Grahamstown, South Africa was a prerequisite for the commencement of data collection (Appendix E), HKE-2017-02.

Informed Consent

All participants were informed in writing about the nature of the study (Appendices B and C). The purpose of the study, including aims, expectations and any associated risks or benefits, as well as the procedures that were to be carried out, were explained in the letter. Each participant gave voluntary consent. The option to accept or decline participation in the survey was posed as a question in the survey itself. In the case of face-to-face interviews, written consent was required once the participant was fully informed verbally and in writing (Appendix C). Upon completion of the study, all participants were provided with detailed feedback regarding the results of the study if they required.

Privacy and anonymity of results

To ensure the anonymity of the coaches, a coding system was used so that all information gathered could not be traced back to them. The coaches' school names were used on each survey to know which schools had responded for recording purposes and to compare categories of schools. Coaches were informed before experimentation that data would be held on file for statistical analyses and be deleted following the completion of the study, with only one copy being stored in the Department of Human Kinetics and Ergonomics, Rhodes University, for archive purposes.

STATISTICAL PROCEDURES

The survey consists of both fixed response (quantitative) questions and open-ended (qualitative) questions. The responses were exported by the survey host (Kwiksurvey) to a Microsoft Excel spreadsheet. Thematic analysis was used for qualitative data to identify patterns of meaning across the datasets that provides insight into the relevant question being addressed. This is performed using the process of data familiarisation, data coding, theme development and revision. Patterns or themes were identified in accordance to the methods used by previous publications on strength and conditioning principles (Ebben and Blackard, 2001; Ebben *et al.*, 2004). Braun and Clarke (2006) identified a six-phase process to thematic analysis that was closely followed in the current study. The qualitative questions were collated and content analysed for specific major and minor themes.

Categorical and ordinal data was reported as percentages of the responses. Univariate analysis was used to describe the basic features of the data and was stratified by the types of schools involved in the study. Microsoft Excel was used for data analysis.

CHAPTER IV

RESULTS

INTRODUCTION

The present study had two aims: to identify the strength and conditioning practices of the top 100 rugby playing schools in South Africa, and investigate the differences between the different types of school.

BACKGROUND INFORMATION

From the list of Top 100 SA rugby schools in 2016, the contact details of the relevant sports department or coaches themselves were gathered for 66 of the schools (15 private and 51 public schools). Contact details were unattainable for 44 of the schools due to unavailability online, language barriers and incorrect details provided on their websites. Twenty-eight of those coaches responded to the survey (12 private schools and 16 public schools). This response rate of 42% was deemed acceptable because it is higher than previous survey-based research on strength and conditioning practices (Duehring *et al.*, 2009; Durell *et al.*, 2003; Wade *et al.*, 2014). Additionally, 15 no-fee paying schools were included in the study; these surveys were completed via face-to-face and telephonic interviews. The total number of responses was therefore 43 coaches (private = 12, public = 16, no-fee paying = 15).

The respondents consisted of 11 1st XV coaches, 11 strength and conditioning coaches, eight teachers, seven sports scientists, two biokineticists, one gym co-ordinator, one high performance manager, one personal trainer and one security guard. All 43 coaches were males with varying levels of experience while only three were certified strength and conditioning coaches by a recognised, credible institution. Seven coaches from no-fee paying schools had a highest education level of high school matric[2] whereas all coaches from private and public schools had some form of higher education. Twenty-three coaches in private and public schools have a postgraduate education (private = 9, public = 14) while only six no-fee paying school coaches have that level of qualification. The basic demographic data of the respondents are shown in Table IV.

Table IV: Basic demographic data of the participants

	Private n = 12	**Public** n = 16	**No-fee** n = 15	**Total** n = 43 (%)
Sex				
Male	12	16	15	43 (100)
Female	0	0	0	0 (0)
Age (years)				
< 30	6	8	2	16 (37)
30 - 39	6	7	6	19 (44)
> 40	0	1	7	8 (19)
Experience (years)				
< 5	4	3	2	9 (20)
5 - 10	5	8	4	17 (40)
> 10	3	5	9	17 (40)
Highest level of Education				
Undergraduate	2	0	1	3 (7)
Postgraduate	9	14	6	29 (68)
Other*	1	2	1	4 (9)
Matric	0	0	7	7 (16)
S&C Certifications				
NSCA	2	1	0	3 (7)
Other*	1	2	0	3 (7)

S&C: Strength and conditioning

- Other refers to additonal qualifications, such as certificates or diplomas in health and wellness

[2] Matric: The South African government administered qualification received on graduating from high school.

PHYSICAL TESTING

Thirty-one out of 43 coaches (72%) indicated they did some form of physical testing. Of these, 11 (92%) were from private schools, 15 (94%) from public schools and five (33%) from no-fee paying schools.

The most commonly tested phenotype was speed (58%), which remained the most popular for private schools (75%) and no-fee paying schools (27%) alike (Figure 2). The public schools indicated a preference to testing muscular strength (88%) (Figure 2). All but one of the private and public schools' coaches that tested speed used a 40m sprint, whereas all four coaches from no-fee paying schools tested speed using a 100m sprint. The only other phenotype tested by no-fee paying schools was aerobic capacity with all three coaches utilising the multistage fitness test or "bleep test". One private school coach and five public school coaches used the Multi-Stage-Fitness-Test as a measure of aerobic capacity. Other tests included the yo-yo intermittent test, 2.4km, 3km and 5km time trials.

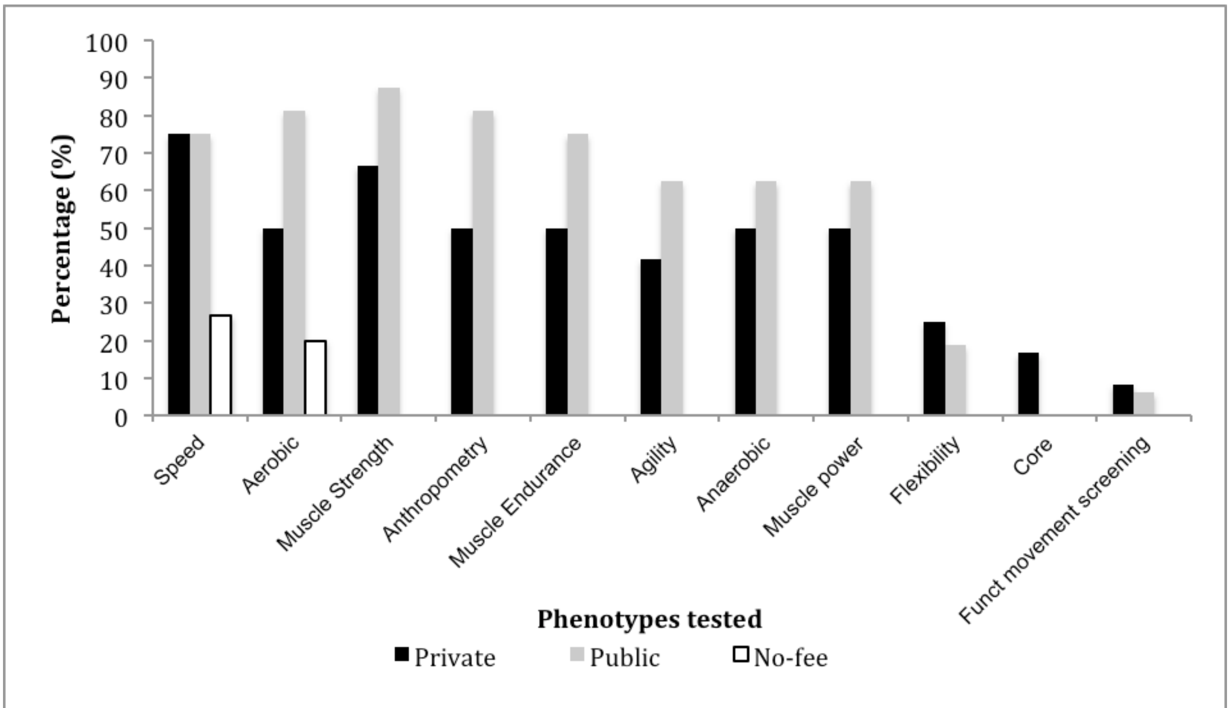

Figure 2: Different physical phenotypes tested (%) across the schools (n = 31).

Nineteen coaches reported testing anthropometry including measures of height, mass, skinfolds, waist circumference and bioelectrical impedance. Measures of muscular strength included one to five rep max bench press, squat, deadlift, clean and press, bent over row, pull ups and shoulder presses. Various muscular endurance tests were reported included maximum pull-ups completed, the number of sit-ups and push-ups completed in 1-minute and one respondent counted the number of repetitions on a bench press set at the player's weight.

The most common measure of agility was the Illinois agility test (n = 10, Private = 3, Public = 7). Other agility tests included pro-agility test, t-test, 5-0-5 agility test and one respondent indicated having their own test but did not elaborate. The repeated sprint ability test was the most commonly prescribed measure of anaerobic capacity (n = 15, Private = 6, Public = 9). Measures of muscular power included standing broad jump, vertical jump height, "tendo jump" and counter movement jump height. All six coaches that prescribed flexibility tests used the sit-and-reach assessment. Two private school coaches included core strength tests excluding the sit-up test, which was categorised under muscular endurance tests. The core tests used included maximum plank time and the "8 stage plank test". Two respondents used functional movement screening to identify inefficient movement patterns in their players.

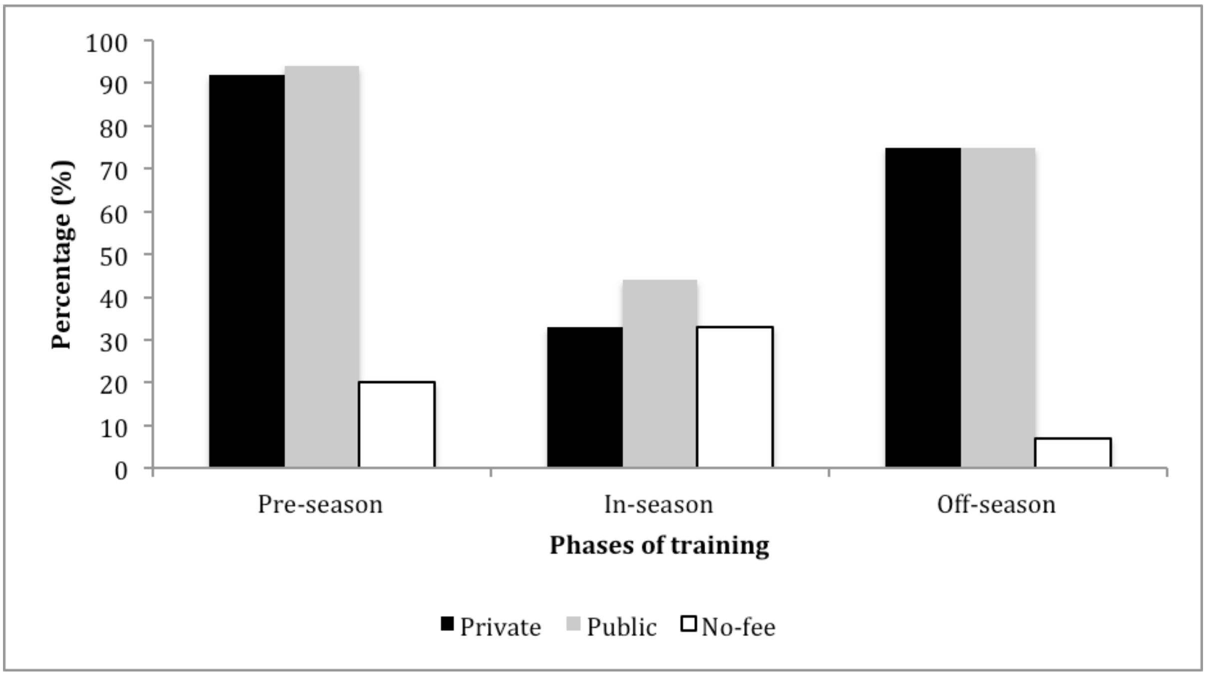

Figure 3: Timing of physical performance tests (%) across the schools.

The most common phase to conduct physical tests for private schools was in the pre-season (92%) compared to in-season (33%) and off-season (75%) (Figure 3). Public schools also favoured pre-season (94%), where no-fee paying schools tested most commonly in-season (33%) (Figure 3). Overall the least number of coaches tested in-season (n = 16) and the most during pre-season (n = 29).

STRENGTH AND CONDITIONING PRACTICES

Flexibility development

All 43 coaches reported that their teams did some type of flexibility training. The types of flexibility exercises are provided in Figure 4. Dynamic exercises were most common overall (n=38, private = 100%, public = 100%, no-fee paying = 67%). Static exercises were the most common form of flexibility training for no-fee paying schools (80%) and the second most common overall (n=36, private = 83%, public = 88%). The only other flexibility exercises employed by no-fee paying schools were passive (13%) and active stretches (7%). Passive stretches were prescribed by 25% of private school coaches and 31% of public school coaches. Active stretches were reported in 50% of private schools and 56% in public schools.

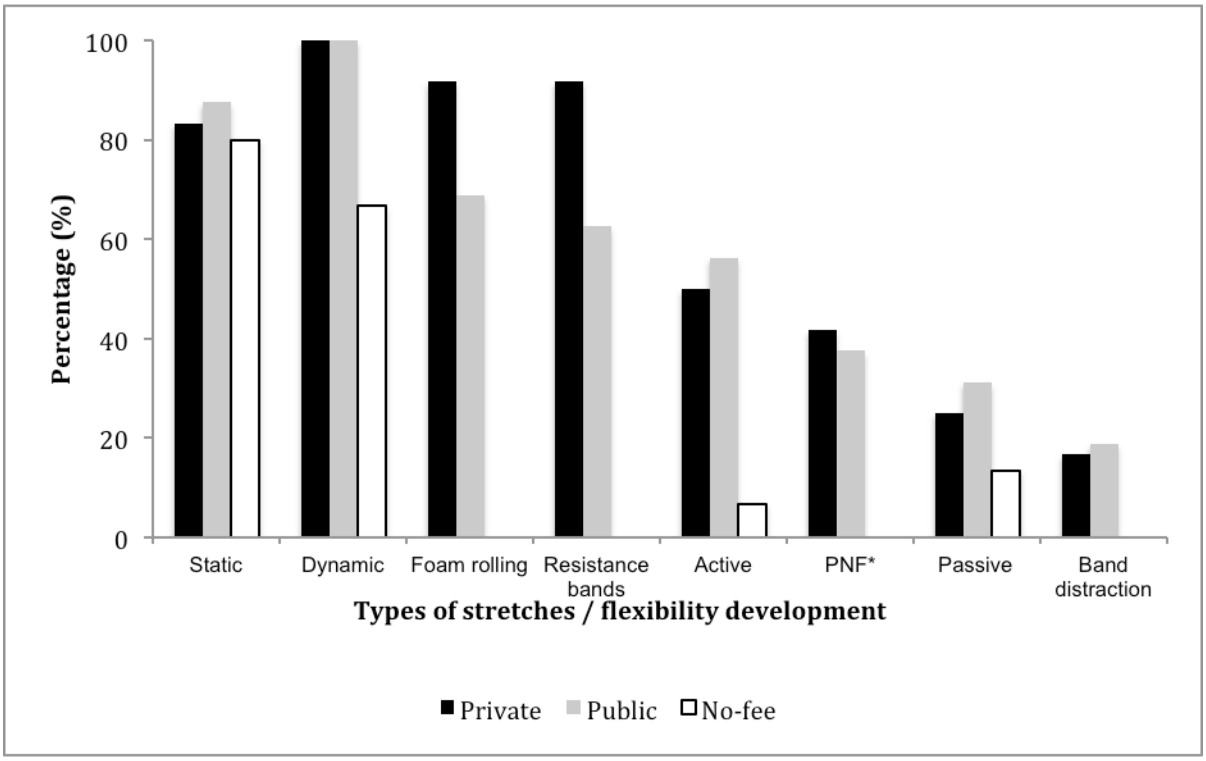

Figure 4: Types of flexibility exercises (%) across the schools.

*PNF: Proprioceptive neuromuscular facilitation.

Twenty-two coaches (private = 92%, public = 69%) reported prescribing foam rolling as a technique for flexibility training. Twenty-one coaches (private = 92%, public = 63%) reported that they employ resistance band exercises during flexibility training. Other flexibility exercises included proprioceptive neuromuscular facilitation (n = 11, private = 42%, public = 38%), band distraction (n = 5, private = 17%, public = 19%) and yoga (n = 2, public = 13%). Private and public schools overall did eight various types while no-fee paying schools did only four.

Table V describes the times at which coaches prescribe flexibility exercises. The most common time is before a match (n = 42, private = 100%, public = 100%, no-fee paying = 93%). Twenty-four coaches prescribed flexibility exercises after a match (private = 92%, public = 56%, no-fee paying = 27%).

Table V: Times when players are required to do flexibility exercises.

	Private (%)	Public (%)	No-fee (%)	Total (%)
Field Training				
Before practice	11 (92)	12 (88)	13 (87)	38 (88)
During practice	2 (17)	2 (13)	1 (7)	5 (12)
After Practice	8 (67)	9 (56)	4 (27)	21 (49)
On their own	6 (50)	5 (31)	0 (0)	11 (26)
Matches				
Before match	12 (100)	16 (100)	14 (93)	42 (98)
After match	11 (92)	9 (56)	4 (27)	24 (56)
Gym workout				
Before workout	8 (67)	12 (75)	1 (7)	21 (49)
After workout	7 (58)	7 (44)	1 (7)	15 (35)

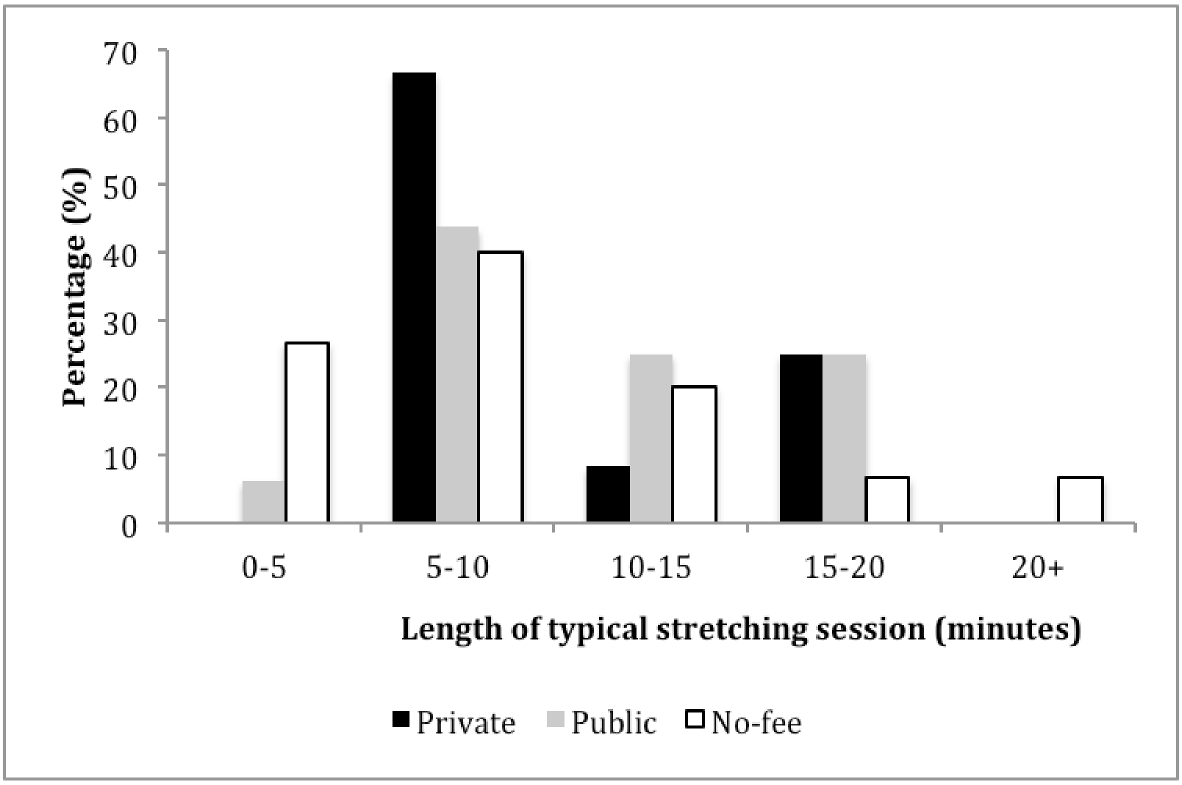

Figure 5: Length (minutes) of typical flexibility session.

Figure 5 describes the amount of time coaches encourage their players to take part in flexibility exercises. Twenty-one coaches reported prescribing flexibility sessions between 5 and 10 minutes long (private = 67%, public = 44%, no-fee paying = 40%). Eight coaches prescribe a period between 10 and 15 minutes (private = 8%, public = 25%, no-fee paying = 40%). Eight coaches administered flexibility sessions between 15 and 20 minutes (private = 25%, public = 25%, no-fee paying = 7%). One top public school coach and four no-fee paying school coaches prescribed short periods of flexibility exercises (less than 5 minutes). One coach from a no-fee paying school reported the length of a typical flexibility session to be longer than 20 minutes.

Speed development

All 43 coaches reported that their teams did some type of speed development training. Thirty-three coaches reported holding speed development sessions on a weekly basis (private = 58%, public = 94%, no-fee paying = 73%). One private school coach reported monthly sessions of speed development while the remaining conducted speed training more than once per week (n = 9, private = 33%, public = 6%, no-fee paying= 27%).

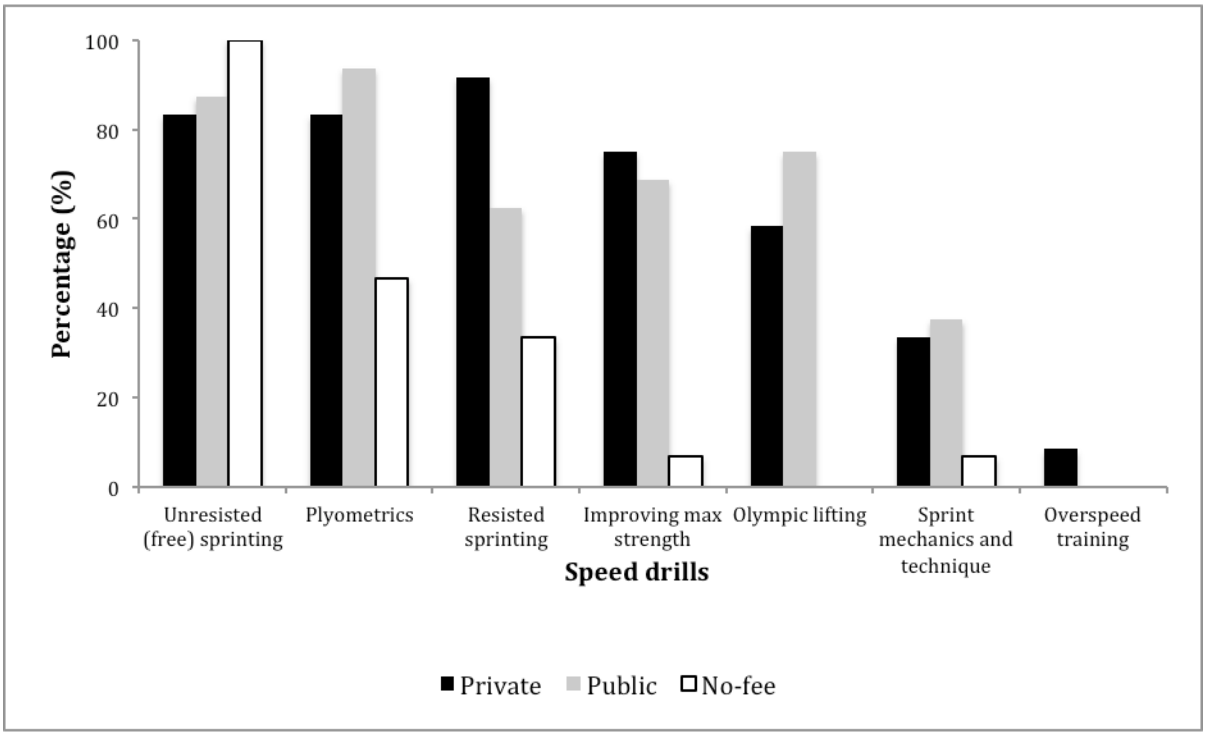

Figure 6: Types of speed-development exercises (%) used by coaches.

Figure 6 illustrates the speed development exercises prescribed by the coaches. Thirty-nine coaches (private = 83%, public = 88%, no-fee paying = 100%) reported free sprinting as a method for speed development. Plyometrics was reported as a method of speed development by 32 (Private = 83%, public = 94%, no-fee paying = 47%). Twenty-six coaches used resisted sprinting (private = 92%, public = 63%, no-fee paying = 33%). Other methods included improving maximum strength (n = 21), Olympic lifting (n = 19), developing sprint mechanics and technique (n = 11) and one coach used "overspeed" training

Agility training

Thirty-seven respondents reported prescribing agility exercises (private = 92%, public = 100%, no-fee paying = 67%). Table VI displays the higher order themes of agility training methods used by coaches.

Table VI: Training methods used by coaches for agility training

Higher order themes	No of responses (%)			Select raw data representing responses to this question
	Private [n=12]	Public [n=16]	No-fee [n=15]	
Self designed	6 (50)	6 (38)	6 (40)	"I design my own." "A few of my own criteria testing I have developed." "Homemade drills."
Speed ladder	3 (25)	8 (50)	4 (25)	"Speed ladder." "Agility ladder." "Ladder drills."
Change of directon	11 (91)	16 (100)	6 (40)	"Change of direction." "X-agility." "L-agility." "Illinois agility." "Z drill."
Hurdles	1 (8)	2 (13)	1 (7)	"Hurdles"
Reactive agility/ decision making	1 (8)	2 (13)	0 (0)	"Mirror movements." "Decision making." "Reactive agility tests."
Small sided games	0 (0)	1 (6)	0 (0)	"Small sided games"

Twenty-four coaches did agility exercises on a weekly basis (private = 58%, public = 56%, no-fee paying = 53%). Ten coaches reported using agility training more frequently than once per week (private = 25%, public = 38%, no-fee paying = 7%), and three did agility exercises on a monthly basis (private = 8%, public = 6%, no-fee paying = 7%).

Figure 7 describes the timing of agility training exercises. Thirty-three respondents did agility training during pre-season (private = 83%, public = 88%, no-fee paying = 60%). The same respondents in public schools (88%) and no-fee paying schools (60%) implemented agility-training in-season. Fewer private schools did agility training in-season (67%). Nine respondents reported making use of agility training in off-season (private = 33%, public = 25%, no-fee paying = 7%).

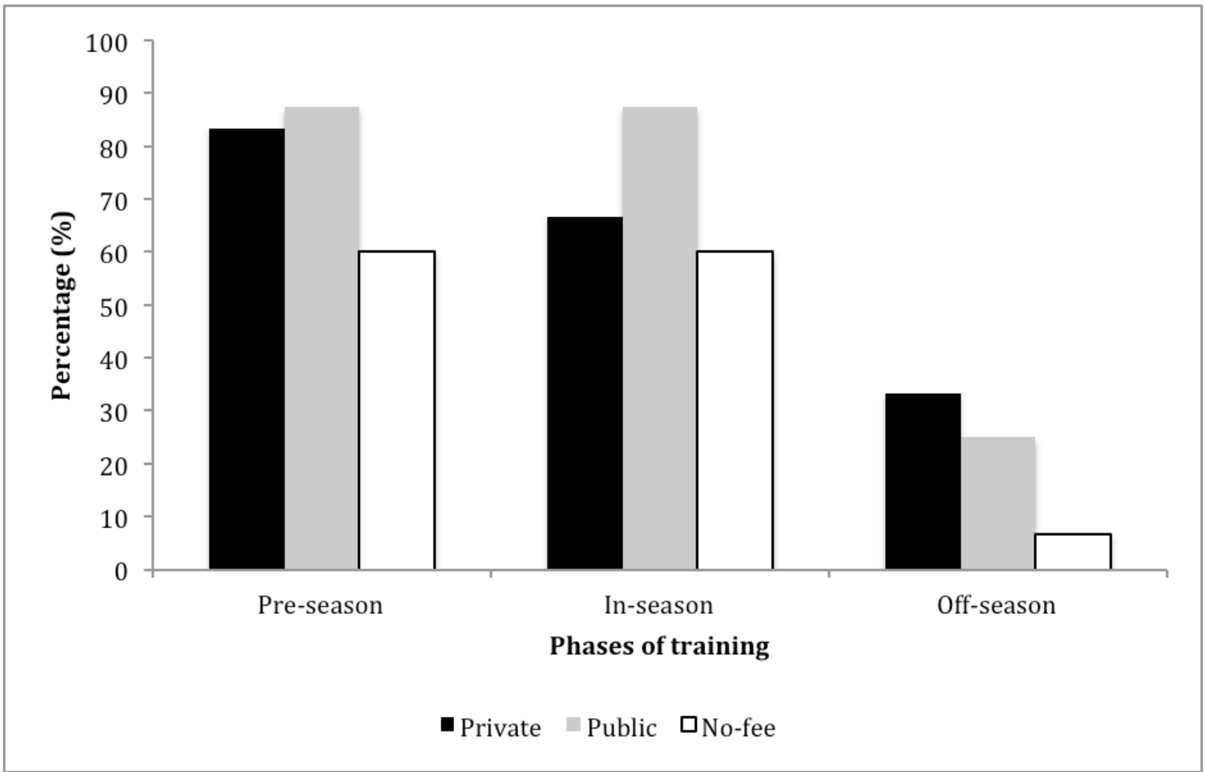

Figure 7: Timing of agility training exercises (%) across the schools.

Plyometrics

Thirty-four coaches prescribed plyometric exercises (private = 83%, public = 100%, no-fee paying = 53%). The subsequent question in this section asked what types of plyometric exercises are prescribed by coaches and responses are detailed in table VII.

Table VII: Training methods used by coaches for plyometrics.

Higher order themes	No of responses (%) Private [n = 12]	Public [n = 16]	No-fee [n = 15]	Select raw data representing responses to this question
Jumps	7 (58)	6 (38)	5 (33)	"Broad jumps." "Triple jumps." "Jumps with different variations." "Bilateral and unilateral jumps."
Hops	2 (17)	3 (19)	4 (27)	"Hops"
Box drills	6 (50)	10 (63)	4 (27)	"Box jumps and their variations"
Bounds	3 (25)	5 (31)	0 (0)	"Bounds." "Different variations of bounds."
Skips	2 (17)	5 (31)	2 (13)	"Skips"
Upper body plyo	3 (25)	6 (38)	0 (0)	"Slam balls." "Clap pushups." "Medicine ball throws."
Hurdles	2 (17)	3 (19)	0 (0)	"Hurdles"
Power lifts	0 (0)	3 (19)	0 (0)	"Explosive Power in the gym." "Weighted jump squats."
Miscellaneous	3 (25)	6 (38)	0 (0)	"Kettelbell swings." "Explosive work." "Own body weight." "Confidential."

Various forms of jumping exercises were the most common method of plyometric training for private (58%) and no-fee paying schools (33%). While box drills were most popular with public school coaches (63%). Overall box drills were most common with 50% of private school coaches and 27% of no-fee paying school coaches using them. No-fee paying school coaches utilised fewer plyometric-training techniques with only four types compared to eight for private schools and all nine for public schools.

Twenty-six coaches did plyometric exercises on a weekly basis (private = 67%, public = 75%, no-fee paying = 40%). Five coaches did plyometrics more than once a week (private = 8%, public = 19%, no-fee paying = 7%) and two did them on a monthly basis (private = 8%, public = 6%, no-fee paying = 0%).

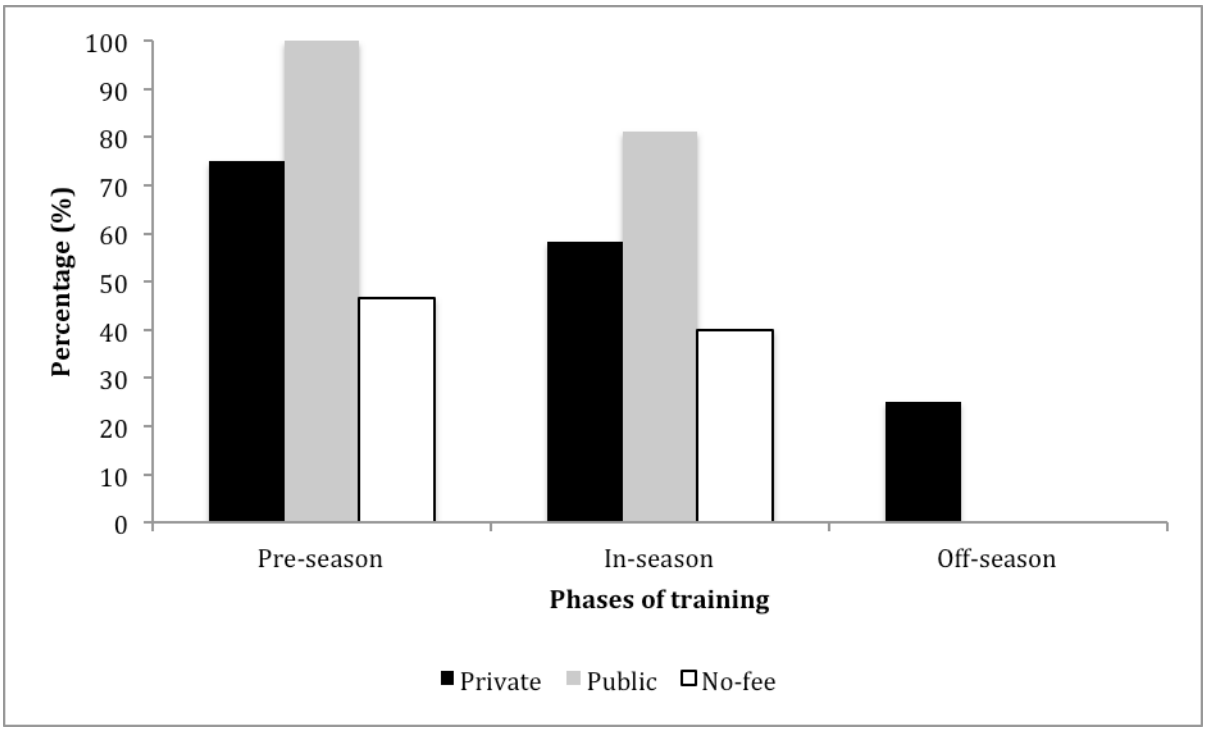

Figure 8: Timing of plyometric training (%) across the schools.

Thirty-two coaches reported utilising plyometric training in pre-season (private = 75%, public = 100%, no-fee paying = 47%). Plyometrics is used less during the in-season (n = 26, private = 58%, public = 81%, no-fee paying = 40%) and off-season (n = 3, private = 25%, public = 0%, no-fee paying = 0%).

Resistance training

Thirty-six coaches reported prescribing resistance-training methods for their players (private = 100%, public = 100%, no-fee paying = 53%). The most common number of resistance training sessions is 3 times a week (n = 16, private = 42%, public = 63%, no-fee paying = 7%) (Figure 9). Ten coaches prescribed resistance training to their players twice a week (private = 25%, public = 19%, no-fee paying = 27%). None of the private or public school coaches prescribed resistance training once a week, both preferring 3 sessions per week. In contrast no-fee paying school coaches preferred resistance training twice a week with a few respondents training once a week (20%) and three times a week (7%). Seven coaches from private (33%) and public (19%) schools reported prescribing resistance training four times a week to their players.

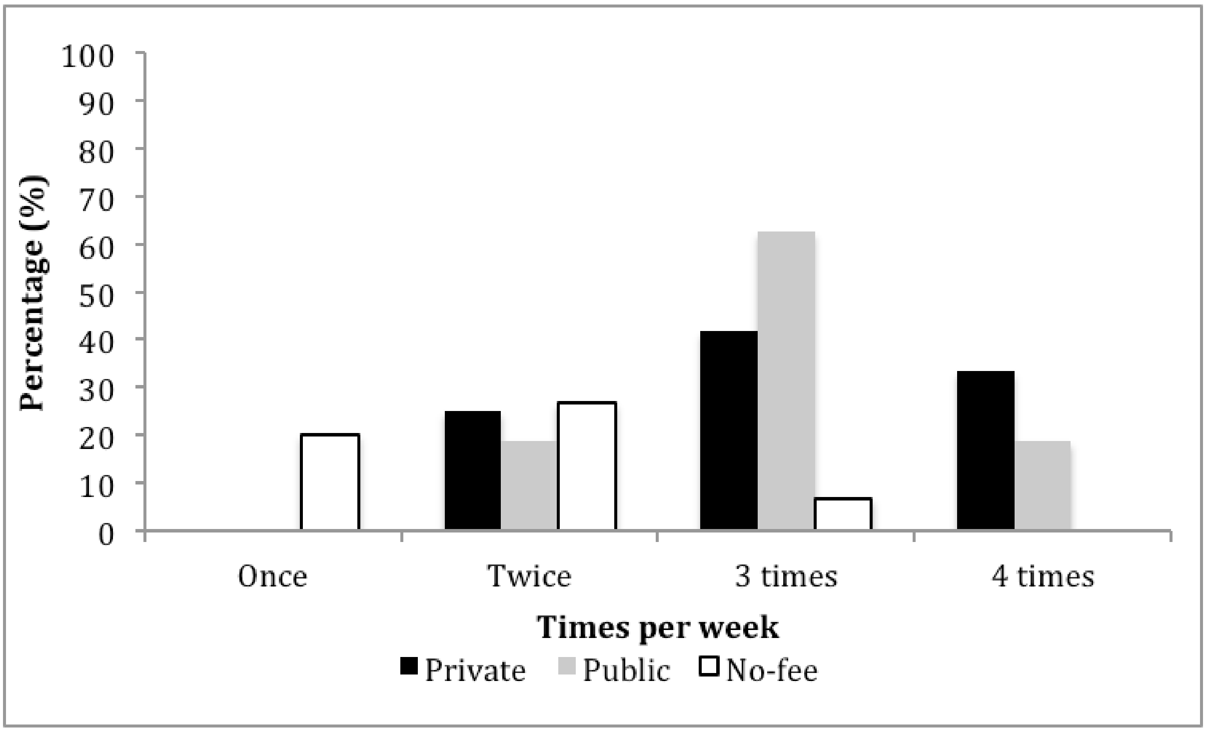

Figure 9: Number of times a week coaches prescribes resistance training.

Thirty-five coaches required their players to take part in resistance training during pre-season (private = 100%, public = 100%, no-fee paying = 47%) (Figure 10). Thirty-two continue resistance training in-season (private = 92%, public = 94%, no-fee paying = 40%) and 23 during off-season (private = 92%, public = 69% and no-fee paying = 7%).

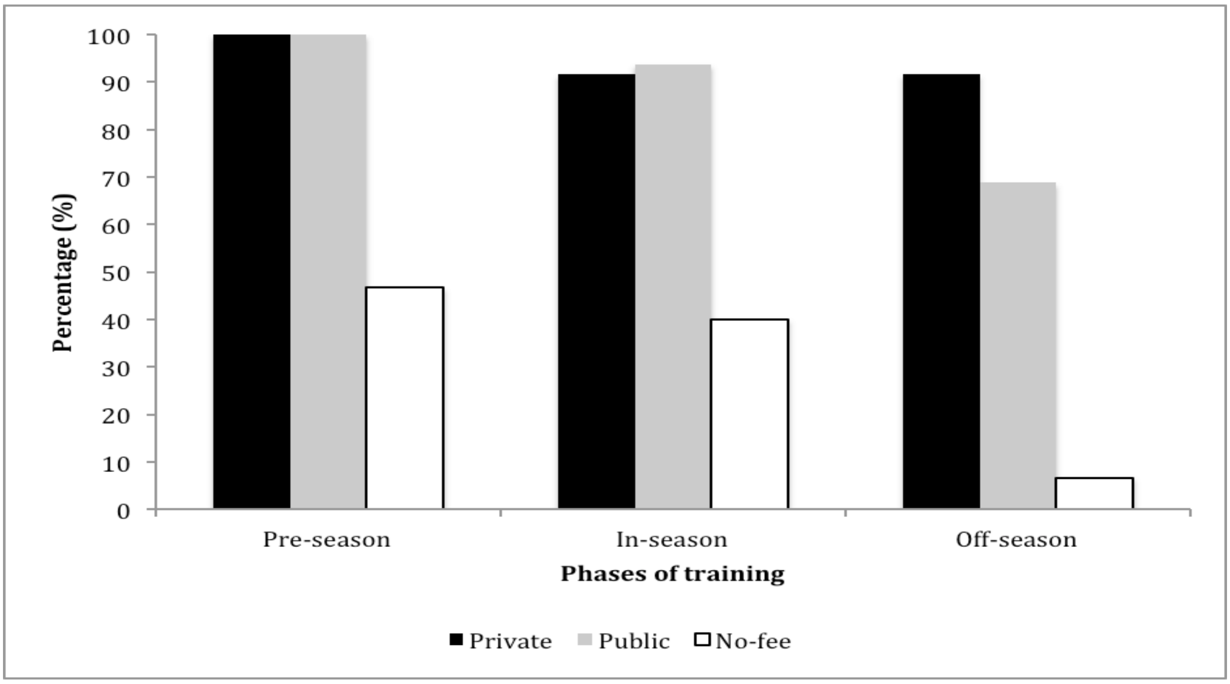

Figure 10: Timing of resistance training (%) across the schools.

Equipment

Table VIII: most common equipment used for each type of training.

Type of training	Equipment		
	Private (%)	**Public (%)**	**No-fee (%)**
Flexibility	Resistance bands (100%)	Resistance bands and foam roller (69%)	None
Speed	Resistance bands (75%)	Sled (62.5%)	Cones (40%)
Agility	Agility poles (88.33%)	Agility poles (87.5%)	Cones (33.33%)
Plyometrics	Boxes (75%)	Boxes (87.5%)	Cones (33.33%)
Resistance training	Free weights (100%)	Free weights (100%)	Body weight (53.3%)

The most common pieces of equipment are detailed in table VIII. Private and public schools share four out of five of the most common equipment used. The only difference is in speed development where the majority private schools use resistance bands and public schools use sleds. The most common pieces of equipment used in no-fee paying schools across three training principles are cones.

RUGBY SPECIFIC QUESTIONS

Table IX demonstrates the use of periodisation between different schooling structures. Only one (7%) no-fee paying school coach reported using periodisation methods as compared to 83% of private and 81% public school coaches.

Table IX: Conceptualisation of training.

	Number of responses (%)			**Total (%)**
	Private [n = 12]	**Public [n = 16]**	**No-fee [n = 15]**	
Periodisation	10 (83)	13 (81)	1 (7)	24 (56)
Nonperiodisation	2 (17)	3 (19)	14 (93)	19 (44)

A question was posed to get further insight into the periodisation periods prescribed by coaches and is detailed in table X. The most common responses indicated dividing the phases of training into hypertrophy (n = 13, private = 42%, public = 50%, no-fee paying = 0%), strength development (n = 16, private = 58%, public = 50%, no-fee paying = 7%) and power development (n = 13, private = 42%, public = 50%, no-fee paying = 0%). The one no-fee paying school coach that utilised periodisation separated training periods by strength development and aerobic conditioning. Two coaches (one private and one public) each reported including active recovery and prehabilitation into periodisation programs. One private school coach included anaerobic conditioning as a training method during pre-season.

Table X: Conceptualisation of periodisation periods.

Higher order themes	Number of responses (%)			Select raw data representing responses to this question
	Private [n = 12]	Public [n = 16]	No-fee [n = 15]	
Hypertrophy	5 (42)	8 (50)	0 (0)	"Hypertrophy- 4 weeks off season."
Strength development	7 (58)	8 (50)	1 (7)	"Strength- 4-6 weeks pre season."
Power development	5 (42)	8 (50)	0 (0)	"Power- 3-4 weeks pre season."
Maintenance	3 (25)	3 (19)	0 (0)	"Maintain in season." "Strength and Power maintenance."
Aerobic conditioning	1 (8)	2 (13)	1 (7)	"General aerobic during off season then transitioning to intense aerobic."
Anaerobic conditioning	1 (8)	0 (0)	0 (0)	"Anaerobic conditioning in pre-season."
Active recovery	1 (8)	1 (6)	0 (0)	"Active recovery – Dec."
Prehabilitation	1 (8)	1 (6)	0 (0)	"Injury rehabilitation and prehabilitation: 4 weeks."

Twenty (private = 58%, public = 69%, no-fee paying = 13%) coaches report using different conditioning practices for different positions (Table XI). Only two no-fee paying schools included position specific conditioning into their training programs. The back row positions had the most number of unique training components with 28 different practices.

Table XI: Different conditioning practices for specific positions.

	Private n = 7	Public n = 11	No-fee n = 2	Total (%) n =20
Front row				
Core	1	5	0	6 (30)
Strength	4	8	2	14 (70)
Collision conditioning	1	0	0	1 (5)
Aerobic training	0	1	0	1 (5)
Scrummaging exercises	2	2	0	4 (20)
Second row				
Strength	3	4	2	9 (45)
Explosive power	3	4	0	7 (35)
Aerobic training	0	1	0	1 (5)
Collision conditioning	1	0	0	1 (5)
Core	0	2	0	2 (10)
Flexibility	0	1	0	1 (5)
Back row				
Anaerobic training	2	1	0	3 (15)
Explosive Power	2	6	0	8 (40)
Strength	2	2	2	6 (30)
Ruck specific exercises	2	3	0	5 (25)
Aerobic training	1	3	0	4 (20)
Speed	0	2	0	2 (10)
Half backs				
Passing drills (weighted)	2	2	1	5 (25)
Speed	1	3	0	4 (20)
Explosive Power	0	1	2	3 (15)
Aerobic training	1	2	0	3 (15)
Wrestling	2	0	0	2 (10)
Decision making / reactive agility	1	2	0	3 (15)
Strength	0	2	1	3 (15)
Agility	0	1	0	1 (5)
Flexibility	0	1	0	1 (5)
Centers				
Explosive Power	3	6	2	11 (55)
Speed	1	6	1	8 (40)
Wrestling	1	0	0	1 (5)
Collision conditioning	1	0	0	1 (5)
Strength	1	5	0	6 (30)
Agility	0	1	0	1 (5)
Outside backs				
Speed	4	7	1	12 (60)
Power	1	5	2	8 (40)
Agility / Reactive agility	1	3	0	4 (20)
Strength	0	1	0	1 (5)

Workload monitoring

Workload monitoring was reported as common practice in private (75%) and public schools (56%), whereas none of the no-fee paying schools reported monitoring player workloads (Table XII). Two respondents indicated monitoring player workloads but did not provide further information as to how they are monitored. The most popular form of workload monitoring was ratings of perceived exertion, reported by 8 coaches (private = 25%, public = 31%). Advanced GPS technology was more prevalent in private schools (25%) as opposed to public schools (6%).

Table XII: The different methods used for workload monitoring.

Higher order themes	Number of responses			Select raw data representing responses to question
	Private [n = 12]	Public [n = 16]	No-fee [n = 15]	
RPE	3 (25)	5 (31)	0 (0)	"Ratings of perceived exertion."
Communication / player feedback	1 (8)	3 (19)	0 (0)	"Constant feedback is required and provided according to how they feel in training and during matches."
Questionnaires (physical and online)	2 (17)	0 (0)	0 (0)	"Questionnaire." "Online form."
Strength testing	1 (8)	0 (0)	0 (0)	"Weight lifted."
Omega wave	1 (8)	0 (0)	0 (0)	"Omega wave."
Durations and frequency of exertion	1 (8)	2 (13)	0 (0)	"Game time." "Durations." "Repetitions." "Volume of sprints."
Heart rate data	2 (17)	1 (6)	0 (0)	"Heart rate monitoring." "Heart rates at rest, work and more importantly recovery heart rates."
Distance covered (GPS)	3 (25)	1 (6)	0 (0)	"Distance monitoring." "GPS."

Unique themes for rugby strength and conditioning

This section asked coaches of any aspects to their strength and conditioning practices that are unique to rugby as compared to other sports. The responses were content analysed and detailed in table XIII. "Specificity" was identified as the most common unique aspect of rugby conditioning in private (42%) and public schools (56%), whereas none of the no-fee paying school coaches mentioned this. The unique themes mentioned by no-fee paying schools included "core stability and strengthening" (13%), injury prevention (7%) and miscellaneous (20%). Four responses were recorded for no-fee paying schools whereas private schools reported 13 responses and public, 22.

Table XIII: Unique themes for rugby conditioning

Higher order themes	Number of responses (%)			Select raw data representing responses to question
	Private [n = 12]	Public [n = 16]	No-fee [n = 15]	
Specificity	5 (42)	9 (56)	0 (0)	"Specificity." "Position specific Exercises." "Most of the program is unique to rugby."
Core stability & strengthening	3 (25)	6 (50)	2 (13)	"I place a lot of emphasis on core training." "Core stability." "Core strength is crucial in the contact situation."
Injury prevention	3 (25)	1 (6)	1 (7)	"Injury prevention work such as eccentric muscle programs, active recovery or pool recovery session."
Power	2 (17)	0 (0)	0 (0)	"Power lifting movement." "Lots of explosive work rather than normal bodybuilding gyming."
Strength	0 (0)	2 (13)	0 (0)	"We just focus on strength and having it transfer to field." "More strength training."
Miscellaneous	0 (0)	4 (25)	2 (13)	"Flexibility." "Mobility." "Safety." "Strongman lifts."

INJURIES

The injury section of the survey sought to identify common injuries in high school rugby and how coaches prepare strength and condition programs to prevent injuries. Twenty-four coaches (private = 67%, public = 81%, no-fee paying = 20%) reported recording injury incidence amongst their players'. Thirteen coaches reported that they did not record injuries while the remaining six indicated they did so inconsistently. The subsequent question asked coaches what position was most commonly injured (Table XIV). Only coaches who responded "yes" or "inconsistently" to recording injuries were prompted to answer this question however some others did and their results were excluded. Coaches who did not record data would not be able to accurately report on injury statistics, hence their exclusion. Five coaches indicated they recorded injuries but did not answer the following question on the most commonly injured position and were therefore excluded. The most commonly injured position was the back row with eight responses (private = 22%, public = 50%, no-fee paying = 0%).

Table XIV: Most commonly injured positions.

	Front Row (%)	Second Row (%)	Back Row (%)	Half Backs (%)	Centers (%)	Outside Backs (%)
Private n = 9	3 (33)	1 (11)	2 (22)	0 (0)	1 (11)	2 (22)
Public n =12	0 (0)	2 (17)	6 (50)	0 (0)	3 (25)	1 (8)
No-fee n =4	2 (50)	0 (0)	0 (0)	0 (0)	1 (25)	1 (25)
Total n = 25	5 (20)	3 (12)	8 (32)	0 (0)	5 (20)	4 (16)

The following question investigated the most common injury site for each position and the responses are displayed in table XV. Only three no-fee paying schools indicated they recorded injuries thus they were excluded from table XV due to a small sample size. However, it is worth noting that shoulder injuries were most common in these schools, being recorded in all positions except outside backs. Additionally, ankle injuries were mentioned by all three coaches as a common occurrence in the back row. Since all the private schools and remaining public schools are in the top 100 rugby playing schools list for 2016, their results were combined for the purpose of table XV.

Table XV: Most common injury types for specific positions; excluding no-fee paying schools and those who do not record injuries (Top 100 schools only).

n=25	Front Row	Second Row	Back Row	Half Backs	Centers	Outside Backs	Total
Shoulders	10	9	15	3	15	0	52
Ankle	4	7	8	8	5	8	40
Hamstring	0	0	2	3	6	13	24
Groin	1	2	5	8	1	5	22
Head (including concussion)	6	4	6	0	3	1	20
Calves	0	1	1	4	2	8	16
Lower back	7	5	1	0	0	0	13
Quadriceps	0	1	2	0	2	1	6
Knee	2	0	2	1	0	1	6
Wrist and hand	1	0	3	0	1	0	5
Other*	2	1	0	0	0	0	3
Neck & Spine	0	1	0	0	0	0	1
Total	33	31	45	27	35	37	-

*** face, bicep and tibialis anterior**

The most common sites of injury were the shoulders, with 52 recordings of shoulder injuries. Ankle injuries were common (n = 40) but no more so than in the back row and outside backs (32%). The most commonly afflicted injury site and position is shoulder injuries in both back row and centres alike (60%). Hamstring (52%) and calf (32%) injuries were most common in outside backs (52%). Groin injuries were most prevalent in half backs (32%). The most common positions for head injuries were the front row and back row with 24% alike. The front row suffered the greatest number of lower back injuries (28%). Overall the back row received the most number of responses for injuries (45).

Injury prevention

Twenty-five coaches reported employing injury prevention exercises as described in table XVI. The majority of private (83%) and public school (94%) coaches reported utilising injury prevention exercises whilst only one non-fee school coach did.

Table XVI: Respondents who employ injury prevention exercises.

	Private	**Public**	**No-fee**	**Total (%)**
Yes	10	14	1	25 (58)
No	2	2	14	18 (42)

Table XVII describes the injury prevention exercises utilised by coaches. The one no-fee paying school coach who implemented injury prevention exercises did so using targeted strengthening of certain areas, eccentric work and core strengthening. This respondent mentioned getting help and expertise from a friend who is a practicing physiotherapist. The most popular injury prevention exercises overall were strengthening target areas (n = 13, private = 60%, public = 43%, no-fee paying = 100%). Eccentric work (private = 40%, public = 14%, no-fee paying = 100%) and balance, stability and movement exercises (private = 30%, public = 29%, no-fee paying = 0%) each received seven responses. Core exercises, flexibility, recovery techniques, and high-speed exertions were also included as forms of injury prevention exercises used by coaches.

Table XVII: Conceptualisation of injury prevention exercises.

Higher order themes	Number of responses			Select raw data representing responses to question
	Private [n = 10]	Public [n = 14]	No-fee [n = 1]	
Strengthening target areas	6 (60)	6 (43)	1 (100)	"Specific strength exercises in the gym that target the most injury prone areas." "Shoulder girdle exercises to strengthen the soft tissues in the shoulder impact area." "Neck strengthening."
Eccentric work	4 (40)	2 (14)	1 (100)	"Nordic hamstring lows." "Eccentric work."
Balance, stability and movement exercises	3 (30)	4 (29)	0 (0)	"Stability & movement work." "Mobility exercises of all joints." "Balance and stability."
Core	1 (10)	3 (21)	1 (100)	"Core stability and strength in all positions to ensure correct posture and spine alignment." "Planking is used for front rowers for core stability"
Flexibility	2 (20)	1 (7)	0 (0)	"Stretching and yoga." "Flexibility." "PNF stretches."
Recovery techniques	1 (10)	0 (0)	0 (0)	"Correct stretching and recovery techniques."
Plyometrics	1 (10)	0 (0)	0 (0)	"High speed exertions (box jumps) to mimic the explosiveness of sprinting."

The one no-fee paying school coach who used injury prevention exercises did them during the pre-season. The results for the private and public schools were combined as schools falling in the top 100 rugby list and are displayed in figure 11.

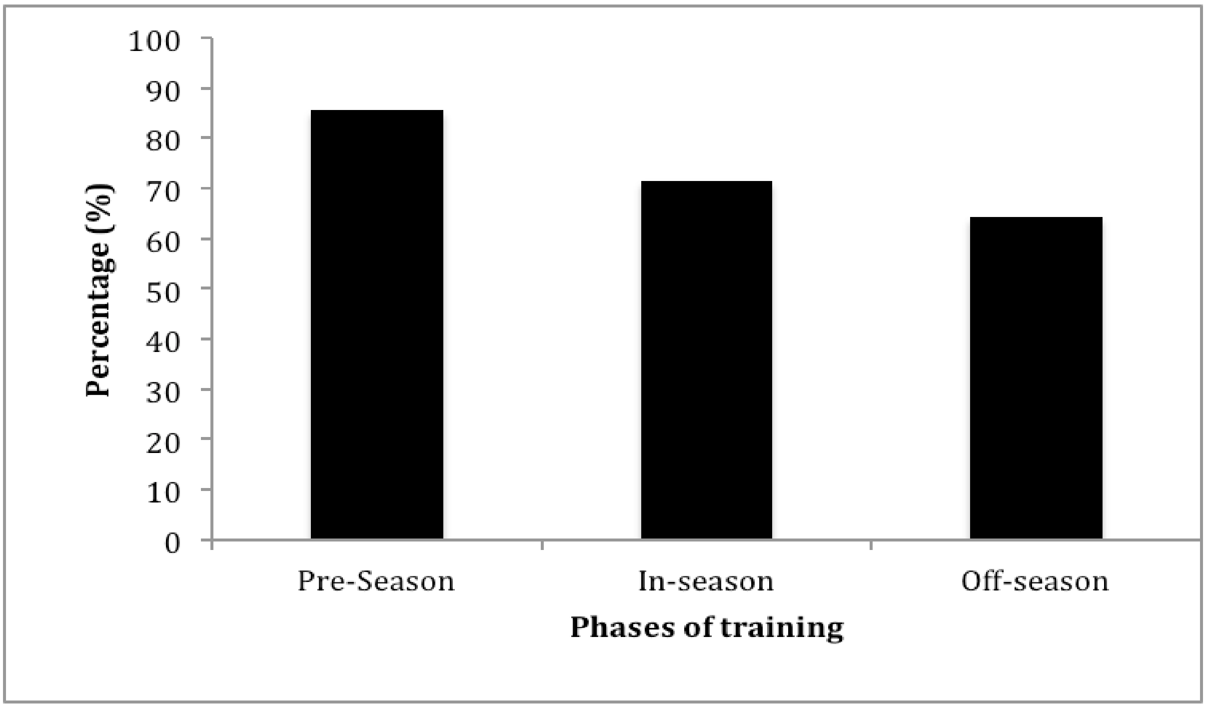

Figure 11: Timing of injury prevention exercises (%) for top 100 schools only.

GENERAL COMMENTS

The last section of the survey provided the coaches an opportunity to suggest possible ways to improve their strength and conditioning practices (Figure 12) and to make any comments on the survey (Table XVIII).

The most common area for improvement was identified as personal development of the respondent himself (n = 31, private = 75%, public = 81%, no-fee paying = 60%). Improved facilities (n = 30, private = 75%, public = 50%, no-fee paying = 87%) and staff improvement (n = 26, private = 42%, public = 50%, no-fee paying = 87%) were also common, more so in no-fee paying schools compared to others. Staff improvement included improving the number of staff members present to supervise the players correctly. Thirteen (private = 33%, public = 31%, no-fee paying = 27%) coaches identified that change needed to be made to their training programs and three (private = 8%, public = 13%, no-fee paying = 0%) respondents identified issues surrounding their relationship with the head coach and the trust that is afforded to them. Both coaches mentioning trust issues between themselves and the head coach has issues with the final calls being made by head coaches. The players were able to convince the head coaches', who lack of strength and conditioning expertise, to reduce their training intensities and frequencies. None of the participants indicated that no change needed to be made to their strength and conditioning practices.

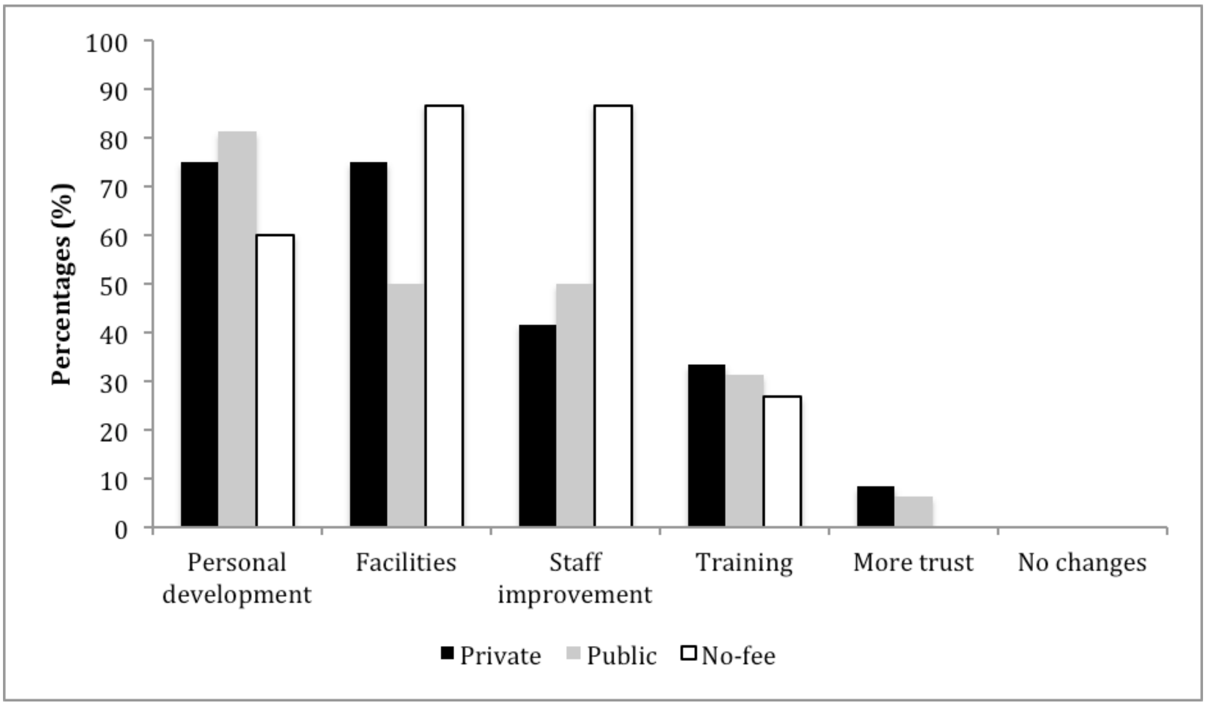

Figure 12: What coaches would like to do differently in their conditioning programs (%).

The general comments question asked if there were areas they felt should be highlighted in the survey but were not. The number of responses were counted and tabulated in table XVIII. Private and public schools mentioned training specific questions and three coaches' highlighted issues with periodisation due to school holidays and other conflicting sports.

Table XVIII: General comments

Higher order themes	Number of responses			Select raw data representing responses to question
	Private [n = 5]	Public [n = 5]	No-fee [n = 11]	
Inclusion of other techniques	1	2	0	"Cross training with various training philosophies." "Psychological component should be included."
Concerns about specificity of questions	1	0	0	"Some of the questions in the survey could be slightly more specific, it is tough to put a session in for the pre-season for example when most sessions vary."
Periodisation issues	1	2	0	"Planning of a proper macrocycle is difficult due to school holidays." "Some schools do not have specialized rugby players, this makes pre-season and off-season hard."
Miscellaneous	3	1	2	"Good survey." "Conflict with head coach." "New to position."
Lack of facilities	0	0	4	"The school has no gym facilities." "There are no gym facilities to do strength training."
Socioeconomic issues	0	0	3	"The children cannot afford to join a gym." "The school is in an area with high unemployment and poverty so the boys are given diet advice but they do not follow it and they don't understand what a healthy diet is."
Time commitment issues	0	0	3	"I am merely a volunteer at the school." "It is difficult to give the time for conditioning as I am not a professional coach and i am a full time teacher."
Need S&C expert	0	0	2	"I need experts to assist me with gym work, strength and conditioning."
Focus is fun	0	0	4	"I just want to facilitate a fun environment for them to learn rugby." "We have lots of fun and the kids love rugby that is the main thing."

The comments observed from no-fee paying school coaches were vastly different. Four coaches indicated a lack of facilities that do not allow for appropriate strength and conditioning. One respondent mentions being provided with gym equipment by the South African Rugby Union but not being provided with sufficient knowledge of how to use such equipment. Additional issues reported were socioeconomic issues not allowing for proper nutrition or access to facilities. Time commitment issues were reported by three coaches, who mentioned the voluntary nature of their position and the excessive time required for effective strength and conditioning. Two respondents mentioned the need for a strength and conditioning expert to guide the players through appropriate training and assist the coaches. While four no-fee paying schools' coaches mentioned that their main focus is to instil a fun environment to learn and enjoy rugby.

Comparatively, the comments from top 100 school coaches did not include any mention of issues surrounding lack of access to facilities or any other problems associated to socioeconomic status. Two coaches mentioned a professional conflict between themselves as strength and conditioning specialists and the head coach, who ultimately makes the final decisions.

SUMMARY

For most of the measures throughout the survey the public and private schools (top 100) questioned remained similar, however no-fee paying schools had large differences to the top 100 schools. Physical test measures indicated a comparable difference between the number and type of tests conducted in top 100 schools and no-fee paying schools. In the strength and conditioning practices section, it was apparent that fewer training principles were applied by no-fee paying schools in comparison to top 100 schools. Additionally, no-fee paying schools relied almost entirely on cones as the only pieces of equipment during training as compared to top 100 schools who had far more access to different equipment. In the rugby specific section, the use of periodisation, position specific conditioning, workload monitoring and injury prevention methods are far lower in no-fee paying schools, where private and public schools remain similar.

The reported differences observes top 100 schools being far closer to industry norms than no-fee paying schools, where few essential strength and conditioning concepts are implemented. The principles reported could be closely related to the level of education and expertise in strength and conditioning, which is far lower in no-fee paying school coaches. There is an apparent lack of knowledge in strength and conditioning in no-fee paying schools, which puts these schools at a further disadvantage over and above any socioeconomic standpoint.

CHAPTER V

DISCUSSION

INTRODUCTION

This study serves as the first comprehensive description of strength and conditioning practices employed by 1st XV high school level rugby coaches in South Africa. Only two previous studies have identified strength and conditioning practices in rugby at an elite level (Jones *et al*., 2016; Jones *et al*., 2017). The number of responses (43) was higher than that of similar studies in high school cricket (Pote and Christie, 2016), elite rowing (Gee *et al*., 2011), elite hockey (Ebben *et al.*, 2004), elite basketball (Simenz *et al.*, 2005) and elite American football (Ebben and Blackard, 2001). The previous studies in elite rugby had 43 (Jones *et al*., 2016) and 40 (Jones *et al*., 2017) responses, similar to the current study.

The two primary aims of this study were to 1) describe the strength and conditioning practices among the top 100 rugby playing schools in South Africa from 2016, and 2) compare the practices from top 100 ranked teams to no-fee paying schools. Subsequently, the current study included 28 top 100-school coaches and 15 no-fee paying school coaches who are not in the top 100 schools list from 2016. To avoid redundancy, the two components of the study were discussed together with comparisons to previous literature.

PARTICIPANT CHARACTERISTICS

All the respondents were males so the field of strength and conditioning in high school rugby in South Africa is male-dominated. The two previous studies in elite rugby had only two female (less than 5%) strength and conditioning coaches as respondents (Jones *et al*., 2016; Jones *et al*., 2017), and a South African study on school and university level cricket coaches had only one (Pote and Christie, 2016). This is unsurprising since rugby is male dominated and most girls' schools in South Africa don't offer rugby as a sport.

In terms of level of education of the coaches, only six (40%) of the coaches in the no-fee paying schools had a postgraduate degree compared to 23 (82%) of the top 100 rugby schools coaches. Additionally, the three top 100 rugby coaches without an undergraduate degree had obtained a diploma in sports science or personal training. All of the no-fee paying school coaches with a postgraduate degree (6 coaches) had a "postgraduate certificate in education", which is the national standard to become a licensed teacher and none of them had any relevant background in strength and conditioning. The lack of education in strength and conditioning will certainly influence the coaches' perspectives of the role conditioning plays in rugby performance and the specific principles. All of the top 100 rugby coaches with a postgraduate degree focused specifically on sports science and related fields. Hence, there is a high regard towards formal education in sports sciences in the top performing rugby schools in South Africa, similar to that of elite rugby where 61% of respondents held a masters degree in a sports science related field (Jones *et al.*, 2016).

Three top 100 rugby school coaches held a strength and conditioning certification, far fewer than reported in elite rugby studies (National Strength and Conditioning Association = 9, United Kingdom Strength and Conditioning Accreditation = 10, Australian Strength and Conditioning Association = 5: Jones *et al.*, 2016). It is likely that in order to advance to elite level of rugby, such credentials would be required, although having a degree in the field or related field is arguably more important. Furthermore, not everyone aspires to attaining accreditation, preferring to demonstrate competency to potential employers (Tapley *et al.*, 2014).

The mean age of the top 100 rugby school coaches was 30 (±4.4) years, which is in contrast to the no-fee paying school coaches who had a mean age of 43.8 (± 13.3) years. Jones *et al.*, (2016; 2017) both reported young average age of strength and conditioning coaches, similar to that of the top 100 rugby schools. The young age of qualified strength and conditioning specialists can allude to the relatively new emphasis on athletic development in elite rugby and in South African schools. However, the ages provided in previous studies do not necessarily reflect the senior strength and conditioning specialists in the staff. Professional teams have a crew of experts and the reported ages could depict those of who were tasked to respond to the survey. Many of the strength and conditioning coaches surveyed would be the sole specialist of their kind in that particular school. With the rise of professionalism in high school rugby, there is an increasing demand by parents to ensure their children receive the top level of coaching, including aspects of strength and conditioning. Thus, full-time strength and conditioning specialist in wealthy South African high schools are becoming more prevalent.

Despite the lack of formal education in strength and conditioning, there is a wealth of knowledge and/or experience amongst the no-fee paying school coaches surveyed. These coaches had more coaching experience with an average of 13.5 (± 9.5) years compared to 8.3 (± 4.5) years for the top 100 rugby schools, similar to a study done on the top 50 South African school cricket teams (Pote and Christie, 2016). Theoretical knowledge in strength and conditioning is important, however the coaches with more experience have guided many young athletes throughout their early rugby careers. The years of experience in coaching can't be taken for granted and can play a role in the preferred practices of coaches. Mallet *et al.* (2009) argued that coaches from all sports should utilise a combination of formal education, to gain specific knowledge, and informal experience to facilitate learning and the coaches' development. Previous research did however identify that coaches believe they learned more from experience than formal education, which would be encouraging for no-fee paying school coaches (Gould *et al.*, 1990; Cushion *et al.*, 2003; Lemyre *et al.*, 2007; Mallet *et al.*, 2009). As experienced rugby coaches, the no-fee paying school coaches have probably learned the physical demands of the game and hopefully brought physical preparation into their training. The lack of experience of the top 100 rugby school coaches could be due to large amount of time spent obtaining formal education. With additional years pursuing qualifications and degrees, these coaches would obtain higher levels of knowledge from which to build on with future experience.

PHYSICAL TESTING PARAMETERS

Only five (33%) no-fee paying school coaches reported conducting physical testing on their players, compared to 26 (93%) top 100 rugby school coaches. The top 100 rugby school coaches are closer to that of elite rugby strength and conditioning specialists who all reported conducting some form of physical testing on their players (Jones *et al*., 2016; Jones *et al*., 2017). The common use of physical testing in an elite rugby environment suggests it plays a critical role in tracking player progress and ensuring effective training methods are being used. The shortage of physical testing by no-fee paying school coaches could be attributed to the lack of strength and conditioning education in this sample. However, by and large the no-fee paying school coaches lacked in general strength and conditioning practices, negating the need for comprehensive physical testing batteries. The only benefit of physical testing in this case would be to warrant team selection between players with similar skill levels but varying physical capabilities and to monitor return to fitness of players following injury (Vaz *et al*., 2016).

The top 100 rugby coaches reported testing a total of 11 aspects of fitness, more than previously reported in other sports such as baseball (3-4 aspects (Ebben *et al.*, 2005)), hockey (7-8 aspects (Ebben *et al.*, 2004)), rowing (4-5 aspects (Gee *et al*., 2011)) and basketball (7-8 aspects (Simenz *et al.*, 2005). The most common aspects being speed, muscle strength, body composition, muscle endurance, muscle power, aerobic and anaerobic capacities. Previous studies favoured body composition, speed, muscular strength and aerobic capacity (Ebben *et al.*, 2004; Ebben *et al.*, 2005; Simenz *et al.*, 2005; Gee *et al*., 2011). The 11 aspects of physical fitness tested by the top 100 rugby coaches were similar to that previously reported in American football (9-10 aspects (Ebben and Blackard, 2001)) and elite rugby (11 aspects (Jones *et al*., 2016)). Jones *et al*. (2016) interpreted similarities between rugby and American football testing due to the similar contact, intermittent and evasive nature of these team sports. The American football study was however conducted in 2001, increasing the likelihood that assessment batteries have progressed since then. Recent observations by Jones *et al*. (2016; 2017) suggest the coaches in this study are up to date with recent physical testing protocols. However, the tendency to test certain aspects that are redundant in rugby performance should be noted in this study and others in elite rugby.

For example, muscle endurance is a commonly tested aspect of physical fitness whereby tests set out to monitor the ability of specific muscles to contract repeatedly (Lambert, 2009a). However, the lack of specificity in tests, such as push-ups in one minute, does not differentiate proficiency of rugby players (Duthie *et al.*, 2003). Additionally, tests such as the 40m sprints, which determine a players running speed, do not reflect the demands of rugby where players are required to change direction, carry a ball and prepare for contact (Sayers, 2007). Therefore, the observed number of physical aspects tested does not represent the gold standard for performance testing. There are tests that could be excluded and would not change the coach's approach to structuring strength and conditioning programs, making them redundant.

The no-fee paying school coaches conduct far fewer physical tests (n = 2) with only two aspects tested; speed (n = 4) and aerobic capacity (n = 3). All four coaches that reported testing speed used 100m sprints, where all but one top 100 rugby school coach used a 40m sprint. The majority of top 100 rugby school coaches presumably understand that 40m sprints better replicate the sprinting distances in rugby where players are rarely given the opportunity to sprint 100m (Hartwig *et al.*, 2011; Cahill *et al.*, 2013) although its use is still debated (Sayers, 2007). The multistage fitness test was the only test of aerobic capacity in no-fee paying schools and a popular test in top 100 rugby schools, however it is limited in its capacity to replicate the demands of rugby (Duthie, 2006). The yo-yo intermittent test was less common than the multistage fitness test among top 100 rugby schools, despite the fact that it is more specific to the work demands of rugby (Duthie, 2006) and is commonly utilised at an elite level (Jones *et al.*, 2016). Out of the seven respondents in the top ten of the top 100 rugby schools in 2016, only the two teams ranked first and second utilised the yo-yo test. The other schools favoured repeat sprint ability tests, which is designed to mimic the movement patterns and metabolic demands of various sports, and has been deemed reliable in a previous study in rugby league (Fitzsimons *et al.*, 1993; Johnston and Gabbett, 2011). Repeat sprint tests might also provide more specific measures of competitive performance in rugby and were very common (54%) as a test of anaerobic capacity in the top 100 rugby schools.

The most commonly tested aspect of physical fitness in the top 100 rugby schools was muscle strength (79%), with the majority of respondents using a one repetition maximum bench press. Strength is unquestionably an important physical quality with rugby performance requiring high levels of contractile strength (Mayes and Nuttall, 1995; Robinson and Mills, 2000), however the usefulness of bench press as an indicator of rugby performance is debateable. Lower body strength indicators are more indicative of rugby performance especially in positions such as the front row where maximum exertion in the lower body benefits scrum performance (Green *et al.*, 2017). However, the bench press incorporates various upper body pushing muscles and is considered the gold standard for upper body strength testing due to reliability and accuracy (Delextrat and Cohen, 2008; Headley *et al.*, 2011). Coaches should combine the bench press with a reverse grip chin up test to ensure upper body measures include both pushing and pulling movements (Ross, *et al*, 2015).

Other commonly assessed aspects of physical fitness were speed (75%), aerobic capacity (68%) and muscle endurance (64%) which is in contrast to previous studies where body composition was commonly measured; 83 – 100% (Ebben and Blackard, 2001; Ebben *et al.*, 2005; Simenz *et al.*, 2005; Jones *et al.*, 2016). Body composition plays an important role in determining the success of a player as it can be modified to benefit speed, power and endurance capabilities (Withers *et al.*, 1987) so it is surprising only nineteen (68%) of top 100 rugby playing coaches test it.

There was a notable variance in measures of agility with five different tests across 15 coaches, which was similarly reported by Jones *et al*. (2016; 2017) in elite rugby. A common and relevant agility test would be helpful for comparisons between studies and is a consideration for future research. Although a common use of agility testing is to combine these types of tests with sprint measures in order to compensate for the drawbacks of each test in isolation. Therefore, researchers acknowledge the drawbacks and lack of specificity but suggest a combination of agility and sprint tests as a useful physiological assessment (Svensson and Drust, 2005; Sheppard and Young, 2006).

Another measure of physical fitness that was less commonly measured was muscular power (57%), which held a lot more importance to elite rugby strength and conditioning specialists (86%) (Jones *et al*., 2016). Power output has been identified as an important physical quality in rugby players so the lack of popularity is surprising (Jones *et al*., 2016). The fewer power measures is also unexpected considering several coaches deemed power to be a crucial quality in the rugby specific section of the survey. The most commonly used tests of muscular power in elite rugby are easy to replicate and inexpensive such as the standing broad jump and countermovement jump height (Jones *et al*., 2016). However, with the high level of education among top 100 rugby school coaches it is likely that these coaches understand the significant correlations between maximum strength and power output (Stone *et al.*, 2007; Peterson *et al.*, 2006), illustrated by high positive correlations (r = 0.68 – 0.85; Baker, 2001; r = 0.77 – 0.94; Asci and Acikada, 2007). With such strong associations, the coaches could choose to exclude power tests on the basis that strength tests are adequate and testing batteries need to be time effective.

Other measures of physical fitness that were less common included were flexibility (21%), core strength (7%) and functional movement screening (7%). The functional movement screen is far more utilised in elite rugby (Jones *et al*., 2016) as an assessment of movement patterns and a player's functional capacity (Cook *et al*., 2014). This assessment can form part of an injury prevention strategy along with flexibility tests to determine inefficiencies that could lead to injury. However, the responding coaches did not have a high regard for physical testing measures that formed part of an injury prevention strategy and rather focused on performance optimisation. This makes sense with so few coaches prescribing injury prevention exercises as discussed further in the injury section. On the other hand, Pote and Christie (2016) found high school cricket coaches paid particular attention to injury prevention strategies and prescribed flexibility training regularly. The lack of focus in rugby testing could be due to the nature of rugby injuries compared to cricket. With the high number of rugby injuries coming from tackles and external forces, it is likely that coaches pay less attention to injury prevention during training. A larger focus could be held on improving tackle and contact techniques as they have shown to reduce the risk of injury (Gianotti *et al.*, 2009).

In the top 100 rugby schools, physical testing was most commonly conducted during pre-season (93%) and less so during in-season (39%). The issue with physical testing in a school environment is largely due to school terms, vacations and other sporting commitments. There are over three months of the year where players are not at school and therefore not accessible to the strength and conditioning coach. During this period of time testing cannot be conducted and progress can't be tracked. A major issue is the winter vacation that falls over rugby season, as during this period, players cannot be tested or monitored. Additionally, testing needs to correspond with other sporting commitments when it is not rugby season (summer sports in South Africa are commonly water polo and cricket). Difficulties can arise in scheduling and ensuring physical testing does not impede a player's performance in the other sports. Among no-fee paying school coaches the most common time for physical testing was in-season in contrast to the top 100 rugby schools who typically reduce physical tests during the in-season, most likely to compensate for an increase in workload. However, the testing performed in-season by no-fee paying school coaches' correlates with responses indicating these schools don't necessarily have an off- or pre-season. They start rugby training almost immediately before their matches begin. This indicates no preparation whatsoever before rugby season to improve physical performance and reduce the risk of injury.

Overall there is a clear disregard of the importance of physical testing in the no-fee paying schools, in contrast to the top 100 rugby schools who have similar testing protocols to elite rugby (Jones *et al.*, 2016). Physical profiling highlights players' strengths and weaknesses in several different physical domains and once these are established; appropriate plans can be implemented to improve individual development. Due to increased professionalism, physical preparation is a necessity for success in rugby (Duthie, 2006) and physical testing ensures the success of the training framework in developing player progression.

STRENGTH AND CONDITIONING PRINCIPLES

Flexibility development

All of the respondents implemented some form of flexibility development, despite the scarcity of flexibility testing. Regardless of education, the respondents consider flexibility development beneficial to rugby performance or injury prevention in adolescents. Similar beliefs are held in elite rugby, where 95% of coaches reported including flexibility development in their training programs (Jones *et al.*, 2016). Similar forms of flexibility development methods were used among the schools and in elite rugby, with the most popular being static and dynamic stretches (Jones *et al.*, 2016). The major difference is the exclusion of other methods of flexibility development in no-fee paying schools such as foam rolling, resistance bands, proprioceptive neuromuscular facilitation and band distraction. Additionally, active (n = 1) and passive (n = 2) stretches were utilised to a lesser extent in these schools compared to the top 100 rugby schools. However, with fewer facilities available, the types of flexibility development used in no-fee paying schools is well in line with the recommended BokSmart guidelines (Posthumus, 2010c).

There is conflicting literature surrounding the use and types of flexibility development to improve performance. Some studies suggest certain flexibility practices such as dynamic stretches benefit physical qualities such as strength, power, speed and agility (Mcmillan *et al.*, 2006; Little and Williams, 2006; Fletcher and Anness, 2007; Chaouachi *et al.*, 2010). Interestingly, dynamic stretches were the most popular amongst the top 100 rugby school coaches and elite rugby coaches (Jones *et al.*, 2016). The beneficial physiological effects of dynamic stretches is said to arise from post-activation potentiation, increase in core temperature and decrease in muscle tendon stiffness (Bishop, 2003). However, a commonly utilised method of flexibility development; static stretching, has come under critique and evidence suggests it may play a role in performance decrements in the aforementioned physical qualities (Vetter, 2007; Fletcher and Anness, 2007; Gee *et al.*, 2017). Research has highlighted that far from helping athletes, static stretches may inhibit performance by reducing power output (Behm *et al.*, 2001; Young and Elliot, 2001; Cook, 2003), which is a potential concern as it is the most common form of flexibility development in no-fee paying schools. The best available data indicates that performance might be lowered at extreme's of flexibility and that, at least some muscle and joint groups, have optimal levels of flexibility that would enhance performance (Thacker *et al.*, 2004; Yaniv and Sever, 2015). This emphasises the importance of flexibility tests in a physical testing battery to provide the coach with this type of information.

The most referenced benefit of flexibility training is to reduce the risk of injury (Thacker *et al.*, 2004; Chaouachi *et al.*, 2009). Although there is theoretical evidence to suggest a positive link between flexibility exercises and a reduced risk of injury, the clinical evidence is not as strong (Gliem and Mchugh, 1998; Pope *et al.*, 2000; Thacker *et al.*, 2004). At the same time, the evidence is not strong enough to recommend altering or eliminating flexibility development from a conditioning program. Stronger evidence demonstrates that various approaches to conditioning that include warm-up and flexibility exercises as well as other techniques such as resistance training and plyometrics, can both enhance athletic performance and prevent certain kinds of injuries (Thacker *et al.*, 2004). Some researchers argue the warm-up before a match is more important than stretching in preventing injuries in sports (Safran *et al.*, 1989; Thacker *et al.*, 2004). In hindsight, an improved survey would also gain insight into the full warm-up routine before a match to identify these practices. Different techniques could be used before and after practices and matches, therefore no conclusions can be drawn on the prescribed methods used by these coaches.

The use of equipment in flexibility development is limited to the top 100 rugby schools only. Interestingly the use of resistance bands for flexibility development was only reported in one recent cricket study demonstrating 71% of respondents using such equipment (Pote and Christie, 2016), similar to the current study (75%). However, no other studies on strength and conditioning practices mention foam rolling as a method of flexibility development. This is likely due to the relatively recent trends in foam rolling as a method of myofascial release, and is deemed effective in improving lower body flexibility (Junker and Stöggl, 2015).

The most common times when coaches require players to perform flexibility exercises were before matches (100%) and before practice (82%), similar to results from other studies on team sports (Ebben and Blackard, 2001; Simenz *et al.*, 2005). Stretching before training and competition is advocated as effective injury-prevention strategies, even though limited and conflicting evidence demonstrates it as effective in reducing soft tissue strains (Safran *et al.*, 1989; Kujala *et al.,* 1997; Petersen and Holmich, 2005). Recent literature values foam rolling as a method of recovery between training loads (Rey *et al*., 2017), which highlights a limitation to the current survey as it does not include recovery techniques. Flexibility development and recovery techniques can sometimes be interchangeable but separate sections in this survey would have benefitted the understanding for the coach and researcher.

Speed development and plyometrics

All of the respondents implemented some form of speed development, similar to elite rugby (93%: Jones *et al*., 2016), hockey (96%: Ebben *et al.*, 2004), basketball (100%: Simenz *et al.*, 2005), American football (100%: Ebben and Blackard, 2001) and baseball (100%: Ebben *et al.*, 2005). The majority of coaches across the types of schools implemented speed development on a weekly basis. Unresisted or "free" sprinting was the most popular method of speed development in all types of schools, the same as previous studies in rugby union (Jones *et al*., 2016; Jones *et al*., 2017). There are various ways to manipulate simple speed drills to suit the demands of rugby and the specific position of the player. Unresisted or "free" sprinting, encompasses all these techniques where no equipment is required and the exercises are performed on a flat surface. This is easy to implement especially for no-fee paying schools that have less resources. Manipulating stride length, stride frequency, sprinting distances, intensities, and varied-pace exercises all form part of an effective "free" sprinting speed training program (Cissik, 2005) that can be implemented without equipment. This type of sprint training does enhance speed in a straight line, however there is a limited transfer to change of direction or agility tasks, which is required in rugby (Young *et al*., 2001).

Plyometrics was reported as the next most common method of speed development training with 32 coaches prescribing it (top 100 = 89%, no-fee = 47%). The prevalence of plyometrics as a training method was similar to that of the previous studies in elite rugby (Jones *et al.*, 2017). Jones *et al.* (2017) did however demonstrate a preference for plyometrics in southern hemisphere teams (15% more) as compared to northern hemisphere teams. South African high school coaches could hold the same ideology as their southern hemisphere elite coaches suggesting that this is instilled at a young age in rugby players in South Africa. Research investigating the effects of plyometrics training has shown conflicting results, but the principle of improving the ability of muscles to produce force at high speeds remains desirable to rugby performance (Rimmer and Sleivert, 2000). A study conducted on rugby players showed a plyometrics intervention improved sprint performance over 10m, with no change over longer distances (Rimmer and Sleivert, 2000) that are frequently measured by high school coaches. Plyometrics aims to develop the stretch-shortening cycle of muscle contraction by developing explosive contraction of the muscle (Delecluse *et al.*, 1995; Rimmer and Sleivert, 2000), central to the performance of certain positions highlighted by respondents. The conflicting views of plyometrics came about due to certain interventions finding no difference in sprint performance (Salonikidis and Zafeiridis, 2008). However, the benefits are shown in jumping performance, which correlates to improvements in acceleration from a static start (Matavulj *et al.*, 2001; Kotzamanidis, 2006) and could benefit rugby performance. Southern hemisphere teams could place a larger emphasis on acceleration, which bodes well in South Africa where players are typically bulkier, creating difficulty in reaching high top speeds. Initial acceleration could prove more beneficial since sprints in rugby are shorter than the distance require to reach top speed (± 30m) (Duthie *et al.*, 2006b; Walsh *et al.*, 2007).

Resisted sprinting was more common in the top 100 rugby schools (75%) compared to no-fee paying schools (33%) and was similarly less common in elite rugby (30%) (Jones *et al.*, 2016). This method of training uses additional loads in an attempt to increase stride length by improving power and strength (Lockie *et al.*, 2003; Cronin and Hansen, 2006). Intervention studies have shown resisted sprints to improve initial acceleration from a static start in sprinting (Zafeiridis *et al.*, 2005; Harrison and Bourke, 2009; Spinks *et al.*, 2007), bringing similar benefits to that of plyometrics which is also common in the top 100 rugby schools. Due to the nature of rugby and the importance of acceleration, improving these characteristics can be important across several positions and it is surprisingly underutilised in elite rugby. However, there are no studies that investigate the difference between weighted sprinting and specific power exercises in the gym, which is where coaches could be supplementing these exercises.

A notable difference is the lack of developing strength (7%) and use of Olympic lifting (0%) as a method of speed development in no-fee paying schools compared to top 100 schools (71% and 68% respectively). The use of such techniques to improve speed was less common in elite rugby however the benefits are documented (Lockie *et al.*, 2012). Weightlifting, olympic lifting and strength training are common methods for developing power under high load (Hori *et al.*, 2005), however they do require specialised equipment most likely unavailable to no-fee paying school coaches. Power is a critical mechanical quality in many sports and developing it can improve athletic performance (Hori *et al.*, 2005) and coaches would be expected to develop such qualities despite the lack of power tests to monitor progression. Research suggests combining strength training with plyometrics is more beneficial than performing each individually (Adams *et al.*, 1992; Fatouros *et al.*, 2000; Faigenbaum *et al.*, 2007), however the survey was unable to identify if this occurred or not.

Agility Development

The coaches were comprehensive in their agility training exercises used, with a wide variety of methods prescribed. Agility training is prescribed by 67% of no-fee paying schools compared to 96% in the top 100 rugby schools. Similar to plyometrics, agility training was more commonly prescribed by southern hemisphere rugby coaches (Jones *et al*, 2017) and this trend seems to filter into South African schools. Agility training has been shown to be effective in developing speed qualities in young athletes (Bloomfield *et al.*, 2007), highlighting further a need to prescribe these exercises at a high school level. There could be a greater importance for development in young athletes since studies in rugby show a small amount (33%) of agility testing conducted (Jones *et al.*, 2016).

Collectively, previous studies on agility performances in rugby league could not differentiate significant differences between playing positions (Meir *et al.*, 2001; Gabbett, 2007; Gabbett *et al.*, 2008). This questioned the usefulness of pre-planned change of direction tests and therefore, the validity in training such qualities. Thus, reactive-agility where a sudden change of direction is required in response to a stimulus became more of a focus, developing perceptual components of agility (Gabbett *et al.*, 2008). However, in the current study, reactive agility was less common (11%) than general change of direction (96%) or self-designed drills (43%).

Similar to plyometric exercises and speed development, agility training was most commonly used on a weekly basis (56%). The similarity in frequency of training plyometrics, speed development and agility could be due to combining such techniques into a single training session. The integration of these practices is reported in previous studies (Ebben and Blackard, 2001; Jones *et al.*, 2016; Jones *et al.*, 2017). Ebben and Blackard (2001) demonstrated in American football, several coaches preferred implementing "speed days" where speed development, plyometrics and agility drills are combined into one session weekly. This is most likely the case in school teams as players need to balance sports performance, schoolwork and personal life.

Resistance training

The biggest difference in training programs between the top 100 rugby schools and the no-fee paying schools come in the principles of resistance training. All of the top 100 rugby school coaches found resistance training to be a crucial part of physical preparation, whereas only 53% of no-fee paying school coaches included it in their program. Previous studies in elite rugby (Jones *et al.*, 2016), American football (Ebben and Blackard, 2001), baseball (Ebben *et al.*, 2005), basketball (Simenz *et al.*, 2005) and hockey (Ebben *et al.*, 2004) all showed 100% inclusion of resistance training in their strength and conditioning programs, similar to that the top high school teams in South Africa. A resistance-training program is a crucial aspect of performance enhancement and injury prevention in both elite and youth level rugby (Beaven *et al.*, 2011; Argus *et al.*, 2012; Smart and Gill, 2013; Weakley *et al.*, 2017), and its exclusion in no-fee paying schools will likely impact the incidence of injuries in the team and the level of play reached by the players. However, with fewer facilities the coaches could deem resistance training to be difficult to implement, highlighting the importance of education around the use of own body weight for resistance training. Seven out of eight no-fee paying school coaches, who did implement resistance training, only used bodyweight exercises, which requires no equipment and is conveniently outlined by the "underground" strength-training program provided by BokSmart (Posthumus, 2010a). However, it could be suggested that access to proper gym facilities would improve the effectiveness of a resistance program and consequently the performance of no-fee paying school players.

The majority of top 100 rugby school coaches prescribed resistance training throughout the year, including pre-season (100%), in-season (93%) and off-season (79%). With regard to resistance training frequency, 15 (54%) coaches reported prescribing resistance training three days a week, similar to that of elite rugby coaches (81%) during in-season, however Jones *et al*. (2016) reported four days a week was most popular during off-season. The frequency of resistance training balances muscle repair with optimal workload (Fleck and Kraemer, 2014), and should be considered by coaches in all levels of rugby. With fewer rugby practices in off- and pre-season, more resistance training sessions could take place, however coaches need to consider workloads from additional high school sports. Resistance training programs can play a leading role in the development physical qualities desirable to rugby performance and thus becomes a large focus over the off- and pre-seasons (Lambert, 2009a; Jones *et al*., 2016). During in-season, players need to recover from matches and prepare for their upcoming match to follow. Hence, reducing the amount of time and focus spent on resistance training. During this period performance enhancement is not essential, maintenance of already achieved physical characteristics should be the primary goal (Lambert, 2009b).

Equipment

No-fee paying school coaches most frequently used cones as opposed to the top 100 rugby schools mentioning pieces of equipment such as prowler sleds, resistance bands and agility poles. This in itself highlights the disparities between facilities in the two types of schools. One no-fee paying school coach mentioned that resistance training facilities were provided by the South African Rugby Union, however no guidance and expertise was provided on how to effectively utilise the equipment. The lack of knowledge and education in strength and conditioning is prevalent in no-fee paying schools and simply providing access to facilities is not an effective intervention in developing such qualities.

Summary of strength and conditioning principles

Overall the no-fee paying school coaches were less likely to implement agility, plyometrics and resistance training which can probably be explained by a lack of knowledge and access to equipment and/or facilities. As these are key principles for injury prevention (Faigenbaum and Shram, 2004; Lloyd *et al*., 2014) and performance (Duthie, 2006; Baker, 2007; Sedeaud *et al*., 2012) in rugby, this can have a negative impact on these players.

Flexibility and speed training were commonly utilised in all schools, however the techniques varied between school types. The no-fee paying school coaches focus mostly on basic dynamic and static stretches outlined by the BokSmart program, while the top 100 rugby school coaches incorporate more recent trends in flexibility development such as the use of resistance bands and foam rollers. Speed development training by no-fee paying school coaches' focused on unresisted 100m sprints, whereas the top 100 rugby school coaches incorporated different techniques and included unresisted sprints over shorter distances similar to the practices reported in elite rugby (Jones *et al*., 2016).

The difference in principles and techniques prescribed by coaches needs to take into consideration the coaches' education, the schools level of rugby play, and the socioeconomic standpoint of the school and the community in which is serves. The no-fee paying school coaches, with no formal education in strength and conditioning arguably have less understanding of the advantages of physical development. Additionally, they do not have the adequate knowledge or facilities to implement effective strength and conditioning programs for their players. Furthermore, the players themselves are often plagued with socioeconomic disparities where general health and wellbeing is hindered (Williams *et al.*, 2016). A coach cannot expect to place the same physical training programs on a healthy adolescent with proper nutrition to those who are malnourished (Ryan, 2015). Furthermore, these children are already expending more energy by virtue of the fact that they walk to school and do physically demanding chores at home such as collecting water and firewood (Muthuri *et al.*, 2014). These factors need to be taken into consideration.

The coaches surveyed in the top 100 rugby schools for 2016 were amongst the nation's best rugby playing schools historically, boasting the best coaches, resources and players. These schools employ specialised strength and conditioning coaches who tend to align their practices with the best-known international trends in rugby represented by the findings of Jones *et al*. (2016). The no-fee paying schools cannot be expected to achieve such a high level of strength and conditioning expertise when they compete at a lower level of rugby, with fewer resources and no background in strength and conditioning. This highlights the complexities of sport and athletic development in a country such as South Africa where inequality and poverty is rampant.

RUGBY SPECIFIC PRINCIPLES

Periodisation

Twenty-eight (82%) of the top 100 rugby school coaches reported using periodisation strategies to promote performance improvements, which elite rugby strength and conditioning coaches found to be the most important method for negating the muting effect associated with concurrent strength and aerobic training (Jones *et al*., 2016). Periodisation strategies result in greater improvements in strength, power and body composition compared to non-periodical programs (Willoughby, 1993; Rhea *et al.*, 2006), and are prioritised in previous studies in rugby (90%: Jones *et al*., 2016), basketball (91%: Ebben *et al.*, 2004), hockey (90%: Simenz *et al.*, 2005) and baseball (83%: Ebben *et al.*, 2005)).

However, the no-fee paying school coaches did not have a pre-season or a structured breakdown of timeframes to achieve physical goals. The clear focus of these coaches was on developing aerobic fitness, defeating the need for periodisation as other principles of fitness are neglected. A lack of understanding of scientific training principles is thus evident in this sample.

Position specific practices

Eighteen (64%) of the top 100 rugby school coaches indicated implementing different conditioning practices for positions, compared to only two (13%) of the no-fee paying school coaches. The purpose of position specific condition is to train the athlete according to the physical demands of their position (Van Wyk, 2015), which is crucial in rugby with varying positional requirements. The principles of “specificity” and “individualisation” are key aspects of developing an effective strength and conditioning program to suit the needs of each player (Jones *et al.*, 2016). In no-fee paying schools, the lack of importance in developing each individual could be due to time constraints and/or an absence of knowledge. To achieve a high level of success every individual in the team needs to reach their peak physical capabilities to meet the demands of their position and benefit the team as a whole.

In the top 100 rugby schools, strength training was indicated as the largest focus for the front row (67%) and second row (39%) which makes sense as these positions require large amounts of force production at low velocities during scrums, a crucial aspect of their gameplay (Bevan *et al.*, 2010). Explosive power was reported as the most important aspect of training for the back row (39%) and centres (50%) as these positions require a great capacity for power in tackling, scrumming, rucking, mauling and breaking through tackles (Bell *et al.*, 1993; Nicholas, 1997). The main focus for halfbacks was weighted passing drills (22%), despite the fact that a previous study in youth rugby players indicated no significant differences in passing performance variables between weighted ball and non-weighted ball training interventions (Hooper *et al.*, 2008). Despite this lack of evidence, coaches seem to believe in an added benefit of performing weighted passes for half back positions. There might be a case for progressive implementation of weighted ball passes to reduce shoulder injuries in halfbacks, where frequent forceful passing actions are required. This possibility is addressed in the survey in the subsequent questions on injury prevention, however weighted ball exercises are not specifically mentioned. The biggest focus for outside backs was speed development (61%), which is crucial since they are often required to beat the opposition by means of speed (Morehen *et al.*, 2015).

Workload monitoring

Workload monitoring was reported by 64% of the top 100 rugby school coaches and none of the no-fee paying school coaches. Similarly to the top 100 rugby school coaches, 69% of high school and university cricket coaches in South Africa implemented some form of workload monitoring (Pote and Christie, 2016) as it is used to detect and identify injury risk and thresholds. This is important as excessively high workloads can lead to overuse injuries, especially in the developing musculoskeletal systems of adolescents (Phibbs *et al.*, 2017). The most common form of workload monitoring used was "ratings of perceived exertions or RPE" (29%) which combine subjective ratings of intensity with measures of duration (minutes), and have proven to be valid and reliable in monitoring physical loads (Scott *et al.*, 2013). However, Lambert and Borresen (2010) argue that session-RPE is not suited to rugby union due to the oversight of the collisions that contributes to muscle damage, and the intermittent short duration of physiological stress experienced. More comprehensive monitoring includes objective measures of physical loads such as physiological responses and movement patterns (Quarrie *et al.*, 2016). In the current study four (14%) coaches used GPS data responders, three (11%) used heart rate monitoring and one used "Omega Wave". GPS tracking allows the assessment of movement demands placed on players, where heart rate and "Omega Wave" systems track physiological responses to activity. The Omega Wave Sport System is a testing device to analyse heart rate variability and can provide useful live information into the athletes' adaptation to exercise (Parrado *et al.*, 2010). The monitoring of day-to-day heart rate variability of rugby players can help guide coaches on optimal training loads (Parrado *et al.*, 2010). However, Bosquet *et al.* (2008) suggest small alternations required and the difficulty of measuring day-to-day in a team sport limits their usefulness. From a practical point of view for school coaches, heart rate measures are more accessible than heart rate variability and are used to monitor training load and performance capacity (Bosquet *et al.*, 2008). However, the application of heart rate as a measure of exercise intensity has several limitations especially during resistance, intermittent and plyometrics training (Foster *et al.*, 2001). GPS measures distance covered and speed during training or match and is widely utilised in the professional domain, however the accuracy during sports with short durations and high intensity is limited (Barbero-Alvarez *et al.*, 2010).

None of these techniques consider the impact of contact situations or static exertions in rugby such as rucks, mauls and scrums. To the researcher's knowledge, there are no studies investigating workload monitoring strategies or examining optimal workloads to reduce the risk of injury in youth rugby players. However, the optimal methodology must account for the specific demands of rugby. Several methods can also be combined in an attempt to negate possible disadvantages of using only one system. The use of various methods of workload monitoring including subjective, physiological and performance measures are common practice among elite rugby teams (Elloumi *et al.*, 2012).

Unique aspects of programming to rugby

The question about aspects of training that are unique to rugby players had only four responses from the no-fee paying school coaches, with two highlighting the importance of "fitness" in rugby and another two mentioning a greater concentration on core strength to reduce injuries in certain positions. The responses of "fitness" were vague and could be interpreted in many ways. The researcher believes these coaches are referring to aerobic endurance, as this formed a large portion of their conditioning practices.

The most common response from top 100 rugby school coaches was the "specificity" of training methodologies, highlighting the importance of matching training loads to competition loads (Duthie, 2006). The terms "individualisation" and "specificity" were used interchangeably by respondents in the current study, despite there being differences in literature (Haff and Triplett, 2015). Therefore, the responses were similar to that reported by

Jones *et al*. (2016) who stated that coaches valued individualization of training where programs are designed towards each unique player and specific positional requirements.

Summary of rugby specific principles

The no-fee paying school coaches have a clear deficiency in the physical development of their players. There was an absence of workload monitoring, periodisation and position specific conditioning. It is understandable how a coach without the knowledge of safe and effective training techniques and principles would exclude workload monitoring and periodisation from their programs. Despite their known benefits, the degree to which these concepts may help could be fewer when simple training techniques are under utilised or not understood. The first step in improving strength and conditioning in no-fee paying schools would be to ensure proper training of the coaches to get the benefits of basic training concepts for athletic development and injury prevention. However, the context of each athlete also needs to be understood. Technical principles cannot be focused on when most of the players live below the poverty line and don't get adequate nutrition. The average South African adolescent attending a no-fee paying school cannot afford to worry about rugby conditioning due to a multitude of socioeconomic factors affecting them and their families.

INJURIES AND INJURY PREVENTION

Injury data gathered from no-fee paying school coaches was limited due to the number of coaches (< 20%) who kept records of injuries. The majority (75%) of the top 100 rugby school coaches did record injuries of their players. In this sample, the most commonly injured position was the back row (29%), which is probably due to the predominance of tackling by players in this position (Fuller *et al*., 2008b). This is in line with a study done in New Zealand that found that forwards sustained higher contact loads than the backline (Quarrie *et al*., 2013). However, the majority of studies have found a negligible difference in injury risk between positional groups despite the varying demands (Quarrie *et al*., 2001; Brooks *et al*., 2005a) and this is further supported by a meta-analysis conducted on elite rugby union injuries (Williams *et al*., 2013).

Shoulder injuries were the most frequently cited in this study (52 responses) and have shown to account for between 9% and 15% of all injuries in previous rugby related studies (Garraway *et al.*, 2000; Brooks *et al.*, 2005a; Brooks *et al.*, 2005b; Headey *et al.*, 2007). The highest number of shoulder injuries were to the back row and centres (n = 15 each), which makes sense since shoulder injuries are most common in the tackle situation, a crucial aspect of both these positions (Brooks *et al.*, 2005a; Fuller *et al.*, 2008b). Despite this high incidence, only two coaches mentioned implementing shoulder injury prevention exercises for their back row and only three implemented these for their centres. Developing the soft tissue of the shoulder is critical for resisting external forces and increasing the stability of the shoulder joint and therefore, prehabilitation and specific strengthening exercises could reduce the risk of such injuries (Longo *et al.*, 2011). Shoulders injuries were also the most common type of injury in the front and second row (n = 10 and 9 respectively), which could also be expected as front row forwards experience high impact forces on the shoulder during the scrum (Quarrie and Wilson, 2000). Similarly to the back row, the second row is involved in many contact situations, including tackling and rucking where shoulder injuries could occur (Fuller *et al.*, 2008b). Likewise with the back row, little focus was placed on prehabilitation of the shoulders in second rowers.

The most common types of injuries in halfbacks were ankle and groin injuries with eight responses each. The most common injury in the outside backs was to the hamstrings (n = 13). Lower limb injuries were most frequent in backline players and literature suggests they are the most commonly injured anatomical site throughout all levels of rugby (42% - 55% of all injuries) (Jakoet and Noakes, 1998; Bathgate *et al.*, 2002; Brooks *et al.*, 2005a). Since the backline dominate the open running portion of the game at high speeds, lower limb injuries could originate from such movement patterns (Brooks *et al.*, 2005a). To combat this, eccentric hamstring exercises (Nordic hamstring low) were prescribed by six coaches in backline positions and have proven to be effective in reducing the risk of injury in rugby (Brooks *et al.*, 2006; Bourne *et al.*, 2015). The Nordic hamstring low reduces the risk of injury by increasing eccentric torque and shifting the torque-joint curve angle of the hamstrings to longer muscle lengths (Opar *et al.*, 2012). Eccentric work was also the second most prescribed method of injury prevention by the current cohort of coaches.

Overall, the back row received the most number of injuries with 45 responses and the least injured position was halfbacks with 27 responses. Current literature has conflicting results on the most commonly injured position. These statistics could however be slightly skewed by the definition of injury used in each study.

Only one no-fee paying school coach prescribed injury prevention exercises, which should be an integral part of a rugby training program to ensure adequate exposure to high impact forces before play (Beam, 2002; Meir *et al.*, 2007). Recent position statements have identified the importance of strength and conditioning in identifying deficits in young players and addressing individual limitations (Lloyd *et al*., 2014), and thus the lack of such programs is worrying in no-fee paying schools. The musculoskeletal system becomes more prepared for the demands of rugby and competition when the young player participates in a regular multifaceted strength and conditioning program (Faigenbaum and Myer, 2010).

The majority (86%) of top 100 rugby-playing school coaches reported prescribing injury prevention exercises similar to that of high school cricket in South Africa (Pote and Christie, 2016). Strengthening target areas (43%) was reported as the most common type of injury prevention, which entails targeting anatomical areas prone to high impacts and collisions to reduce the risk of injury to that area (Gamble, 2008). Pote and Christie (2016), found similar results in South African school and university level cricket, where coaches used flexibility development and strengthening of high risk areas as the most common practices for injury prevention.

Summary of injuries and injury prevention

A comparison of injury data could not be made due to the small sample size of the no-fee paying schools that recorded injury. Provided this data could be obtained in future studies, comparisons could be made of the effectiveness of individual strength and conditioning programs on the injury rates of these players. This would be an effective method in identifying possible programs that could reduce injury risks across South African high school rugby. As with previous studies, the contact scenario proves to be a crucial focus in injuries where the shoulders are at a high level of risk (Garraway *et al*., 2000; Brooks *et al*., 2005a; Brooks *et al*., 2005b; Headey *et al*., 2007).

Managing and preventing injuries is a primary goal of a strength and conditioning specialist or coach's job. The top 100 rugby schools have a far more advanced injury prevention program compared to no-fee paying schools, however the effectiveness cannot be compared due to lack of injury data in no-fee paying schools. It must be considered however that the no-fee paying schools are subjected to lower level of rugby playing competition compared to schools in the top 100 rugby rankings. The no-fee paying schools face opponents with similar attributes to theirs and within similar geographical areas. It could very well be the case that these schools experience fewer player injuries. Despite these possibilities, injury prevention should be the most important training goal of a schools pre-season regimen. To improve the pool of talented rugby players in South Africa, athletic development should begin with reducing the frequency and severity of injuries experienced on the rugby field. An appropriately designed and administered strength and conditioning program can benefit not only performance (Duthie, 2006; Baker, 2007; Sedeaud *et al*., 2012) but also the risk of injuries (Faigenbaum and Shram, 2004; Lloyd *et al*., 2014) in adolescent athletes and should form part of the South African long-term player development plan.

GENERAL COMMENTS

A general trend in the top 100 rugby school coaches was the desire for personal improvement (79%), which is encouraging since despite the high level of education they appear to want to learn more and improve their knowledge. While less common, the no-fee paying school coaches also desired personal development (60%). On the contrary, these sentiments were not shared among the elite coaches in rugby (Jones *et al*., 2016), baseball (Ebben *et al.*, 2004), basketball (Simenz *et al.*, 2005) and hockey (Ebben *et al.*, 2005). The desire to constantly improve at a high school level in South Africa lays a positive outlook for strength and conditioning in high school rugby.

The most common areas for improvement identified by no-fee paying school coaches were staff improvement (87%) and facility improvement (87%) which highlights far reaching areas of concern when discussing schools catering for the lower socioeconomic status population (Burnett, 2009). Facility improvement and general lack of facilities such as gymnasiums can make certain aspects of strength and conditioning more difficult. One respondent said "*the boys cannot afford to attend a gym and the school is unable to provide one either*". Another respondent sums up their situation by saying "*we do not have many materials to work with so we have to improvise… we make do with what we have*." Personal development and staff improvement both acknowledge the coaches lack of understanding in strength and conditioning and the desire to either learn or get help from qualified individuals. Interestingly the one respondent from a no-fee paying school attempting to implement injury prevention exercises mentioned his gratitude towards a physiotherapist who helps him implement effective training principles and assists the team with strength and conditioning. The underlying issue among no-fee paying schools is the lack of any strength and conditioning expertise who can make do with minimal facilities but provide an effective program. There is a misconception that providing facilities to conduct training would improve the level of strength and conditioning provided. However, it could be argued that the most important step towards improving the level of strength and conditioning in no-fee paying schools would be to educate the coaches.

SUMMARY AND KEY RESEARCH FINDINGS

The present study sought to conduct a comprehensive survey of strength and conditioning in high school rugby in South Africa. The survey data obtained from a portion of the top 100 rugby playing schools in South Africa demonstrated a high level of strength and conditioning knowledge, with similar practices to that of elite rugby (Jones *et al.*, 2016). Similar aspects were identified in physical testing, training principles and rugby specific principles (Jones *et al.*, 2016; Jones *et al.*, 2017). Unfortunately previous surveys in rugby did not assess injury prevention techniques or workload monitoring. The high level of formal education in the field of sports science or related fields observed in the top 100 rugby schools lends itself to the findings that these schools have a high level of understanding in the field of strength and conditioning. To improve among these schools, more coaches should strive to become accredited strength and conditioning specialists as these certifications require continued education throughout ones career.

In comparing the top 100 rugby school coaches and no-fee paying school coaches, it is clear that no-fee paying school coaches fall short in understanding important strength and conditioning principles. While they may have a wealth of rugby coaching knowledge due to many years as rugby coaches, many of these schools lack the expertise and facilities to implement effective strength and conditioning programs. The no-fee paying school coaches fall short in their formal education, physical testing, training principles, rugby specific principles, workload monitoring and injury prevention techniques. Undermining the importance of such techniques can not only lead to reduced performance but also, more importantly, an increase in the incidence of injuries in adolescents. If the South African Rugby Union wishes to improve the level of rugby in South Africa, these issues need to be addressed. The wealth of knowledge in strength and conditioning in the top 100 rugby schools and elite teams needs to be shared throughout the schools, to ensure sufficient development of rugby players nationwide.

LIMITATIONS

There were limitations to the current study, over and above those that have already been outlined, which should be acknowledged.

Due to the nature of survey-based studies, several possible biases need to be acknowledged in the study. Researcher bias was possible in the design and analysis of questions, however a review panel was created to ensure the researcher had significant input from experts to reduce any bias. Additionally, response bias could have occurred by the respondent answering the question the way they perceived them, was of interest to the researcher. Response bias would be more likely from the interviews with no-fee paying school coaches. Finally, selection bias could have occurred in no-fee paying schools, whereby the researcher selected schools in the same geographical area due to transportation limitations. Therefore, the responses from no-fee paying schools cannot represent the views of no-fee paying school nationwide.

The questionnaire used in the current study is heavily based on previous questionnaires in different sports at an elite level. In hindsight, the inclusion of strength and conditioning principles specific to adolescents should have been included in the questionnaire.

The questionnaire was also in English, so non-English speaking coaches may not have been able to participate. This was expected as a limitation in the questionnaire design especially for no-fee paying schools, however it may have been the top 100 rugby school coaches that were impacted the most. Due to the reliance on Internet based responses in top 100 rugby schools and the abundance of Afrikaans speaking coaches, the survey language could have deterred certain individuals from responding where English was their second language.

Although the questionnaire was reviewed by a panel of experts and sports scientists before implementation, rewording some questions would be required to reduce ambiguity. One respondent mentioned the inability to understand what a specific question was asking. This question was to discover the ways in which coaches are able to implement position specific training within a team-training environment. From the majority of responses provided for the question, it was clear that many coaches did not understand the premise of the question and so it was excluded from the study.

Although private, public and no-fee paying schools were surveyed, it must be noted that the private and public schools all formed part of the top 100 rugby playing schools list for 2016. These schools were spread throughout South Africa and represented the best South African high school rugby has to offer, and therefore likely to have large investments in their rugby programs. Their inclusion as one combined group is justified by them catering for the same socioeconomic status of scholars, which was the differentiation to no-fee paying schools. The no-fee paying schools were taken from the Grahamstown region and close surrounds, predominantly Port Elizabeth. The restriction of schools to this region was due to the researcher’s ability to travel to such destinations. No-fee paying schools often lack access to computers and Internet making them easier to approach locally where the researcher was based. Using private and public schools from the same region proved difficult with a small sample size (three private schools) limiting the possible responses.

Additionally, reliability and validity was not ensured by repeating the questionnaire on the same sample. Doing this after a period of time allows for comparisons of responses, ensuring the questions were answered similarly.

Another limitation of the study was the lack of statistical analysis providing correlation data. However, due to the descriptive nature and data sets provided in the study, univariate analysis was sufficient to describe the basic features of the data.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The aim of this study was to investigate the strength and conditioning practices of high school rugby coaches in South Africa and compare the practices between schooling systems. Although there are recent studies on strength and conditioning practices in elite rugby (Jones *et al*., 2016; Jones *et al*., 2017), there is no data on the practices implemented at a high school level. Additionally, previous studies have not been conducted that focus on the specific practices conducted on a unique South African population.

The findings of the study showed that the majority of top 100 rugby schools from 2016 had specific specialists employed for strength and conditioning. Most of the specialists had formal education in sports sciences or related fields and implemented practices similar to those in elite rugby (Jones *et al*., 2017; Jones *et al*., 2017). Periodisation strategies and injury prevention exercises were adopted by the majority of coaches with workload monitoring being slightly less popular, however still common (75%). Perhaps one area to improve on is in injury prevention, where the majority of coaches do some form of injury prevention but the techniques reported are limited. Developing an injury prevention protocol can assist players in benefitting from one of the most crucial aspects of a strength and conditioning program, reducing the risk of injury to the players. Overall, the 28 schools responding from the top 100 high school rugby rankings of 2016, had a high level of knowledge in strength and conditioning and implemented practices similar to that of elite rugby (Jones *et al*., 2016).

A major finding highlighted in the study is the little attention paid by the no-fee paying school coaches towards the physical development of their players. None of the coaches had any background or education in strength and conditioning or related fields and were all 1st team coaches rather than strength and conditioning specialists. These coaches in general lacked any specialised understanding of the requirements to develop a player's physical characteristics to benefit rugby performance.

The responses of the no-fee paying school coaches show the need to invest in rugby development in poverty stricken areas in South Africa. Coaches reported struggling for access to facilities and personal development as some of the major hindrances holding back their potential for rugby coaching success. The no-fee paying schools are falling behind other schools in South Africa as high school rugby becomes more professional and the wealthy schools can afford to employ top tier coaches. An avenue needs to be created to allow potential rugby stars from lower socioeconomic backgrounds to develop and reach an elite level. To succeed as a fully transformed national rugby team, development of youth players needs to take priority and this study has taken the first step to identifying the pitfalls in South African youth player development.

RECOMMENDATIONS

Future strength and conditioning research

This data should be used for future investigations as a source of comparison. Additionally this study provides the necessary starting point from which to build future research on strength and conditioning in South African adolescents. To work on improving the training practices employed in schools, it was essential to first gauge the current level of training practices.

Research should investigate the validity and reliability of physical testing batteries used specifically for rugby. Tests could be created alongside current literature on the demands of rugby. It is common to see coaches using a wide array of physical tests in an attempt to acquire as much data as possible, however the data acquired could be markedly improved if the tests accurately replicate the demand of rugby matches. This would also have an effect on the training practices adopted by coaches as the data can more accurately reflect players' abilities.

While research at the top level of high school rugby in South Africa is crucial for advancing the practices, particular focus should be placed on improving the level of strength and conditioning in the majority of the population. Future research should include a needs analysis to determine the requirements of developing a player centred physical development program in lower socioeconomic schools. Additionally, further research is required to establish the incidence of injury in no-fee paying schools across South Africa and compare these results to known data for other adolescent populations. Interventions should be conducted to assess the efficacy of certain training programs that do not require advanced equipment as this will have a further reaching impact on the practices implemented in lower socioeconomic communities than simply improving the facilities available.

Practical recommendations

First, and most importantly this study can be used as an educational tool to inform coaches of the correct conditioning practices that should be utilised. This is important as many high school rugby coaches are implementing practices based on anecdotal evidence instead of scientific findings. Additionally, it provides a rich source of ideas to improve current training practices and expand on current knowledge.

It is clear from the lack of adequate conditioning in no-fee paying schools that methods need to be created to provide opportunities of learning and education of the coaches less fortunate than those in wealthier schools. The South African Rugby Union should employ qualified individuals to promote player development among the no-fee paying schools and educate the coaches. Failing to do so, structures should be implemented to allow qualified strength and conditioning specialists in the top rugby playing schools to assist with underprivileged schools.

Closing statement

In summation, strength and conditioning has far reaching benefits for rugby performance and injury prevention in rugby players. The level of strength and conditioning practices among South African schools mirrors the inequality in school structures and the divide between socioeconomic classes. It is a recommendation of the study that further focus be placed on youth player development from disadvantaged backgrounds to ensure the future success of a transformed South African rugby team.

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APPENDICES

Appendix A: Top 100 list

FIRST XV RANKINGS 1 SEPTERMBER 2016

RANK	TEAM	PLAYED	AVG PTS
1	PAARL BOYS HIGH	17	7,041
2	AFFIES	15	7,027
3	GREY COLLEGE	16	6,853
4	PAARL GIM	17	6,641
5	DALE COLLEGE	19	5,253
6	BOLAND LANDBOU	20	5,240
7	KEARSNEY COLLEGE	17	5,206
8	MONUMENT	21	5,114
9	HELPMEKAAR	17	4,976
10	SELBORNE COLLEGE	19	4,916
11	PAUL ROOS GYM	18	4,828
12	GLENWOOD	18	4,817
13	EG JANSEN	19	4,653
14	JEPPE	19	4,647
15	GREY HIGH SCHOOL	17	4,471
16	KINGSWOOD COLLEGE	17	4,371
17	OUTENIQUA	15	4,260
18	SACS	19	4,147
19	GARSFONTEIN	17	4,024
20	OOS MOOT	15	3,727
21	OAKDALE	16	3,688
22	SWARTLAND	15	3,680
23	DIAMANTVELD	16	3,588
24	NELSPRUIT	13	3,408
25	BEN VORSTER	15	3,300
26	WELKOM GYM	18	3,272
27	HILTON COLLEGE	15	3,233
28	ST ANDREWS COLLEGE	20	3,195
29	PAREL VALLEI	19	3,142
30	VEREENIGING GIM	12	3,142
31	RONDEBOSCH	17	3,129
32	FOCHVILLE	19	3,116
33	DHS	15	3,087
34	ELDORAIGNE	14	3,079
35	BRACKENFELL	18	3,044
36	PIETERSBURG	17	3,018
37	HTS MIDDELBURG	15	3,000
38	DUINEVELD	11	2,982
39	ST ANDREWS SCHOOL	11	2,955
40	DANIEL PIENAAR	21	2,938
41	LIGBRON	13	2,923
42	UNION HS	10	2,910
43	VRYBURG	16	2,869
44	AHS KROONSTAD	9	2,856
45	HUDSON PARK	19	2,805
46	KALAHARI	9	2,767
47	STELLENBERG	18	2,739
48	HANGKLIP	15	2,727
49	PARKTOWN	16	2,606
50	VOORTREKKER BETH	17	2,559

(Source: http://www.saschoolsports.co.za/tag/Rugby-Rankings-First-XV.html)

51	HTS DROSTDY	21	2,529
52	HERMANUS	16	2,475
53	OVERBERG	11	2,473
54	ST ALBANS COLLEGE	18	2,461
55	WORCESTER GYM	15	2,460
56	NICO MALAN	18	2,350
57	MERENSKY	12	2,325
58	QUEENS COLLEGE	16	2,263
59	ERMELO	10	2,260
60	ST BENEDICTS	16	2,238
61	LICHTENBURG	12	2,233
62	MARITZBURG COLLEGE	19	2,200
63	NOORDHEUWEL	13	2,185
64	RANDPARK	9	2,178
65	CHARLIE HOFMEYR	14	2,164
66	ST JOHNS COLLEGE	12	2,100
67	AUGSBURG	12	2,083
68	ALBERTON	12	2,017
69	BISHOPS	25	2,004
70	WOODRIDGE COLLEGE	12	1,933
71	BEKKER	12	1,917
72	RUSTENBURG	13	1,915
73	SECUNDA	9	1,844
74	ST STITHIANS	17	1,824
75	HEIDELBERG VOLKIES	14	1,807
76	TUINE	14	1,779
77	KES	14	1,771
78	DESPATCH	10	1,760
79	WATERKLOOF	19	1,742
80	LYDENBURG	10	1,730
81	MARLOW	13	1,700
82	ST CHARLES COLLEGE	15	1,680
83	HUGENOTE SPRINGS	12	1,642
84	WONDERBOOM	13	1,638
85	SUTHERLAND	9	1,578
86	ROB FERREIRA	10	1,500
87	LINDEN	15	1,500
88	HTS WITBANK	11	1,455
89	HOOGENHOUT	11	1,436
90	NOORD KAAP	12	1,425
91	STEELCREST	9	1,400
92	MICHAELHOUSE	12	1,292
93	WYNBERG	19	1,279
94	STRAND	16	1,225
95	DURBANVILLE	17	1,200
96	POTCH VOLKIES	16	1,175
97	WESVALIA	12	1,142
98	FICHARDTPARK	9	1,133
99	DIE BRANDWAG	15	1,133
100	TRANSVALIA	15	1,107

Appendix B: Information to participants (online version)

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa

HUMAN KINETICS AND ERGONOMICS

Contact information:

Name: Bradley Robinson

Contact number: 0735962594

E-mail: g12r0094@campus.ru.ac.za

Dear participant,

I would be grateful if you would take a few minutes of your time to complete the following survey. The survey contains questions pertaining to Strength and Conditioning practices in 1st team high school rugby as part of my Masters research. Part of the research will be profiling the strength and conditioning practices of the top schools in South Africa and comparing the practices adopted in private and public schools. Please note that if you do no strength and conditioning for your team that in itself is a finding and should be reported.

The survey consists of 57 questions in four categories:

- General background and conditioning (35 questions)
- Rugby specific conditioning (8 questions)
- Injuries/ injury prevention (12 questions)
- Comments (2 questions)

The questions are short and as concise as possible and will not take long to answer (time frame depends on depth of certain answers). The information gained from this survey will benefit the future strength and conditioning practices in South African high school rugby. Personal information gathered in the survey includes name, age, place of employment, job title, time in position and qualifications. The personal information gathered will only be accessible by the researcher and supervisor and will not be shared or made public at any point. Coach and institution anonymity will be protected in the form of coding and names will not be released to any people other than the researcher and their supervisor.

If you wish to take part in the survey, please click on the link below and follow the instructions. Before the survey can be completed the first page in the link will ask to provide consent to using the information provided as part of my Masters research.

https://kwiksurveys.com/s/5Qn1NbPk

Please note that you are in no way obligated to take part in this research and may exit the survey at any time, thereby terminating your consent to participate. Furthermore, the results obtained will be completely anonymous and there will be no mention of you, your team or your institution in any correspondence that may follow. Feedback will be provided if requested via email. Feedback will be provided in the form of a general overview of the findings of the research; therefore comparisons can be made between your practices and those of the rest of strength and conditioning coaches around South Africa. Additionally further information will be provided on the best-known S&C practices at the time.

If there are any queries or questions please do not hesitate to contact me at any time.

Bradley Robinson

Appendix C: Information to participants and consent form (printed version)

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

HUMAN KINETICS AND ERGONOMICS

<u>Contact information:</u>

Name: Bradley Robinson

Contact number: 0735962594

E-mail: g12r0094@campus.ru.ac.za

Dear XXXXX

I would be grateful if you would take a few minutes of your time to complete the following survey. The survey contains questions pertaining to Strength and Conditioning practices in 1st team high school rugby as part of my Masters research. Part of the research will be profiling the strength and conditioning practices of the top schools in South Africa and comparing the practices adopted in private and public schools. Please note that if you do no strength and conditioning for your team that in itself is a finding and should be reported

The survey consists of 57 questions in four categories:

- General background and conditioning (35 questions)
- Rugby specific conditioning (8 questions)
- Injuries/ injury prevention (12 questions)
- Comments (2 questions)

The questions are short and as concise as possible and will not take long to answer. Furthermore, statistics gained from this survey will benefit the future strength and conditioning practices in South African high school rugby. Personal information gathered in the survey includes name, age, place of employment, job title, time in position and qualifications. The personal information gathered will only be accessible by the researcher and supervisor and will not be shared or made public at any point. Coach and institution anonymity will be protected in the form of coding and names will not be released to any people other than the researcher and their supervisor.

Please note that you are in no way obligated to take part in this research and may exit the survey at any time, thereby terminating your consent to participate. Furthermore, the results obtained will be completely anonymous and there will be no mention of you, your team or your institution in any correspondence that may follow. Feedback will be provided if requested via email. If there are any queries or questions please do not hesitate to contact me at any time. Feedback will be provided in the form of a general overview of the findings of the research; therefore comparisons can be made between your practices and those of the rest of strength and conditioning coaches around South Africa. Additionally further information will be provided on the best-known S&C practices at the time.

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I consent voluntarily to participate as a subject in this study and understand that I have the right to withdraw from the study at any time without in any way it affecting further interactions with the researcher and the Department of Human Kinetics and Ergonomics.

Participants signature____________ Date_______________

Researchers signature___________ Date_______________

Witness signature ______________ Date_______________

Bradley Robinson _________ __________

Appendix D: Survey

Schoolboy rugby Strength and Conditioning survey

Create your own
FREE ONLINE SURVEY

By clicking on the "Agree" button below it indicates that:

- You have read the Information to Participants letter.
- You have had the opportunity to ask questions about it and any questions you have asked have been answered to your satisfaction.
- You voluntarily agree to participate.
- You are at least 18 years of age.
- You are the person in charge of strength and conditioning for the 1st XV rugby for your respective school.

If you do not wish to participate in the research study, please decline participation by clicking on the "disagree" button.

☐ Agree ☐ Disagree

Section 1- General

Background Information

1 Name:

Surname:

2 Age:

Sex:

☐ Male ☐ Female

3 What school are you currently working at?

4 What category of school does your institution fall under:

☐ Independent Private School ☐ Governing body public school ☐ Fully Funded public school

5 What is your position at this institution?

6 How long have you occupied this position?

7 What qualifications do you have (degrees, diplomas, strength and conditioning qualifications etc…)?

8 What experience do you have with strength and conditioning and/or coaching? And for how long respectively?

Physical Testing

9* Do you test your players' physical capabilities and fitness? If no please skip to the next page on flexibility development

- [ ] Yes
- [ ] No

10 What fitness parameters are tested and which tests are used for each (e.g. Agility: Illinois Agility Test. Speed: 100m sprint. Body composition: Skinfolds.. etc)

11 When are the tests implemented?

- [ ] Pre-season
- [ ] In-season
- [ ] Off-season

Other (Please Specify)

Flexibility Development

12 Do you require your players to partake in flexibility training? If no, please skip to the next page on speed development

- [ ] Yes
- [ ] No

13 What type of flexibility practices do they perform?

- [ ] Static
- [ ] Dynamic
- [ ] Passive
- [ ] Active
- [ ] Proprioceptive neuromuscular facilitation
- [ ] Yoga
- [ ] Stretch/resistance bands
- [ ] Band distraction
- [ ] Foam rolling

Other (Please Specify)

14 When do they perform these stretches?

- [ ] Before practice
- [ ] during practice
- [ ] After practice
- [ ] On their own
- [ ] Before a match
- [ ] After a match
- [ ] Before a workout
- [ ] After a workout

Other (Please Specify)

15 Is any specific equipment used to help with flexibility training?

- [ ] Stretch resistance bands
- [ ] Foam roller

Other (Please Specify)

16 What is the duration of a typical flexibility/stretching session?

- [ ] 0-5 minutes
- [ ] 5-10 minutes
- [ ] 10-15 minutes
- [ ] 15-20 minutes
- [ ] 20+ minutes

Speed development

17 Do you require your players to partake in speed training? If no please skip to the next page on agility development.

- [ ] Yes
- [ ] No

18 What speed development drills are used?

- [ ] Unresisted (free) sprinting
- [ ] Resisted sprinting
- [ ] Plyometrics
- [ ] Sprint mechanics and technique
- [ ] Improving max strength
- [ ] Olympic lifting

Other (Please Specify)

19 What equipment is used for speed training (if any)?

20 How often are your players subjected to speed training?

- [ ] More than once per week
- [ ] Weekly
- [ ] Monthly
- [ ] Other (Please Specify)

Agility Development

21 Do you require your players to partake in agility training? If no please skip to the next page on plyometrics.

☐ Yes ☐ No

22 What drills are used for agility development?

23 What equipment is used for agility training?

☐ Speed ladder ☐ Hurdles ☐ Resistance bands
☐ Agility poles

Other (Please Specify)

24 When is training mainly implemented?

☐ Pre-season ☐ In-season ☐ Off-season

Other (Please Specify)

25 On average, how often are your players subjected to agility training?

☐ More than once per week ☐ Weekly ☐ Monthly
☐ Other (Please Specify)

Plyometric training

26 Do you require players to partake in plyometric training? If no please skip to the next page on strength training.

☐ Yes ☐ No

27 What drills are used for plyometrics training?

28 What equipment is used for plyometric training?

29 When is plyometric training mainly implemented?

☐ Pre-season ☐ In-season ☐ Off season

Other (Please Specify)

30 On average, how often are your players subjected to plyometric training?

☐ More than once per week ☐ Weekly ☐ Monthly

☐ Other (Please Specify)

Strength/ resistance training

31 Do you require your players to partake in resistance training? If no please skip to the next page on rugby specific questions.

- [ ] Yes
- [ ] No

32 What type of training is implemented?

33 When is strength/resistance training implemented?

- [ ] Pre-season
- [ ] In-season
- [ ] Off season

Other (Please Specify)

34 What equipment is used for this type of training (if any)? (e.g. machines, dumbbells etc...)

35 On average, how often are your players subjected to resistance training?

- [ ] Once a week
- [ ] Twice a week
- [ ] 3 times a week
- [ ] 4 times a week
- [ ] 5+ times per week
- [ ] Other (Please Specify)

Section 2: Rugby specific

36 Does your program consist of several smaller timeframes in which to achieve certain physical parameters? (periodization)

☐ Yes ☐ No

37 If yes, please provide insight into the periods and their respective durations (e.g. strength development- 4 weeks)

38 Do you implement different conditioning practices for different positions on the playing field?

☐ Yes ☐ No

39 If yes, what is different for each specific position?

Front Row:

Second Row:

Back Row:

Half Backs:

Centers:

Outside backs

40 Do you monitor the players workloads?

☐ Yes ☐ No

41 If yes, how?

Front Row:

Second Row:

Back Row:

Half Backs

Centers

Outside Backs

42 Are there any unique aspects to your strength and conditioning program specific to rugby as opposed to other sports (e.g. balance, core stability, specificity..)

43 Please outline the structure of a typical training session. ie: what would a session look like in a) pre-season, b) In-Season and c) Off-season.

(Example: session is typically X hours and consists of the following., this is done X days a week) (Eg: Warm up 10 mins, speed work for forwards 15 mins, functional strength work for forwards 20 mins, endurance work for the squad 25mins, ball handling 15mins, cool down 5mins, etc.).

This question is to establish how specific position work may/may not be incorporated in to team training

a) Pre-season

b) In-season

c) Off-season

Section 3 - Injuries/injury prevention

44 Do you keep record of injured players or specific injuries?

- [ ] Yes
- [ ] No
- [ ] Inconsistently

45 If yes, which is the most commonly injured position?

- [ ] Front Row
- [ ] Second Row
- [ ] Back Row
- [ ] Half Backs
- [ ] Centers
- [ ] Outside Backs

46 What are the most common areas of injury for the front row?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadriceps
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

47 What are the most common areas of injury for the second row?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower Back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadricep
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

48 What are the most common areas of injury for the back row?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadricep
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

49 What are the most common areas of injury for the half backs?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadricep
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

50 What are the most common areas of injury for the centers?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadricep
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

51 What are the most common areas of injury for the outside backs?

- [ ] Head
- [ ] Neck & Spine
- [ ] Shoulders
- [ ] Lower back
- [ ] Groin
- [ ] Hamstring
- [ ] Quadricep
- [ ] Calves
- [ ] Ankle

Other (Please Specify)

52 Do you implement injury prevention exercises?

- [ ] Yes
- [ ] No

53 If yes, what exercises are implemented?

54 What part of the season are these exercises implemented?

- [ ] Pre-Season
- [ ] In-season
- [ ] Off-season

Other (Please Specify)

55 Are different exercises implemented for different playing positions?

- [ ] Yes
- [ ] No

56 If yes, what is different for each position?

Front Row:

Second Row:

Back Row:

Half backs:

Centers:

Outside Backs:

Section 4 - Comments

57 If any, how would you change your current strength and conditioning program?

- [ ] Specific training changes
- [ ] Facility improvement
- [ ] Staff improvement
- [ ] Personal development
- [ ] I would not change anything

Other (Please Specify)

58 If you feel that there are areas of interest that should be taken into account or considered, please provide some information in the area below:

Appendix E: Ethics approval

Human Kinetics and Ergonomics
Ethics Committee
Ethical Clearance

RHODES UNIVERSITY
Where leaders learn

Protocol Number	HKE-2017-02				
Protocol Title	Investigating the strength and conditioning practices of schoolboy rugby coaches in South Africa.				
Applicant	Mr Bradley Robinson				
Applicant ID	g12R0094				
Supervisor	Prof Candice Christie				
Submission Date	06 April 2017				
Submission Type	**Query** ☐		**Primary** ☐		**Full** X (MSc)
Reviewers' Recommendation (mark appropriate field with X)	X	**Approve**			
		Approve with stipulations			
		Disapprove / Rejected			
		No ethics approval required			
		Refer to RUESC			
Review comments					

Further particulars for reporting to NHREC (mark appropriate field with X)

This project involves *Level 2* Health Research	Yes		No	X
This project is a *clinical trial*	Yes		No	X
This project involves *child participants*	Yes		No	X
This project requires *ministerial consent*	Yes		No	X
This project involves *human* blood, tissues and genetic material	Yes		No	X
If yes, this is in accordance with provisions as per Government Gazette No.35099	Yes		No	
This research has *environmental implications*	Yes		No	X

Signed:

Miriam Mattison

MC Mattison
2017 Chairperson of HKE Ethics Committee

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