Quantifying the training demands of an amateur women's Rugby union team using Global Positioning System

By

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ABSTRACT

Rugby union is a dynamic sport that has grown to not only be played by men but by women too. The professionalisation of the sport that happened in 1995 developed the game immeasurably including the focus given to its scientific research. This is important as literature on the demands of the game has become vital in improving the performance of Rugby union players (Deutch *et al.,* 1998; Kay and Gill, 2004; Kruger, 2012). Scientific evidence-based data on the physical and physiological demands is imperative in the planning and setting up of training regimes (Deutch *et al.,* 1998; Kay and Gill, 2004; Kruger, 2012). Unfortunately, the growth in the participation of women's Rugby union has not been matched with scientific evidence-based literature that seeks to improve the performance of this population of players. Therefore, due to the unavailability of match-play during the COVID-19 outbreak, this study aimed to quantify the physical and physiological demands of training sessions of amateur women's Rugby union players from the Sarah Baartman District, South Africa using Global Positioning System (GPS). The training' data collected was compared to previous literature, including studies that also focused on match-play. Furthermore, players were categorized into forwards and backs, allowing for the comparison between the two playing categories.

An exploratory, descriptive, observational, and comparative research design was used for the current study. The physical and physiological demands of eighteen women Rugby union players (eight forwards and ten backs) aged between 18 – 36 years old were assessed during training (for a total of nine sessions). To inform the participants' characteristics, the players' demographic, and anthropometric characteristics (age, stature, and body mass) were obtained. Using GPS and Zephyr technology the players' training physical (time spent in speed zones, maximum speed, total distance travelled, number of impacts in the various impact zones) and physiological (heart rate) demands were explored. Statistical analysis methods including descriptive, independent t-test, one-way and two-way ANOVA tests were employed to analyse the data and evaluate the differences between forwards and backs.

The mean age and stature for all players was 25,44±5,6 years and 1,60±0,06 m respectively, with no significant differences found between backs and forwards. With regards to body mass, forwards weighed 82,0±9,4 kg while backs weighed significantly lighter at 58,0±5,8 kg. Significant differences ($p < 0,05$) were found for all players in the time spent in speed zones and the number of impacts in impact zones. When all forwards' and backs' physical and physiological demands were compared the results showed no significant differences. The average time spent in all six speed zones combined was 11,41 and 11,62 mins for forwards and backs, respectively. The maximum speeds reached by forwards (21,35±5,72 km/h) and backs (22,85±3,88 km/h) were similar. All players combined travelled an average total distance of 2,14±0,76 km. The total number of impacts in all six impact zones, totalled 116 impacts for forwards and 97 for backs. Heart rate responses recorded for forwards and backs were 139±15 bpm and 134±13 bpm.

Based on the findings of this study, the training intensity of amateur women's Rugby union was lower than the demands experienced in the training and match-play of previous research. It was also observed that there was no specificity with regards to the training programs allocated between forwards and backs of this study. Further research on amateur women's Rugby union is required to characterise training and match-play demands of these players.

Keywords: Rugby union, Amateur, Women, Global Positioning System, Demands

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CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Rugby union is a dynamic contact, and intensified team sport that is played by men and women around the world from junior amateur to senior professional level (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2014; Sheppy *et al.,* 2019; Bradley *et al.,* 2020; Busbridge *et al.,* 2020; Posthumus *et al.,* 2020; Woodhouse *et al.,* 2021). The sport is intermittent in nature and requires players to participate in short periods of repeated bouts of high-intensity exercise (running, sprinting, tackling, scrummaging, rucking, and mauling), interrupted by longer periods of low to moderate transitional movements (standing, walking, and jogging) (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2014; Harty *et al.,* 2019; Sheppy *et al.,* 2019; Bradley *et al.,* 2020; Posthumus *et al.,* 2020; Woodhouse *et al.,* 2021). These characteristics confer a wide range of physical, physiological, mental, and social well-being benefits which include improved aerobic fitness, cardiovascular function, metabolic fitness, and reduced mortality (Griffin *et al.,* 2020).

From when Rugby union was first introduced in the 1800s, to its current professional era (established in 1995), the game has developed and evolved significantly making it more demanding than it ever was (Nicholas, 1997; Phillpots, 2000; Coughlan *et al.,* 2011; Owen, 2019; Dubois *et al.,* 2020). Despite Rugby union being physically and physiologically demanding, it has and is continuing to gain popularity globally, as it has become an important international sport for men of many countries (Nicholas 1997; Coughlan *et al.,* 2011: Muzek, 2015; Nauright, 2018). Until recently women were excluded from playing Rugby as it was considered an aggressive sport reserved for gentlemen of the high class (Suarez-Arrones *et al.,* 2014; Nauright, 2018; Chapel, 2021, Woodhouse *et al.,* 2021). The history of women's participation in Rugby is marked by division and discrimination (Smiles, 2012); however, it is also filled with major accomplishments and important advances for gender equality and the empowerment of women and girls (United Nations, 2007).

Prior to 1994, the role of women was that of being a "domestic worker" who transported, cleaned Rugby gear, cooked, and attended to the injured bodies of men (Hene, 2011). After multiple developments in men's Rugby, in 1994 women were

officially included as part of the International Rugby Board (IRB) (Suarez-Arrones *et al.,* 2014), and only in 2017 was women's Rugby union professionalized (Tucker *et al.,* 2021; Woodhouse *et al.,* 2021). Although the participation of women in Rugby union took time to be officially accepted and recognized, women are now active participants in the sport, and women's Rugby union is growing all over the world (Virr *et al.,* 2014; Suarez-Arronez *et al.,* 2014; Parker, 2017; Bradley *et al.,* 2020; Woodhouse *et al.,* 2021). In the year 2000 the recognition in the growth of women's Rugby was also extended to South Africa (Hene, 2011). The South African women's team first took part in a test match leading to Rugby World Cup (RWC) in 2004 and has since appeared in four RWCs since their debut which took place in the 2006 Cup (South African Rugby Union, 2022).

Since the introduction of women's Rugby union in South Africa, participation and performance continues to improve, although it varies greatly according to the country's provincial unions (Posthumus, 2013) who make up the national team. In 2022 South African Women's Rugby union registered 6801 players which was an increase in participation from previous years (South African Rugby Union, 2022). Therefore, amongst many needs a concomitant need to provide these players with appropriate high-performance analysis, supported by research is needed to help bring in more numbers. Currently, only a few scientific studies have explored women's Rugby union performance characteristics, while even fewer have quantified the physical and physiological demands using modern technology (Virr *et al.,* 2014; Saurez-Arrones *et al.,* 2014; Sheppy *et al.,* 2019; Busbridge *et al.,* 2020; Woodhouse *et al.,* 2021) especially on women's amateur- and club level Rugby union.

Scientific research investigating the performance characteristics of professional men's Rugby union has brought to light important insights about the game, the preparation of players for competition, and its demands (Smit, 2012; Stoop *et al.,* 2018; Busbridge *et al.,* 2020; Woodhouse *et al.,* 2021). Because of these insights men's Rugby continues to grow and improve in performance, an important need that can be of benefit to women's Rugby. However, because of the gap in the published research of women's Rugby union, these players are forced to rely on the research conducted on men's Rugby union players (Hodun *et al.,* 2016; Busbridge *et al.,* 2020). Considering the physical and physiological differences that exist between

men and women, with women reportedly having for example reduced speed and less agility, lower muscular power, lower estimated maximal aerobic power inferring men's workloads on women Rugby players is inappropriate and potentially injurious to the players concerned (Lewis *et al.,* 1968; King *et al.,* 2019; Tucker *et al.,* 2021). Hence, an increase in scientific research on women's Rugby union performance characteristics is imperative to be able to provide a scientific approach to the training of these players (Smit, 2012; Virr *et al.,* 2014; Suarez-Arrones *et al*. 2014). Research on the performance characteristics of women's Rugby union could help in optimally preparing for competition, knowing the game's contemporary demands, improving performance, reduce the risk of injuries and errors in skill execution, and develop and identify quality talent (Virr *et al.,* 2014; Posthumus *et al.,* 2020; Woodhouse *et al.,* 2021).

Research has shown that the performance characteristics of players has a heavy influence on how coaches allocate players to specific playing categories (Nakamura *et al.,* 2016). Hence, in the current study, playing categories have also been explored. The playing categories of Rugby union are divided into two positional categories, namely forwards and backline players (sometimes referred to as backs) (Sheehan *et al.,* 2022. The differences between backs and forwards are related to their specific roles on the field (Nakamura *et al.,* 2016; Brazier *et al.,* 2018). Forwards are known to be heavier and taller compared to backs (Nakamura *et al.,* 2016; Brazier *et al.,* 2018).

Forwards are required to participate in more collisions (Sheehan *et al.,* 2022) eliciting high physiological responses (e.g., > 90% of maximal heart rate), interspersed with low to moderate locomotor activities (Nakamura *et al.,* 2016). Collision activities such as tackling, scrum, rucking and mauling comprise 14% of total game time for forwards, and 2% of game time for backs (Sheehan *et al.,* 2022). With regards t distance travelled elite Rugby union players travel 4500–7500 m with 300–800 m of this running taking place at high speed (Sheehan *et al*., 2022). With backs travelling the greater distances of between 6000 to 7000 m (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2014; Swaby *et al.,* 2016; Reardon *et al.,* 2016; Virr *et al.,* 2014). Backs also tend to enter high speed zones and reach higher maximum speeds of

usually more than 28 km/h (Cunniffe *et al.,* 2009, Coughlan *et al.,* 2011, Suarez-Arrones *et al.,* 2014; Owen *et al.,* 2019).

To obtain in-depth knowledge on the above Rugby union' demands, several modern technologies have been employed as the tools to collect and interpret these data (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2014; Hodun *et al.,* 2016; Yamamoto *et al.,* 2020; Hoppe *et al.,* 2018; Bradley *et al.,* 2020). Recently the use of the Global Positioning System (GPS), to track players' activity profiles on the field has been the most popular tool (Hodun *et al.,* 2016). GPS is currently the most used as it is less time-consuming and error-prone with various other benefits in comparison to older methods (Cunniffe *et al.,* 2009, Suarez-Arrones *et al.,* 2014; Hoppe *et al.,* 2018).

Studies that have used GPS have provided researchers and coaches with informative data such as on the total distance travelled on the field, (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2012; Suarez-Arrones *et al.,* 2014; Portillo *et al.,* 2014; Campbell *et al.,* 2017; Sheppy *et al.,* 2019; Busbridge *et al.,* 2020; Bradley *et al.,* 2020; Callanan *et al.,* 2021), maximum speeds reached (Coughlan *et al.,* 2011; Tee and Coopoo, 2015; Suarez-Arrones *et al.,* 2014; Busbridge *et al.,* 2020; Bradley *et al.,* 2020), time spent in speed zones (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Reid *et al.,* 2013; Tee and Coopoo, 2015; Bradley *et al.,* 2020) and the number of impacts in impact zones (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Suarez-Arrones *et al.,* 2014; Tee and Coopoo, 2015; Grainger *et al.,* 2018; Yamamoto *et al.,* 2019). However, as previously mentioned most of these studies have been conducted on men and little research exists on women. Considering that the demands within this context are likely to be unique because of the different contexts, this gap in the literature is a great opportunity for researchers to fill in.

The author's initial intentions were to quantify the physical and physiological demands of women's Rugby union players from Eastern Cape South Africa using GPS during both training and match-play. However, due to COVID-19, this was not possible as no matches were being played at the time of data collection, prohibiting the ability of the author to collect relevant data. Moreover, the author had intended to collect data for a minimum period of

three months. Instead, the researcher collected data over one month (nine sessions) and analysed data for only the training sessions of the players.

1.2 Statement of the problem

There is limited scientific knowledge on the physical and physiological demands placed of amateur women's Rugby union players during training. The existing research has been conducted on professional players with little to no data available on amateur players. Considering the nature of women's Rugby in South Africa and many other countries, amateur and semi-professional play is popular. Hence there is an urgent need to gain a better and deeper understanding of the physical and physiological demands of this population, to improve the planning of their training programmes (Smit, 2012).

Therefore, the first aim of the current study was to characterize the demographic and anthropometric characteristics, physical and physiological demands of amateur women' Rugby union in the Eastern Cape Province of South Africa. Additionally, the potential different demands placed on the different playing categories of women's amateur Rugby union players has not been adequately explored yet. Hence, the second aim of the study was to elucidate differences in the demands experienced by forwards and backs at an amateur level within South African women's Rugby union.

1.3 Significance of the study

To date no studies have attempted to quantify the demands of training or match play in amateur women's Rugby union within the Eastern Cape province in South Africa. The information gained from this study could possibly assist coaches, practitioners, and players with valuable insights that will help in the understanding of the demands of women playing Rugby union. Furthermore, it will elucidate the nature of current training characteristics. This understanding can then be used to inform how training programs should be structured going forward. By using the data collected from this study, coaches will be able to design scientifically based training programs, which might help improve performance. Furthermore, as this study aimed to provide data on the differences between forwards and backs, this will be used to help differentiate training programs of the two playing categories.

1.4 Hypotheses of the study

With several hypotheses, it must be noted that the order was displayed in a way that it starts with hypotheses between the playing categories (forwards and backline players) then followed by hypotheses within the playing categories' relevant variables (speed and impact zones).

Hypotheses A: Between playing categories (forwards and backs)

1. Demographic and anthropometric characteristics

Null hypothesis: There will be no significant differences in the demographic and anthropometric characteristics between forwards and backs.

Alternative hypothesis: There will be significant differences in the demographic and anthropometric characteristics between forwards and backs.

a. **null hypothesis:** Ho: μforwards = μbacks

b. **alternative hypothesis:** Ha: μforwards ≠ μbacks

Where the demographic and anthropometric characteristics will be age, stature, and body mass.

2. Physiological characteristic

Null hypothesis: There will be no significant difference in the physiological characteristic between forwards and backs.

Alternative hypothesis: There will be a significant difference in the physiological characteristic between forwards and backs.

a. **null hypothesis:** Ho: μforwards = μbacks

b. **alternative hypothesis:** Ha: μforwards ≠ μbacks

Where the physiological characteristic will be heart rate.

3. Physical characteristics

Null hypothesis: There will be no significant differences in the physical characteristics between forwards and backs.

Alternative hypothesis: There will be significant differences in the physical characteristics between forwards and backs.

a. **null hypothesis:** Ho: μforwards = μbacks

b. **alternative hypothesis:** Ha: μforwards ≠ μbacks

Where physical characteristics were total distance travelled, maximum speed, time spent in speed zones, and number of impacts in impact zones.

Hypotheses B: Within playing categories.

1. Time spent in speed zones

Null hypothesis: There will be no significant differences in the time spent between speed zones.

Alternative hypothesis: There will be significant differences in the time spent between the speed zones.

a. **null hypothesis:** Ho: μsz1 = μsz2 = μsz3 = μsz4 = μsz5 = μsz6

b. **alternative hypothesis:** Ha: μsz1 ≠ μsz2 ≠ μsz3 ≠ μsz4 ≠ μsz5 ≠ μsz6

Where sz1 – sz6 are speed zone 1 – speed zone 6.

2. Number of impacts in impact zones

Null hypothesis: There will be no significant differences in the number of impacts between impact zones.

Alternative hypothesis: There will be significant differences in the number of impacts between impact zones.

a. **null hypothesis:** Ho: μz1 = μiz2 = μiz3 = μiz4 = μiz5 = μiz6

b. **alternative hypothesis:** Ha: μiz1 ≠ μiz2 ≠ μiz3 ≠ μiz4 ≠ μiz5 ≠ μiz6

Where iz1 – iz6 are impact zone 1 – impact zone 6.

1.5 Organization of the study

Chapter two below contains the literature review exploring the in-depth perspective of previous research that relates to the history of Rugby, women's Rugby union, physical and physiological demands of Rugby union and techniques of quantifying the demands. This chapter is followed by the research methodology with a presentation of a precise step-by-step procedure of how the current study was carried out to achieve the study's aims and objectives. The results chapter, which is compiled in chapter four contains the demonstration of the study's organized, summarised, and analysed findings. The discussion of the results follows in chapter five in which the implications of the findings of the study are discussed and related to the literature reviewed in chapter two of the current study. In closing is chapter six

which contains the study’s hypotheses outcomes, researcher's conclusions and limitations of the study and recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Developments of Rugby football

2.1.1 The origins of Rugby football

Rugby is a direct descendant of mob football played throughout Europe in the Middle Ages (Phillpot, 2000; Muzek, 2015), and considered for society's civilized and affluent gentlemen (Gustafsson and Gjörlof, 2013). At first Rugby was strictly an amateur sport played for recreational purposes (Phillpot, 2000; Muzek, 2015). There was no uniformity concerning the rules of the game, and for many years it was played differently in various regions (Van der Schyff, 2006). Modifications done on the mob football by English public-school scholars are what led to several other forms of football such as Rugby, Australian rules, American and Canadian football (Phillpot, 2000, Muzek, 2015; Nauright 2018).

Modern Rugby started in 1823 when a young scholar, William Webb Ellis, who attended the Rugby School in England, picked up and ran with the ball instead of kicking it toward the opponent's side (Muzek, 2015). This distinct modification is what resulted in the creation of the handling game of Rugby, something that had never been seen before (Phillpot, 2000; Muzek, 2015; Nauright, 2018). As years went by Rugby started to spread rapidly from its upper-class origins in England, Scotland, and Ireland to the middle- and working-class men in the north of England, Wales, and British colonies in South Africa, Australia, and New Zealand (Muzek, 2015; Nauright, 2018). During the mid-19th century more Rugby clubs began forming (Nauright, 2018), and the working-class men embraced the game so much that by the late 19th century, the northern working-class men were dominating the game of Rugby (Phillpot, 2000).

In August 1895, the working-class men from the Rugby clubs in the north of England split and formed their own professional version of Rugby now known as Rugby league while the remaining players from other parts of the world continued to play what is now known as the Rugby union (Phillpot, 2000; Muzek, 2015; Bradley, 2017; Nauright, 2018). The split of Rugby league from Rugby was a result of the Rugby league players wanting to be compensated for their time of playing the game

(Phillpot, 2000; Muzek, 2015). Rugby union players on the other hand believed that Rugby should not be taken seriously to the point where players are being paid to play it (Phillpot, 2000). Rugby union players believed that making Rugby professional would make the sport lose its most important quality, which was seeing Rugby as just play rather than work (Phillpot, 2000; Muzek, 2015).

Rugby union then remained an amateur sport for a century, from 1895 to 1995 (Muzek 2015). Meanwhile, in the amateur era of Rugby union, most sports started becoming commercially oriented and professional (Phillpot, 2000). However, in the desire of the sport's main governing body, the International Rugby Board (IRB) wanting to maintain, promote and control Rugby union they decided to allow professionalism (Phillpot, 2000). Although some players were already getting incentives from sponsors and sports companies, the decision to make Rugby union professional meant that players would officially get payments for playing the sport and this brought about a series of events (Phillpot, 2000).

2.1.2 Rugby union post-amateur era

Shortly after making Rugby union professional, the IRB experienced many struggles concerning ethical and financial issues (Dubois *et al.,* 2020). After 1995 the IRB struggled to retain control of the sport and its revenue, and most people feared for its survival (Phillpot, 2000). Although some supporters and players were against the idea, scared that it would ruin the game, some were in full support as they watched it being done successfully by other descendants of mob football sporting codes (Phillpot, 2000). Eventually, the game started gaining back the support from society, and this made it more demanding because society always expected success from their favourite Rugby clubs (Phillpot, 2000; Nauright, 2018), which meant that players had to always be in their optimum playing states. Financial success also started to pick up through commercialism when the IRB permitted cups and leagues such as the Super Rugby, Tri-nations, and the Rugby World Cup (RWC) (Muzek, 2015; Nauright, 2018).

Professionalism and the possibility of these competitions meant that players would get paid enough that they would be able to quit their 9-5 jobs and dedicate more of their time to playing the sport (Phillpot, 2000). It is now believed that the decision

taken in 1995 to end amateurism and reward players for their time and dedication broadened the Rugby union's appeal and moved the game immeasurably (Muzek, 2015; World Rugby, 2020). However, this came with more responsibility for players as coaches demanded more from them, claiming that Rugby was now their 9-5 job and not just being played for recreational purposes (World Rugby, 2020).

Outside of just the players, Rugby union through cups and leagues hosted in different countries has also had a positive influence on other important factors such as international tourism, infrastructure development, business innovations, investors, political and sociocultural debates, gender identities, and youth development (Batty *et al.,* 2018). There are 129 national unions as members of World Rugby, player numbers are nearing 10 million, and there has been a significant increase in fan base driven by RWC successes that include most countries around the world (World Rugby, 2022a). The introduction of professionalism has meant that the game has continued to evolve as teams/countries look for innovative ways to outperform others. In no order, Rugby union, according to RWC, is enjoyed and led by very diverse countries such as England, New Zealand, Ireland, Australia, Wales, France, Scotland, Canada, USA, Italy, Japan, Argentina, and South Africa for men and women (World Rugby, 2022a). Which leads to the next topic of this study, the South African Rugby Union (SARU) which is the context in which the study was conducted.

2.1.3 Rugby union in the context of South Africa

The chronology of South African sporting history is complex because of the socio-economic environment established in the early 1700s (Archer and Bouillon, 1982). Rugby was introduced in South Africa in 1861 by Canon George Ogilvie (Smiles, 2012). The first written rules and formation regarding Rugby were established and accepted by the International Rugby Football Board (later IRB and now World Rugby) in 1871 (Smiles, 2012) and South Africa's first international Rugby football game, adhering to these rules, was in 1875 (Muzek, 2015; Nauright, 2018). In 1882, the South African Rugby Association was formed (Smiles, 2012). Following that, in 1889 was the formation of the White Rugby federation and the South African Rugby Board while the Black Rugby federation was formed in 1892 (Smiles, 2012).

During these events and especially during apartheid which started in 1948, Rugby was split between Black and White people. Apartheid as defined in the Merriam-Webster dictionary, (2022) is a former policy of segregation and political, social, and economic discrimination against the non-White majority in the Republic of South Africa. During the apartheid era, it was normal that Whites and Blacks played sport in their own social groups (Desai, 2010; Smiles, 2012). South African Rugby was governed and administered under a dichotomous system that comprised an establishment (White) side and a non-establishment (Black) side (Surujlal, 2004). With the establishment side having sporting links with the apartheid government and access to modern facilities, opportunities, and sophisticated training methods while the non-establishment side had to be content with make-shift facilities and virtually no training opportunities (Goslin, 2006; Shuttleworth and Whitefield, 2007).

By the late 19th century, Rugby was firmly established in the Western Cape, Eastern Cape, and Free State provinces of South Africa (Smiles, 2012). The game was played and spread to these areas by British regiments, schoolmasters, soldiers, civil servants, miners, and clergymen (Springbok Rugby, 2003; Spies, 1995). Although the South African Rugby Board was formed in 1889 it only governed and was made for White people, while in 1935 the South African Bantu Rugby Board was formed and governed by Black South African Rugby players (Smiles, 2012). In 1949 South African Rugby joined the IRB as a national union member (World Rugby, 2022b). However, when the IRB carried out the RWC in 1987, South Africa was banned from participating because of its discrimination and apartheid system (Smiles, 2012; Muzek, 2015; Bam, 2019).

Not only was South Africa banned from the RWC but countries such as France removed themselves from South African Rugby hence, they did not take part in any South African tours (Smiles, 2012). Following the ban from RWC, in May 1988, Louis Luyt and other Rugby members met with African National Congress (ANC and now the democratic governing political party of the country) officials in secret meetings to return to international Rugby (Dobson, 1994; Black and Nauright, 1998). They agreed to form a single non-racial controlling body for South African Rugby, with the ANC committing their offices to ensure that the non-racial controlling body for South

African Rugby takes its rightful place in World Rugby (Dobson, 1994; Black and Nauright, 1998).

After discussions to end apartheid that took place between 1990-1994, in the 1995 RWC, the IRB welcomed South Africa to participate and host the RWC, which they went on to win (Smiles, 2012; Muzek, 2015; Nauright, 2018). South African Rugby players were under the impressions that they could now all compete internationally as a national team because apartheid had come to an end (Smiles, 2012). However, when the isolation in the country ended, and international competition was renewed, the behaviour of the sports establishment and supporters seemed to reinforce nostalgia and racialist identities (Black and Nauright, 1998). This was contradicting the arguments of those who saw the sport as a force for breaking down social barriers and promoting unity (Black and Nauright, 1998). After apartheid, the sport was still racialized for a long time and was embraced mainly by Whites and the Afrikaner community (Smiles, 2012).

Although not perfect, Smiles (2012), argues that Rugby laid the foundation and platform for reformation, integration, and eventual transformation of a democratic South Africa. South African Rugby worked its way up from being regarded as a major “White” game and it got to be enormously popular among White and Black South Africans (Smiles, 2012). The sport was and is still cherished by many participants and audiences in South Africa because of its uniting nature. Since 1995 South African Rugby has become one of the world’s great Rugby playing countries. However, as with most sports, women have for a very long time been discouraged from taking part as active participants (Hene, 2011).

2.1.4 South African women’s Rugby union

Due to the lack of published literature on the developments of women’s Rugby in South Africa not much is known on this topic, especially prior to and during apartheid. While women in countries such as United States and Canada began playing Rugby in the early 1970s (Wiley *et al.,* 2000; Carle and Nauright, 1999), during apartheid, it was difficult for women in South Africa to participate in sports dominated by men (Bogopa, 2007), as they were deprived access to good sports’ facilities (Hargreaves, 1997; Chapell, 2005). Fewer resources were available for

women’s sports due to the issue of gender which was considered less important than race and ethnicity (Chapell, 2005). The issue of prioritising race over gender was however not only a South African problem. This is evident from the fact that, the IRB only included and accepted the women's Rugby category in 1994 (Suarez-Arrones *et al.,* 2014), a century after men’s Rugby was accepted.

The World Rugby which changed its name from IRB in 2014, professionalised women’s Rugby union only in 2017, 22 years after men’s Rugby union got professionalised (Bradley *et al.,* 2020; Woodhouse *et al.,* 2021). In terms of the South African context, the end of apartheid and men’s RWC final in 1995 promised the emergence of a new era in South African sport, it was a symbol of a united nation through sport (Chapell, 2005). Changes to the Constitution made provision for a Gender Commission, and the ANC committed itself to a “Women’s Charter of Rights and Effective Equality between the Genders” (Hargreaves, 1997; Bolligelo, 2006; Shuttleworth and Whitefield, 2007). South African women’s Rugby union was accepted and included in the SARU in 2000 (Chapell, 2005; Tesnear and Surujlal, 2012; Hene and Bassett, 2013).

The South African national women’s Rugby union team did however face an uphill battle in their struggle to match the reputation and international respect enjoyed by the men of the South African team (Snyders, 2021). In 2000, South African women’s Rugby had less than 10 clubs playing on a social basis in the middle-class communities (Hene and Bassett, 2013; Tesnear and Surujlal, 2012). To promote women’s Rugby in the country, SARU launched the first women's Rugby union championship in 2003 under SARU Women's Interprovincial Championship (Women24, 08 August 2005). This was an important initiative in making Rugby inclusive, identifying more talent from club Rugby for the national team, and transforming from the pre-democratic era (Women24, 08 August 2005).

Women’s participation has since grown in South Africa with women’s Rugby union registering more Rugby clubs and players within towns, suburbs, and rural districts throughout South Africa (Hene, 2011). However, given the country's lack of a dedicated professional leagues or national competitions, the women’s national team continues to struggle in the international arena (Snyders, 2021). The South African women’s Rugby had its first RWC debut in 2006 (SA Rugby, 2000), eleven years

after the men's team started taking part and currently, the South African women's Rugby team is ranked 13th on the women's World Rugby rankings (World Rugby, 2022c), while the South African men's Rugby team is ranked 3rd on the men's World Rugby rankings (World Rugby, 2022d).

These differences could be accounted for by the fact that the women's game on the national and club level remains an under-resourced largely amateur game with only a small group of semi-professionals (Snyders, 2021; Tucker *et al.,* 2021). Additionally, Posthumus (2013) argued that South African Rugby lacks a standardized format for introducing young girls to Rugby and developing their fundamental Rugby skills. The ratio of men to women playing Rugby results in some introductory Rugby structures for girls involving mixed-gender participation while some must adopt a 7-a-side format, while others have no competition at all (Posthumus, 2013).

Table 1 is a summary of the comparison of the leagues and national competitions that the men and women of South African Rugby Union participate in. It must be noted that the data in Table 1 was compiled from only one source, the SARU website and is only in relation to teams from semi-professional and professional levels (this is excluding amateur Rugby as it is not posted on the website at the time this thesis was being compiled). With regards to South African women's Rugby, it is evident from Table 1 that there are fewer competitions compared to the South African men's Rugby. It is also important to note that compared to men's Rugby, women's Rugby has a much smaller number of players (Posthumus, 2013) and is mostly amateur (Snyders, 2021). This could possibly explain the three competitions seen on Table 1 and the SARU website. Furthermore, from Table 1 it is evident that amateur Rugby is not given much attention as it is difficult to find information about it on the internet.

Table 1: South African Men's and Women's Rugby Union competitions.

South African Men's Rugby Union	South African Women's Rugby Union
The Rugby World Cup is a tournament contested every four years between the top international teams.	**Rugby World Cup** - is a Rugby union tournament contested every four years between the top international teams.
Castle Lager Rugby Championship - is an international Rugby union competition contested annually between four national teams in the Southern Hemisphere.	**Women's First Division** - is a competition between eight South African Women's Rugby union teams.
Castle Lager Lions Series: is a series of test matches between the British and Irish Lions and South Africa.	**Women's Premier Division** is a competition between six South Africa's Women's Rugby union premier provincial teams.
Vodacom United Rugby Championship: is a competition between four South African teams, twelve Ireland, Italy, Scotland, and Wales.	
Carling Currie Cup Premier Division: is South Africa's oldest and premier provincial competition.	
Carling Currie Cup First Division: is a second-tier Currie cup competition between South Africa's provincial teams and three teams from Zimbabwe, Kenya, and Georgia.	
Heineken Champions Cup: is an annual Rugby union tournament organised by European Professional Club Rugby.	
European Professional Club Rugby Challenge Cup: It is the second-tier competition for two South African and other clubs based in European leagues.	

(Adapted from: https://www.saRugby.co.za/tournaments/epcr-challenge-cup/).

In the context of South African Rugby, Posthumus (2013) contends that for participation in women's Rugby to increase and the national women's team to compete successfully, Provincial Rugby sub-unions need to support amateur-level clubs (community and schools' Rugby) as this is currently lacking. The SARU has

also stated that “Any structure must be built on solid foundation and currently it is not the case” (SA Rugby, 2019, p26). Hence, if women are to compete successfully against top countries in Rugby, underage representative participation as part of a pipeline comprising at least three underage categories as well as increased participation opportunities at school level backed up by appropriate high-performance structures are key to success.” (SA Rugby, 2019, p26). This needs the management of the national women’s team and all representatives involved to be on board, have a solid foundation, and promote Rugby from club Rugby and underage representative participation (Posthumus *et al.,* 2020).

Amateur players are often at a disadvantage when it comes to resources, as they do not get the same exposure when compared to their professional counterparts (Dobbs *et al.,* 2017; King *et al.,* 2019). Therefore, more focus on them may allow them the opportunity to succeed. The role club Rugby plays is integral in South African Rugby union, it develops Rugby union players to ultimately play provincial Rugby which forms the amateur structure within the South African Rugby provinces (Coetzee, 2016). This structure holds the majority share in South African Rugby, according to SARU’s constitution (Coetzee, 2016).

2.1.4.1 Research on women’s Rugby union

Since the increase in the participation of women’s Rugby union, there has been an increase in the competitiveness of the game (Callanan *et al.,* 2021). Several authors have argued that this growth requires the development and implementation of sport and gender-specific training programs (Virr *et al.,* 2014; Nyberg and Penpraze, 2016; Callanan *et al.,* 2021). To accomplish this, there needs to be more scientific research conducted on the performance characteristics of women’s Rugby union (Hoppe *et al.,* 2018; Callanan *et al.,* 2021). Such knowledge is important for women’s Rugby and may be helpful in optimizing the performance of these players (Nyberg and Penpraze, 2016; Busbridge *et al.,* 2020; Bradley *et al.,* 2020; Callanan *et al.,* 2021; Woodhouse *et al.,* 2021).

Although there is a large body of literature on performance strategies on men’s Rugby it is lacking for women’s Rugby (Virr *et al.,* 2014; Suarez-Arrones *et al.,* 2014; Nyberg and Penpraze, 2016; Bradley *et al.,* 2020; Callanan *et al.,* 2021). Therefore,

sport performance strategies are often based on research conducted on men (Callanan *et al.,* 2021). Currently, scientific research in women's Rugby union is very limited and the available research focuses much on injuries/safety and not on performance factors that seek to optimize women's Rugby such as physical and physiological, characteristics. This can be seen in Table 2, which shows research conducted on women/female Rugby union clubs before March 2020.

With the use of three reliable search engines, namely Scopus, EBSCOhost, and Web of Science a literature search aiming to understand how much performance characteristics' research has been done on women's Rugby union was conducted. In line with the current study which seeks to establish performance characteristics of women's Rugby union, the keywords used in the search were "Rugby union, women/female(s), physiological, physical and demands". Any studies that looked at Rugby sevens, Rugby league, and men/male studies were excluded from the results of the search (Table 2 and APPENDIX A). Table 2 below shows a reduced version of the studies that resulted from the search due to how long the table was, the rest of the included studies are presented in APPENDIX A. Not all included studies explicitly detailed/mentioned the relevant variables that were looked out for in this study. This is especially with regards to the participants' countries, topics covered and number of participant(s)., hence for some studies these variables were left out or labelled as "unspecified".

1 Table 2: Search results of women's/females' Rugby union studies.

Author(s) and year	Title of the study	Country(s)	Topic(s) covered	Number of participants(s)
1. Abdel-Salam *et al.,* 1991.	Internal fixation of closed tibial fractures for the management of sports injuries	United Kingdom	Injuries.	Group A: 42 men and three women Group B: 41 men and four women
2. Shewring and Matthewson, 1993.	Injuries to the hand in Rugby union football	England	Injuries	72 patients, two of whom were women
3. Gerrard *et al.,* 1994.	The New Zealand Rugby injury and performance project: II. The previous injury experience of a Rugby-playing cohort	New Zealand	Injuries	Clubs & secondary school. Senior A, Senior B, Senior women and Under 21 grades clubs, two schoolboys first XVs and three schoolgirl teams. 92 women and 258 men Rugby players
4. Lewis and George, 1996.	An initial investigation of injuries in women, men and youths playing Rugby union football at the same club	Unspecified	Injuries	Men, women and youth Rugby union players
5. Nicholas, 1997.	Anthropometric and physiological characteristics of Rugby union football players	Combination of data from different countries (Japan, South Africa, US, Britain)	Performance (Characteristics of players and demands of the game)	Rugby union men and women
6. Gerrard, 1998.	The use of padding in Rugby union: An overview	Southern Hemisphere	Injuries	Women Rugby players
7. Wilson *et al.,* 1999.	The nature and circumstances of tackle injuries in Rugby union	New Zealand	Injuries	356 men and women players from Senior A and B club teams, Under 21 teams, and Schoolboy First XV's (Under 18 and 19 grades), Women's and Schoolgirl grades
8. Marshall *et al.,* 2001.	Use of protective equipment in a cohort of Rugby players	New Zealand	Safety and injuries	Men and women players (N = 327)
9. Quarrie, 2002.	Rugby union injuries to the cervical spine and spinal cord	Systematic review	Injuries	Men and women
10. Onyeaso,	Secondary school athletes: A study of mouthguards	Nigeria	Safety	Men and women adolescent Nigerian contact sports athletes

2004.				
11. Comstock and Fields, 2005.	The fair sex? Foul play among women Rugby players	USA	Players' perception of foul play, referee's response to foul play, evaluate the association between players' perception of foul play and injury	258 women
12. Wilson, K.M., Hardy, L., Harwood, C.G. 2006.	Investigating the relationship between achievement goals and process goals in Rugby union players	Unspecified	Performance	78 men and 72 women amateur club, professional club, country, national age group, and national level players.
13. Fong *et al.,* 2007.	A systematic review on an ankle injury and ankle sprain in sports	38 countries	Injury reporting pattern	201600 athletes of different sport
14. Schick *et al.,* 2008.	Injuries during the 2006 Women's Rugby World Cup	All participating countries	Injuries	All participating teams in the 2006 WRWC were enrolled prospectively in this study
15. Gamble, Paul, 2008	Approaching physical preparation for youth team-sports players	Unspecified	Performance	young athletes competing in organized team sports
16. Nicol *et al.,* 2011.	Rugby union injuries in Scottish schools	Scotland	Injuries	School Rugby union
17. Ponseti, 2012.	Correlation of Tackle Ability in High-Performance Spanish Women's Rugby union Player	Spanish	Tackling ability of players	17 players at the highest level in Spain and 12 junior players in the Catalan High-Performance group. Spanish women's Rugby union
18. Brown *et al.,* 2013.	The incidence of Rugby-related catastrophic injuries (including cardiac events) in South Africa from 2008 to 2011: A cohort study	South Africa	Injuries	Men and women amateur and professional Rugby players, 529 483 Junior and 121 663 Senior Rugby union players (population at risk)
19. Suarez-Arrones, *et al.,* 2014.	Match-play activity profile in elite women's Rugby union players	Spanish international team	Performance	8 international women Rugby union players

20. Bohu *et al.,* 2015.	The epidemiology of 1345 shoulder dislocations and subluxations in French Rugby union players: A five-season prospective study from 2008 to 2013	French Rugby union	Injuries	1317 men and 28 women, mean age 22.5±5.9 years from senior professionals, senior amateurs, juniors, cadets, and Rugby school players
21. Mathema *et al.,* 2016.	Concussed or Not? An Assessment of Concussion Experience and Knowledge Within Elite and Semi-professional Rugby union	Wales	Injuries	International, professional and semi-professional players, coaches, medical staff, and referees within Rugby union
22. Hughes *et al.,* 2017.	Performance indicators that discriminate between winning and losing in elite men's and women's Rugby union	World Cup competitions	Performance	Elite men's and women's Rugby union
23. Brown *et al.,* 2018.	Non-sanctioning of illegal tackles in South African youth community Rugby	South Africa	Safety	99 South African Rugby union U18 Youth Week tournament matches were coded between 2011 and 2015
24. King *et al.,* 2019.	Match and Training Injuries in Women's Rugby union: A Systematic Review of Published Studies	Systematic review	Injuries	Women's Rugby- 7s and 15s
25. Posthumus *et al.,* 2020.	The physical characteristics of elite women Rugby union players	New Zealand	Performance	30 elite women Rugby union players

Table 2 shows that out of a total of 117 studies (APPENDIX A) six studies were conducted on the South African women's Rugby union while other studies included several other countries, such as New Zealand, Australia, United States of America, England and 47 unspecified 47. With regards to the topics covered, 37 studies were conducted on performance related characteristics while the remaining studies were conducted on other factors such as injuries and social factors. Women's Rugby in South Africa and many other countries is mostly semi-professional and amateur (Snyders, 2021; Tucker *et al.,* 2021). In South Africa for example, the national teams for sports such as Rugby union are made up of players from the semi-professional level which scouts players from the amateur level (Coetzee, 2016). This supports the need to have more research focused on improving the performance of amateur players as they often make the pool in which semi-professional and professional players are chosen.

Although professional Rugby union men's data is readily available, unfortunately, the data on physical, and physiological demands cannot be used interchangeably between men and women (Harty *et al.,* 2019; King *et al.,* 2019). This is because considerable differences such as anthropometric and body composition variables have been detected between men and women competing in the same sport (Harty *et al.,* 2019; King *et al.,* 2019). Women reportedly have lower speed, strength, and agility, lower muscular power, and lower estimated maximal aerobic power when compared to men (Lakomy *et al.,* 2000; King *et al.,* 2019). Therefore, by virtue of men and women playing the same sport under the same conditions, does not mean they adapt and have the same physique or features (Wellard, 2016).

2.2 Demands of Rugby union

A Rugby union game needs effective planning informed by experience and knowledge of the game (Greenwood, 1978). Establishing and understanding the unique demands placed on Rugby union players and their different playing categories is essential when trying to develop specific training programs and recovery strategies that cater to the specific needs of these players (Venter *et al.,* 2010). Before going into the demands experienced by players in the game, it is essential to first understand the game's characteristics, roles, and responsibilities of the different playing categories.

2.2.1 Rugby union characteristics

A Rugby union game is played over a period of eighty minutes that is split into two halves of forty minutes with an additional ten-minute break (Duthie *et al.,* 2003; Cahill *et al.,* 2012; Suarez-Arrones *et al.,* 2014, Harty *et al.,* 2019). The game is played with an oval-shaped ball between two opposing teams on a grass pitch measuring approximately 100m x 70m (Finnigan, 2014; Muzek, 2015). Each team has a starting line-up comprising of fifteen players and eight reserves that can be substituted at any game time (Finnigan, 2014; Muzek, 2015; Barnard, 2021). The objective of each team is to obtain the ball and keep it until a scoring opportunity avails while the opposing team defends and tries to win the ball (Muzek, 2015). The winners of a game are the players who were able to successfully obtain more points while denying the opposing team both possession of the ball and the opportunity to score (Cahill *et al.,* 2012; Suarez-Arrones *et al.,* 2014, Muzek, 2015).

A team can score points in four different ways. Firstly, to score 5 points by successfully carrying the ball over the opponent’s goal line and forcing the ball to the ground (Muzek, 2015; World Rugby, 2022e). Subsequently, that team is given a chance to score two points through a “conversion”, where one player must kick the ball over the crossbar from the place in line with where the previous try was scored (World Rugby, 2022e). The third way of scoring points is through a drop goal, where during open play, a player drops the ball and kicks it to go over the crossbar (World Rugby, 2022e). Lastly, scoring points can be through a penalty try which the referee awards after an infringement by the opposition (World Rugby, 2022e). It is important to note that although professional Rugby union follows the laws mentioned some

Rugby union tournaments such as Varsity Cup have additional laws (Dobson, 2020). Amongst the few differences, one example is that Varsity Cup has an additional way of earning points which allows a team to score seven points (Dobson, 2020).

2.2.2 Player positions, roles, and requirements

Rugby union players are placed at different playing positions around the field, hence different anthropometry, physiques, roles, and responsibilities are required from each player to meet the demands of the game (Posthumus *et al.,* 2013; Nakamura *et al.,* 2016; Nyberg and Penpraze, 2016; Brazier *et al.,* 2018; Stoop *et al.,* 2018). The playing categories are commonly grouped with other positions of similar attributes but are individually named and reflect distinct roles within the game (Tee and Coopoo, 2015). Players within these groups have different characteristics and tasks executed during the specific phases of the game (World Rugby, 2022e). Typically, players are split into two distinct positional categories known as “forwards” and “backline/backs”, made up of positions number 1-8 and number 9-15, respectively (Finnigan, 2014; World Rugby, 2022e). A more detailed illustration of the 15 different playing positions with their names is shown in figure 1 below.

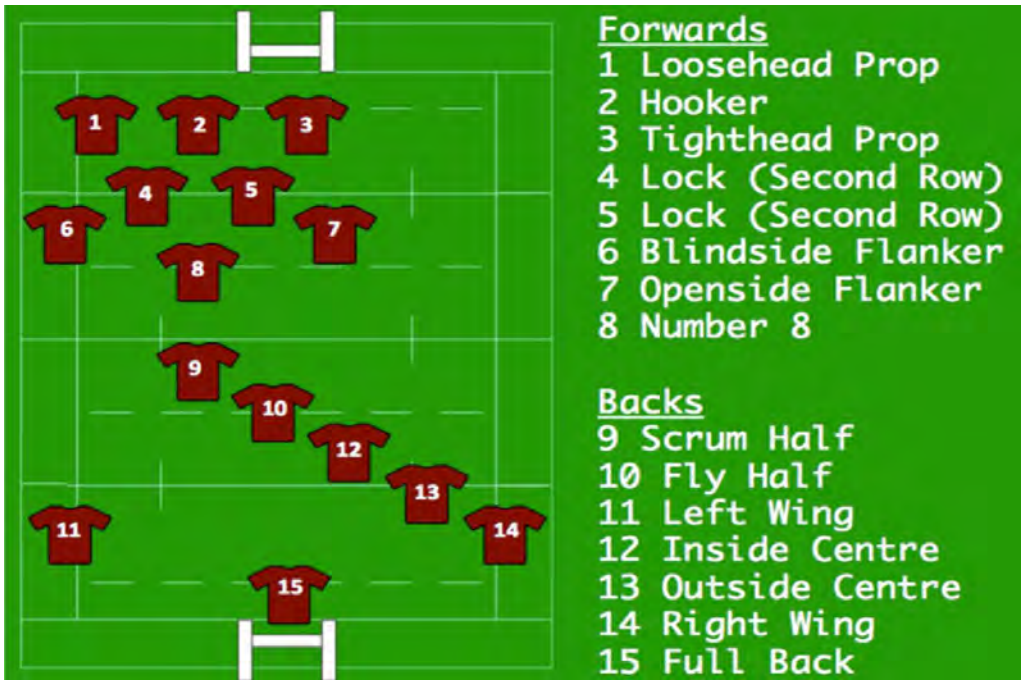

Figure 1: Number and positions of the starting line-up players for a 15-a-side *Rugby* union team (adapted from: https://zululandobserver.co.za/221030/Rugby-positions-explained/)

2.2.2.1 Forwards

Forwards are made up of a hooker, two props, two locks, two flankers, and the "number eight" (Nauright, 2018). Collectively, the forward players are generally responsible for retaining possession of the ball and engaging opposing players in scrums, rucks, mauls, and lineouts (Nicholas, 1997; Duthie *et al.,* 2003; Smart *et al.,* 2013; Quarrie *et al.,* 2013; Harty *et al.,* 2019; Bradley *et al.,* 2020). As a result of their role in scrums, forwards require a greater mass, stature, strength, and power to be successful (Smart *et al.,* 2013) than their backline counterparts. The hooker is typically the smallest and lightest of the forwards (Nicholas, 1997). With the support of props, the hooker is responsible for winning the ball in scrums and throwing the ball in during lineouts (Nicholas, 1997; Nauright, 2018). Agility, fast reaction speed, and leg power to drive a scrum, ruck, and maul forward are essential characteristics for hookers (Nicholas, 1997).

Props require strength, and power as they are involved in gaining possession of the ball, which involves close contact with the opposition and limited opportunity to run with the ball (Nicholas, 1997). Props are the cornerstones of scrums and lineouts because they are typically stout and powerful players who can move heavy loads around (Nicholas, 1997; Nauright, 2018). As a result of props' responsibilities, they are generally the heaviest positions to contest the ruck, maul, and scrums to win or maintain possession of the ball (Smart *et al.,* 2013). The locks, also known as second rows, are positioned in the centre of the second row of the scrum, are usually the tallest players on the team, and are the primary ball winners in lineouts (Nauright, 2018). They also need to develop leg power and jumping ability to win possession at the lineouts; hence, stature is an obvious advantage for this position (Nicholas, 1997). In a scrummage, and in open play, both body mass and power are additional advantages for the successful participation of locks (Nicholas, 1997).

The flankers assume the outside positions on the scrum's second row and are responsible for disrupting the play of the opponent's backs and winning the ball (Nauright, 2018). Number 8 is part forward, part back, and the last line of the scrum. This position is expected to win balls, especially in rucks, to link with the scrum and fly-halves, and make runs as well (Nauright, 2018). Back rows (flankers and number 8) require a great capacity for power, mobility in open play, speed, acceleration, and

endurance in gaining and retaining possession of the ball in loose play (Nicholas, 1997). Strength and power for aggressive tackling and driving forward in the scrum, ruck, and a maul are also essential characteristics for these positions (Nicholas, 1997). In essence, forwards are in continual close contact with opposition players and need to be strong and powerful to gain and retain possession of the ball (Nicholas, 1997). Being tall and having a heavier body mass is advantageous in the forward positions and has been shown to positively correlate with scrummaging force and competitive success (Quarrie *et al.,* 1995; Nicholas, 1997, Quarrie and Wilson, 2000; Duthie *et al.,* 2003; Sedeaud *et al.,* 2012; Nyberg and Penpraze, 2016; Nakamura *et al.,* 2016).

2.2.2.2 Backs

Backs are generally responsible for controlling possession of the ball, defending, gaining field territory, executing tactical movements, and scoring (Nicholas, 1997; Duthie *et al.,* 2003; Quarrie *et al.,* 2013; Tee and Coopoo, 2015; Harty *et al.,* 2019; Bradley *et al.,* 2020). The backs' primary role is beating the opposition in open play, which requires a combination of acceleration, agility, speed, and endurance (Quarrie *et al.,* 1995; Nicholas, 1997; Duthie *et al.,* 2003; Smart *et al.,* 2013; Nakamura *et al.,* 2016). Backs are considerably lighter, involved in fewer impacts/contact, and travel significantly more total distance and distances at high speed (Lindsay *et al.,* 2015, Tee and Coopoo; 2015; Nakamura *et al.,* 2016) than forward players. Backs must accelerate away from opposition players to create scoring opportunities and provide cover in defence (Brazier *et al.,* 2018).

The backs are made up of one fly-half, one scrum-half, two centres, two wings, and one full-back. The first two positions both play a prominent role in the attack (Nauright, 2018). Scrum-halves serve as a link between forwards and backs, control and distribute the possession of the ball by feeding the ball into scrums and delivers it to the fly-half (Nicholas, 1997; Nauright, 2018). The scrum-halves are generally the smallest players, very mobile and agile around the field and initiates play from rucks and mauls (Smart *et al.,* 2013; Nauright, 2018). The fly-half is the primary distributor of the ball and the chief strategist on the field by deciding when the ball should be kicked (Nauright, 2018). Fly-halves are typically the best passers and kickers on the team and are responsible for generating attacks (Nauright, 2018).

The right and left (or inside and outside) centres line up in the middle of the field closer to the fly-half, these positions are vital to the spacing and passing within the attack, as well as active in tackling (Nauright, 2018). Centres have defensive and offensive roles and a considerable field area to run (Nicholas, 1997). They generally have the most physical contact with the opposition, bursts of speed of varied intensity, strength, and power for running at the opposition, and absorbing physical contact in attack and defence are attributes required for this position (Nicholas, 1997). The two wingers, positioned before the fullback and to the right and left flanks of the field, support the fullback in the last line of defence, but their primary role is to use their speed to make long runs and score try's (Nauright, 2018). These three players are required to beat the opposition by utilizing pace, or a combination of speed and strength support running, chasing kicks, and covering in defence are typical requirements for this position (Nicholas, 1997). The fullback is the last line of defence and is expected to make try-saving tackles (Nicholas, 1997). The fullback is also responsible for fielding kicks from the opposition and quickly initiating the attack (Nicholas, 1997).

It is evident that Rugby union is a demanding sport and all playing categories are required to perform different roles and responsibilities. Because of the diverse demands required by each position in Rugby union, a player's physique and anthropometry will affect their suitability for a given position and likely influence personnel assignments by coaching staff (Harty *et al.,* 2019). The placement of players according to the different positions is based on various factors such as the demands of a certain playing position, body characteristics, and ability to perform designated skills (Cahill *et al.,* 2012; Lindsay *et al.,* 2015). However, although the afore mentioned roles and responsibilities can be generic to different contexts (teams), the physical and physiological demands experienced by Rugby union players from different contexts (amateur vs professional, youth vs senior, men vs women) differ (Tucker *et al.,* 2021).

2.2.3 Physical and physiological demands of Rugby union

From the descriptions of the different playing positions, Rugby union requires a range of tactical behaviour, technical proficiency, physical, and physiological skills, and abilities (Cunniffe *et al.,* 2009; Tee and Coopoo 2015; Reardon *et al.,* 2016;

Lindsay *et al.,* 2015; Tee *et al.,* 2015; Hodun *et al.,* 2016; Beard *et al.,* 2019; Owen, 2019). Evidently, playing position has a significant impact on the demands experienced by players on the field. Rugby union studies investigating the demands players experience on the field have categorized players according to their playing categories (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Reid *et al.,* 2013; Suarez-Arrones *et al.,* 2014; Portillo *et al.,* 2014; Owen *et al.,* 2015; Tee and Coopoo, 2015; Tee *et al.,* 2015; Campbell *et al.,* 2017; Grainger *et al.,* 2018; Sheppy *et al.,* 2019; BUsbridge *et al.,* 2020; Bradley *et al.,* 2020; Callanal *et al.,* 2021). Therefore, the physical and physiological demands from this section will sometimes be characterized according to the playing positions. The physical demands refer to the stress placed on the skeletal and muscular structure of a player while the physiological demands refer to the stress placed on the functions of the bodily organs and systems of a player (Owen, 2019).

Knowledge on Rugby's physical and physiological demands is essential as it can practically be useful for performance programs, with a goal of improving the physical and physiological capabilities of players (Nyberg and Penpraze, 2016; Owen, 2019). Due to the lack of scientific literature on the physical and physiological demands of women's Rugby, this section will refer to the literature mostly conducted on men's Rugby. Studies have revealed some tactical, technical, and physical key performance indicators during Rugby union games at different age categories and levels of play (Cunningham *et al.,* 2018; Ungureanu *et al.,* 2019). With several studies; Nicholas, 1997; Hene *et al.,* 2011; Virr *et al.,* 2014; Suarez-Arrones *et al.,* 2014; Hodun *et al.,* 2016; Nyberg and Penpraze, 2016; Harty *et al.,* 2019; Sheppy *et al.,* 2019; Bradley *et al.,* 2020; Busbridge *et al.,* 2020; Posthumus *et al.,* 2020; Woodhouse *et al.,* 2021; Callanan *et al.,* 2021 conducted and exploring the demands experienced by women Rugby union players, and differences in the playing positions.

Based on findings from men's Rugby union, physical performance characteristics, such as strength, power, agility, speed and momentum, and endurance capacity (Argus *et al.,* 2012; Smart *et al.,* 2013) are greater among professionals compared to lower-standard players (Woodhouse *et al.,* 2021). This may be attributed to the fact that Rugby union's game demands have shifted since the professional era started

(Lindsay *et al.,* 2015; Nyberg and Penpraze, 2016; Woodhouse *et al.,* 2021), hence players from lower levels of play (semi-professional and amateur) may experience less demands. Additionally, the nature of a Rugby union game changes from game to game due to factors such as weather, strategies of play, tactical and technical factors, leagues, playing categories, opposition, player availability, and preparation (Maslovat and Frank, 2007; Venter *et al.,* 2010; Schoeman and Coetzee, 2014; Blair *et al.,* 2018). These factors can affect the game through the pace of play, ball in playtime, level of physical contact, and amount of game time (Blair *et al.,* 2018). The above-mentioned factors may result in different outcomes for different teams at different times (Colomer *et al.,* 2020).

Since professionalisation Rugby's demands have increasingly become of interest to researchers as coaches spend more time on the physical preparation of players (Lindsay *et al.,* 2015; Hoppe *et al.,* 2018; Woodhouse *et al.,* 2021). Players in their optimum physical and physiological performance are better suited to perform the technical skills required of contact sports and therefore better execute the strategy, for longer periods of play (Farrow *et al.,* 2008; Argus *et al.,* 2012). Although different playing categories experience different demands on the field during training and match-play, all players are required to have the basic core skills such as running, tackling, and rucking, high levels of aerobic fitness as well as muscular strength and power, stability, and agility (Posthumus, 2009; Cunniffe *et al.,* 2009; Schoeman and Coetzee 2014; Tee and Coopoo, 2015; Jones *et al.,* 2016; Beard *et al.,* 2019). These key performance factors are physically and physiologically demanding on players, who must work extensively in both high and low-intensity activities (Virr *et al.,* 2014; Bradley *et al.,* 2020).

Backs have been found to travel more total distance at higher intensity than forwards due to the specific demands of their role in the game, combined with their more significant opportunity for open-field running (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2014; Lindsay *et al.,* 2015; Reardon *et al.,* 2016; Campbell *et al.,* 2017 Nyberg and Penpraze, 2016; Callanan *et al.,* 2021). While forwards are exposed to high volumes of physical contact and intensive non-running exertions (Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Tee and Coopoo, 2015; Grainger *et al.,* 2018).

The intermittent nature of Rugby union and the capacity to repeat specific high-intensity activities has been reported to make up approximately 15% of the game which is reported to represent crucial facets of the game, whilst approximately 85% of a game may be low-intensity (Sheppy *et al.,* 2019; Beard *et al.,* 2019). Research (Virr *et al.,* 2014; Suarez-Arrones *et al.,* 2014; Beard *et al.,* 2019; Sheppy *et al.,* 2019; Bradley *et al.,* 2020) has shown that less time is spent on high-intensity activities and more time is spent engaged in low-intensity activities for all positions. The game's intensity can also be marked by the fact that Rugby union players usually spend a considerable amount of game time between 91 and 100% of their maximum heart rate (Nyberg and Penpraze, 2016).

It would have been more appropriate to show a comparison in the demands between men and women Rugby union players. However, because of the different techniques in which these were studied, it is almost impossible to do so. Additionally, the physical and physiological demands of Rugby union players are quite extensive and studying and quantifying them has developed over the years (Cunniffe *et al.,* 2009; Virr *et al.,* 2013; Hodun *et al.,* 2016; Hoppe *et al.,* 2018; Bradley *et al.,* 2020). New and better methods have been developed, ensuring high-quality data that is helpful for the success of Rugby.

2.2.4 The assessment of the demands of Rugby union

2.2.4.1 A brief background on performance analysis

Performance analysis (PA) is the discipline of systematic observations used to enhance performance and improve decision making, primarily delivered through objective statistical and visual feedback (Bangsbo, 1994). The transition from the old PA methods to the modern ones has shown great strides towards developing PA in sports, primarily owed to the improvements and availability of computer and video technology (Lindsay *et al.,* 2015; Colomer *et al.,* 2020). Prior to the use of technology in sports, coaches used to rely on subjective recall of the actions of a game, while research has shown that, on average, athletes and coaches can only recall 30% of performance correctly (Lee, 2011), meaning 70% of the game is not recalled. The technology used in PA may now allow coaches to objectively assess the performance of each player and the team while identifying their opposition’s

strengths and weaknesses with the opportunities to exploit these in competition (Colomer *et al.,* 2020).

Recently, PA is done using improved notational analysis and biomechanical analysis, making it easier to understand and enhance tactics, techniques, and movements through the delivery of real- and lapsed-time objective feedback (O'Donoghue, 2010; Coughlan *et al.,* 2011; Quarrie *et al.,* 2013 and Cummins *et al.,* 2013). Notational analysis is a procedure that can be used in any discipline as it identifies and analyses the critical patterns and events in a performance that lead to a successful outcome (Hughes, 2004). The information used for notational analysis is usually gathered by observing a team's performance in a competitive environment and is mainly used for technical and tactical evaluation, analysis of movement, coach and player education, and performance modelling using match analysis databases (O'Donoghue, 2010). The Biomechanical analysis on the other hand allows the detail of good and poor techniques to be studied and later used to identify what and how techniques need to improve or pose a potential for injury (O'Donoghue, 2010).

The varying methods of PA include markers of physiological and psychological stress (Cunniffe *et al.,* 2010), video analysis (Deautsch *et al.,* (2007), computerised tracking systems (Lacome *et al.,* 2014) and Global Positioning System (GPS) technology (Cunniffe *et al.,* 2009). In order to optimally provide PA, manage player recovery, prepare for competition, regarding training prescription and understand the demands of a sport, the demands need to be quantified (Owen, 2015). With all the available options there are, GPS has been become a vital part of analysis in many sports, including Rugby, and will therefore be the chosen technology for analysis within the current project. The following section therefore highlights the use of GPS in Rugby union.

2.2.4.2 Global Positioning System for Rugby union use

GPS is a satellite-based navigational movement tracker technology that was initially devised for military purposes (Cummins *et al.,* 2013). This technology was further developed into portable tracking devices and was first utilized for athlete tracking in 1997 (Cummins *et al.,* 2013), to quantify players' external loads over time (Hodun *et al.,* 2016; Sheppy *et al.,* 2019; Busbridge *et al.,* 2020). For athletes' tracking, GPS

devices have been designed to collect the coordinates of an athlete using a network of earth-orbiting satellites that transmit signals to a receiver worn by the player (Mara *et al.,* 2017). The technology provides additional means for describing and understanding the spatial context of the physical activity of a player or group in a three-dimensional movement tracked over time in air-aquatic-or land-based environments (Schutz, 2000; Larsson, 2001; Gray *et al.,* 2010; Cummins *et al.,* 2013).

Wearable GPS trackers have been of great value in Rugby union settings to provide sports scientists, coaches, and trainers with comprehensive and real-time analysis of on-field activity intensity, physical and physiological load placed on players during competition or training for over a decade now (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Cummins *et al.,* 2013; Suarez-Arrones *et al.,* 2014; Hodun *et al.,* 2016; Tee *et al.,* 2016; Hoppe *et al.,* 2018; Harty *et al.,* 2019; Sheppy *et al.,* 2019; Bradley *et al.,* 2020; Busbridge *et al.,* 2020; Dubois *et al.,* 2020). By measuring player movements, GPS can be used to objectively quantify levels of exertion and physical stress on individual athletes, examine competition performances assess different positional workloads, establish training intensities, and monitor changes in player physiological demands (McLellan *et al.,* 2011).

Through using GPS, players' information on the position, speed, distance travelled, displacement, acceleration, deceleration, and impacts during training and match-play can be reported on, timely have improving the specificity and efficacy of training prescriptions (Cunniffe *et al.,* 2009; Venter *et al.,* 2010; Dwyer and Gabbin, 2012; Cummins *et al.,* 2013; Jones *et al.,* 2016; Bridgeman and Gill, 2021; Nyman and Spriet, 2021). Distance travelled is, historically, one of the first GPS variables to be monitored and thus the most reported variable (Cummins *et al.,* 2013; Bridgeman and Gill, 2021). GPS tracks changes in speed (velocity) which is determined by measuring the changes in signal frequency as the receiver moves (Cunniffe *et al.,* 2009). The player impact data can be collected through that accelerometer incorporated in the GPS device and usually provided in g force (Venter *et al.,* 2010). In addition, the number and intensity of impacts between athletes and objects or surfaces can be quantified by body load and impact measures (Cummins *et al.,* 2013). GPS technology allows for further analysis of speed and impact

characteristics by classification into six activity bands known as speed and impact zones, respectively (Cunniffe *et al.,* 2009; Cummins *et al.,* 2013; Suarez-Arrones *et al.,* 2014). Due to the use of GPS and accompanying technology the demands of Rugby union are being documented, especially since the onset of the professional era where more time is spent in the physical preparation and skill development of players (Lindsay *et al.,* 2015).

2.2.4.3 Advantages of Global Positioning System

GPS developments and application have circumvented the time-intensive challenges of video time-motion analysis (Dwyer and Gabbett, 2012). To keep up with the evolution of the Rugby union game and evolving use of technology, sports scientists have shifted from only relying on camera-based technology to wearable microtechnology devices such as GPS, that can focus on several individual players at once (Hoppe *et al.,* 2018; West *et al.,* 2019; Dubois *et al.,* 2020). Amongst multiple advantages, the ability of a portable GPS to track athlete movement simultaneously among multiple athletes and process large volumes of data quickly is very useful in intermittent running team sports like Rugby union (Cummins *et al.,* 2013). Furthermore, understanding the physical demands players experience during match-play through GPS may allow training sessions to be designed that replicate or even exceed match-play demands to enhance performance (Bridgeman and Gill, 2021). GPS data could also be used to track players' progress and identify players with the potential to play in higher-level competition, understand the differences between different age grade competitions and also to analyse the differences between competitions (Bridgeman and Gill, 2021).

Although when GPS was first introduced, its reliability and validity were primarily influenced by sample rate, velocity, game time, and the type of task (Aughey, 2011). In the last decade, wearable microtechnology sensors have emerged as a practical and reliable tool to monitor physical demands of field sport athletes (Nyman and Spriet, 2021). The outputs of the devices have, over time, had an acceptable level of accuracy, validity, and reliability for total distance travelled and peak speeds during high-intensity and intermittent activities in team sports (Venter *et al.,* 2010, Aughey, 2011; Van der berg, 2013; Yamamoto *et al.,* 2020).

The devices now not only have acceptable accuracy, validity, and reliability level, they have an improved battery life and storage capacity (Venter *et al.,* 2010; Aughey, 2011; Van der berg, 2013; Yamamoto *et al.,* 2020 Sheppy *et al.,* 2019). Additionally, data collected using GPS can now be integrated with other data from other methods such as physiological monitors to significantly expand the body of knowledge of activity in field sports (Aughey, 2011). The increased sampling rate and the improved accuracy and sensitivity of the latest GPS receivers, together with their integration with inertial measurement units have made this technology a valued resource for the assessment of team sports activity (Suarez-Arrones *et al.,* 2014). Early studies of GPS were limited to measuring movement at high speeds, however, this changed when the frequency rate got higher (Aughey, 2011; Cummins *et al.,* 2013).

Devices with frequencies of 1–15 Hz permit a valid and reliable determination of the total distance travelled (Hoppe *et al.,* 2018). However, low sample rate 1–5 Hz devices have limitations for measuring distances travelled during high-velocity runs, accelerated runs over short distances, and velocity measures, primarily when direction changes are performed (Hoppe *et al.,* 2018). While 10 Hz devices overcome most of these limitations, 15 Hz devices show no superior validity and reliability (Cummins *et al.,* 2013; Hoppe *et al.,* 2018). Further research is however still needed to determine whether a true sampling rate above 10 Hz improves the validity and reliability of GPS for measuring team sport-specific movement patterns (Malone *et al.,* 2017).

2.2.4.4 Limitations of Global Positioning System

However, as with most PA systems in sports, GPS also has its limitations. Firstly, the health implications (physical, psychological, and emotional) of wearing the devices have not yet been fully understood in how it impacts the game (Jones *et al.,* 2016). Additionally, there may be errors from analysts and subjectivity during the interpretation of the data (Cunniffe *et al.,* 2009; Jones *et al.,* 2016). The tracking means obtained provide staff with large volume of data to analyse (Dubois *et al.,* 2020); this may be difficult for some coaches with no prior experience using the technology. Working with large data sets can also be time-consuming and labour-intensive, with a need for a specialist to analyse and translate the data into meaningful information that can be used by the coaches (Jones *et al.,* 2016). During

data collection, this technology can sometimes be unable to quantify the intensity of collisions, interpret data live, and there is potential for human error (Reardon *et al.,* 2016). In some cases, GPS may not be permitted in official competition. Therefore, practitioners may be required to integrate information from the training environment with the different solutions permitted in competition (Torres-Ronder *et al.,* 2022).

2.2.4.5 Rugby union Global Positioning System's variables

The demand and interest in the information provided by GPS has gathered greater attention, with manufacturers always working to improve their systems and algorithms by incorporating new variables to satisfy the needs of their consumers (Torres-Ronda *et al.,* 2022). In Rugby union, several variables have been investigated using GPS. In this section different studies that had studied the variables relevant to the current study, provided through GPS will be covered.

a. Speed

i. Time spent in speed zones

The time spent in speed zones is defined according to this study as the number of minutes spent in each of the six different speed zones across all the training sessions observed. This variable was measured to give insights into how much time the players spent in each of the different speed zones or to see how they spent their time on the field (Suarez-Arrones *et al.,* 2012). Different researchers have studied time spent in speed zones with a few similarities amongst the studies, for example Cunniffe *et al.,* (2009), Coughlan *et al.,* (2011), Reid *et al.,* (2013) and Tee and Coopoo, (2015), all studied professional Rugby union men. While Bradley *et al.,* (2020) conducted their study on professional Rugby union women. The differences in the above studies include number of players, GPS files assessed, and games observed. Cunniffe *et al.,* and Coughlan et al (2011) conducted their studies each on two players, and over one competitive game, Reid *et al.,* (2013) conducted their study on eight players, over one game, Tee and Coopoo, (2015) studied 19 players over the duration of the 2013 Rugby season and Bradley *et al.,* (2020) conducted their study on 129 players over 14 games.

Although all the other researchers employed similar speeds ranges of six to categorise the time spent in the speed zones, Tee and Coopoo, (2015) only split their speed zones into four instead of six. Cunniffe *et al.,* (2009), Coughlan *et al.,* (2011), Reid *et al.,* (2013), Tee and Coopoo, 2015 and Bradley *et al.,* (2020) discovered that time spent in speed zones decreased as speed zones increased from low intensity to high intensity for all players. Additionally, the majority of playing time was spent standing and walking for all studies, while the least amount of time was spent on the higher intensity movements. This shows that although there were differences and similarities between the studies the research is unanimous in the finding that the time spent in speed zones decreases as the speed zones increase from the slowest to the fasted speed zone.

ii. Maximum speed

Rugby union players achieve varying maximum speeds during match-play when grouped by positional groups (Owen, 2019), and this variable plays a vital role in defining a team's success (Busbridge *et al.,* 2020). Maximum speed is defined as the fastest recorded speed at which a player travels over a given period (Owen, 2019). Across all Rugby playing positions, players are required to repeatedly reproduce maximal sprints of short duration, interspersed with brief recovery periods over the duration of a match (Hene, 2011; Tee and Coopoo, 2015). Several authors have investigated maximum speeds, with most research finding that forwards reached slower maximum speeds compared to backs (Coughlan *et al.,* 2011; Suarez-Arroness *et al.,* 2012; Portillo *et al.,* 2014; Tee and Coopoo, 2015; Busbridge *et al.,* 2020; Bradley *et al.,* 2020). While Cunniffe *et al.,* (2009), Reid *et al.,* (2013) and Suarez-Arrones *et al.,* (2013) found that there were no significant differences in the maximum speeds reached between forwards and backs.

Specifically, previous studies gathered the following information, Cunniffe *et al.,* (2009) forwards reached 26.3 km/h and backs reached 28.7km/h, Coughlan *et al.,* (2011), forwards recorded 26.1 km/h while backs recorded 30.8 km/h, Suarez Arrones *et al.,* (2012), forwards and backs' maximum speeds were 24.6 km/h and 28.2 km/h respectively. Reid *et al.,* (2013) on the other hand discovered that forwards reached maximum speeds of 25 km/h while backs reached 28 km/h across ss a single professional Rugby union game. In a study by Portillo *et al.,* (2014), 22

professional under-19 Rugby union players participated in two training sessions and one game, where the maximum speeds reached for forwards and backs were 24.9 km/h and 29.3 km/h respectively. Maximum speeds of a South African professional Rugby union team were studied by Tee and Coopoo, (2015) and from the study it was reported that forwards reached 27.4 km/h and backs reached 31.7 km/h over the 2013 Rugby union season.

Although GPS studies are not popular in women's Rugby union, the growth in the participation of women's Rugby union has seen the rise of a few studies that are starting to explore the movement demands of women's Rugby union. Suarez-Arrones *et al.,* (2013) conducted a GPS study on nine Spanish national team women in one game and found that their maximum speeds reached were 22 km/h and 24.4 km/h for forwards and backs respectively. Recently Busbridge *et al.,* (2020) conducted their study on 20 Spanish national team over seven games and found significant differences in the maximum speeds reached by forwards (22 km/h) and backs (26 km/h). Another women's study by Bradley *et al.,* (2020) also found significant differences in the maximum speeds reached between forwards (20.5 km.h) and backs (23.2 km/h). Evidently, from the findings of the different studies conducted under different contexts, forwards reach lower maximum speeds when compared to backline players.

b. Total distance travelled

In Rugby union, GPS has been used extensively to establish movement patterns such as total distance travelled on the field during match-play of men's Rugby union players (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Reid *et al.,* 2013; Portillo *et al.,* 2014; Campbell *et al.,* 2017; Yamamoto *et al.,* 2019;) and women's Rugby union players (Suarez-Arrones *et al.,* 2014; Sheppy *et al.,* 2019; Busbridge *et al.,* 2020; Bradley *et al.,* 2020; Callanan *et al.,* 2021). The analysis of total distance travelled in men's and women's Rugby during match-play reveals that players travel between 5000 m to 7000 m. Campbell *et al.,* conducted a study comparing physical demands during match-play and training, from the study it was reported that total distance travelled during match-play is higher than total distance travelled in training.

Different studies have found that backs travel greater distances compared to forwards (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Suarez-Arrones *et al.,* 2014; Campbell *et al.,* 2017; Yamamoto *et al.,* 2019; Callanan *et al.,* 2021). However, this trend is disputed by Bradley *et al.,* 2020; and Busbridge *et al.,* 2020) who conducted their studies on women's Rugby and found that there were no significant differences in the total distance travelled between forwards and backs during match-play. Tee and Coopoo, (2015) who conducted their study on men's Rugby also found no significant differences between forwards and backs. The different findings may be explained by the fact that these studies are conducted on different players, in different environments.

c. Number of impacts in impact zones

GPS developments have resulted in some devices being able to be linked or contain in-built microsensors which might contain accelerometers, gyroscopes and magnetometers responsible for determining more specific variables such as the number and severity of impacts (Owen, 2019). For this study, the number of impacts in impact zones is defined as the total number of impacts encountered by players in various impact zones. Several studies have explored the number or impacts using GPS (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Suarez-Arrones *et al.,* 2014; Tee and Coopoo, 2015; Grainger *et al.,* 2018; Yamamoto *et al.,* 2019). The general agreement from the above studies was that the number of impacts decrease as the impact zones increase. Studies such as Coughlan *et al.,* (2011), Suarez-Arrones *et al.,* (2013), Tee and Coopoo, (2015), Owen *et al.,* (2015) and Yamamoto *et al.,* (2019) found no significant differences between the number of impacts sustained by forwards and backs across all impact zones. Cunniffe *et al.,* (2009), Suarez-Arrones *et al.,* (2012) and Grainger *et al.,* (2018) did however find significant differences between forwards and backs for some impact zones. These differences were mostly due to the higher number of impacts sustained by forward players.

d. Heart rate

Researchers have used measurements of physiological parameters such as heart rate (Deutsch *et al.,* 1998), to establish the physiological response, aerobic-based

adaptation and fatigue status (Schneider *et al.,* 2018). Heart rate is not a GPS variable, however the measurement a heart rate sensor can be incorporated into GPS technology where it is simultaneously measured with the physical variables of GPS such as total distance travelled and speed. Therefore, because heart rate is one of this study's variables the GPS studies that studied it will be included in this section. Campbell et al (2018) compared heart rate responses between match-play and training, in the study it was discovered that heart rate responses during match play were higher than training. Suarez-Arrones *et al.,* (2013) found that the average heart rate for women's Rugby union players during match-play was 161.4 bpm. The study of Cunniffe *et al.,* (2009) which investigated the heart rate responses of two Rugby union men found that the forward player recorded 170 bpm while the backline player recorded 172 bpm. Portillo *et al.,* (2014) studied the heart rate of under-19 men's Rugby union players and from the study it was found that the average heart rate of forwards and backs was 157,6 and 155, 9 bpm respectively.

2.3 Summary

Since the professionalisation of Rugby Union, the game has evolved as a dynamic field-based contact sport played by men and women at all ages and levels (Coughlan *et al.,* 2011). The requirements for playing professional Rugby Union and developing successful teams include technical skill acquisition and physical conditioning. The increasing physical nature of the game has placed significant importance on coaching staff, sport scientists, sports medicine staff and researchers to develop injury prevention and management strategies. Consequently, most popular in men's professional clubs and national teams the latest technology in the monitoring and evaluation of the physical demands of training and match-play have been integrated, pursuing optimal player performance in gaining advantage over competitors and achieving success.

Unfortunately, with regards to women's Rugby there is still a huge lack of scientific evidence-based literature conducted on the demands these players face in the field during training and match-play. Scientific evidence-based literature that has been conducted on men's Rugby union players has shown that through scientific research, performance of players can be improved. Currently men's Rugby union literature agrees that the sport of Rugby union places different demands on different positions

(forwards and backs) of Rugby union depending on the roles and responsibilities of that position. However, this is not a field that has been explored fully for women's Rugby, hence the aims of the current study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The hypotheses upon which these methods are based can be found in Chapter 1 on pages 5-7. As a result of the lack of documented on-field demands in women's Rugby union globally, the current study's primary aim was to investigate and quantify the physical and physiological training demands of women Rugby union players from the Sarah Baartman District, South Africa. Players were categorized according to the two broad playing categories, known as forwards and backs (Duthie *et al.,* 2003), allowing for the comparison of the training demands data obtained between forwards and backs.

It should be noted that in trying to obtain as much data as possible, the initial intention of this study was to collect quantified physical and physiological data for both training and match-play in the Sarah Baartman district of the Eastern Cape province of South Africa. Data collection for the study commenced on 11 May of 2021 of pre-season training data. However, because of the rise in COVID-19 infections around the district, the management of the sub-union decided to stop training and competition immediately from 8 June 2021. Subsequently, on 29 June 2021, SARU announced that all sub-unions must halt all forms of club and amateur Rugby under the national union (Sport24, 29 June 2021). As of 11 July 2021, the South African government also followed with updated regulations prohibiting professional and non-professional matches for all national sports (South African government, 11 July 2021). Consequently, data could only be collected for a period of five weeks, from 17 May 2021 to 07 June 2021 as the club participating in the study could not participate in any match play beyond these dates.

Furthermore, from the five weeks of experimentation, the first week was used for habituation, meaning collected and included data was only four weeks' worth of comprehensive training data. Although this was not ideal and it is acknowledged that this has a significant impact on the data collected and the ability to compare match data to training data, the circumstances were out of the researcher's control. Additionally, significant financial constraints have meant that it was not feasible to delay data collection for a further year as the researcher was required to take up

employment during 2022 and to study part-time in the evenings. Therefore, only a total of 4 weeks of training data are presented in the current study.

This chapter, it will detail the design and the procedures that were taken to achieve the aims of the study. It will start with the study design employed, followed by the selection of independent and dependent variables, the ethical aspects, participant characteristics, including the inclusion and exclusion criteria that were used to select participants, details on the equipment used, explicit data collection procedures, and lastly the statistical analysis methods used. Lastly, this chapter will then conclude with a summary of the study's research methodology.

3.2 Design of the study

The current study used an exploratory, descriptive, observational, and comparative research design (Hene, 2011, Suarez-Arrones *et al.,* 2014, Sheppy *et al.,* 2019). During the study, training physical and physiological demands of amateur women's Rugby union players were investigated and quantified. The study was exploratory in nature because to date, no research has been conducted on the physical and physiological demands of amateur women's Rugby union players in Eastern Cape, South Africa. Secondly, this study used modern technology available in GPS and Zephyr technology (remote physiological monitoring device) to describe the demands amateur women's Rugby players experience on the field during training. Thirdly, the study was observational because no attempt was made to influence players' responses to training or performance. Lastly, as the secondary aim of the study stated, the study compared the training demands between forward and backline players to see whether there were any differences between these two playing categories of players.

3.3 Selection of study variables

Rugby union is an intermittent sport; meaning that a lot of variables change irregularly and can affect the outcome of the game (Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2012). Several variables, such as the number of players and venue can be controlled, but other variables such as environmental conditions and injuries cannot (Jones *et al.,* 2015, Busbridge *et al.,* 2020). Therefore, to design the current

study as rigorously as possible, the following independent, controlled, confounding, and dependent variables were considered in the experimental design.

3.3.1 Independent variables

Previous research (Cunniffe *et al.,* 2009, Cummins *et al.,* 2013; Suarez *et al.,* 2014; Sheppy *et al.,* 2019; Bradley *et al.,* 2020) has shown that forward, and backline players come across different demands on the field during match play. Hence, they must be provided with varying training regimes unique to their playing categories (Sheppy *et al.,* 2019, Bradley *et al.,* 2020). Therefore, an important independent variable of interest for the current study was playing position. The data collected for this study's forwards and backs were compared across all the various dependent variables collected, to explore the potential differences between the training loads within this cohort of players.

3.3.2 Dependent variables

Multiple factors cause overtraining, undertraining, and injuries; however, research has identified poor workload management as one of the major contributors (Gazzano, 2019). With the current advanced technology available, the workload imposed on players during training and competition can be understood much better than it was two decades ago (Colomer *et al.,* 2020). To evaluate the training workload of amateur Rugby union women players, the following dependent variables were selected based on the resources and equipment available for the study and the previous research (Suarez-Arrones *et al.,* 2014, Sheppy *et al.,* 2019, Bradley *et al.,* 2020, Busbridge *et al.,* 2020).

3.3.2.1 Demographic and anthropometric variables

The purpose of measuring these data was first to understand the physical attributes of the participants and establish the demographic and anthropometric characteristics of amateur women’s Rugby union players from the Sarah Baartman District, Eastern Cape, South Africa. Secondly, these variables were recorded to compare forwards versus backs’ demographic and anthropometric characteristics.

a. Age (years) – was recorded to understand the age group in amateur women's Rugby union community Rugby in the Sarah Baartman District, Eastern Cape, South Africa.

b. Body mass (kg) – was measured using a KRUPS scale to understand the body mass, in amateur women's Rugby union players.

c. Stature (m) –was measured using an inhouse portable stadiometer to provide insights into the stature of the players from this study's participants and their specific context.

3.3.2.2 Physical variables

When the physical demands applied to the player exceeds the player's capacity, the risk of injury increases (Soligard *et al.,* 2016). To optimize performance and decrease the risk of injuries, an understanding of the physical demands such as total distance travelled, speed, and player impacts are needed. Hence, this study investigated and quantified four different physical variables.

a. Speed

i. **Time spent in speed zones (mins)**

For this study, the speed zones were categorized identically to Suarez-Arrones *et al*. (2012) and were as follows; speed zone 1: standing or walking 0.0–5.9 km/h, speed zone 2: jogging 6.0-11.9 km/h, speed zone 3: running at low intensity 12.0-13.9 km/h, speed zone 4: medium intensity 14.0-17.9 km/h, speed zone 5: high intensity 18.0-19.9 km/h and speed zone 6: sprinting 20.0+ km/h. Speed zone 1 indicated the lowest level of effort, with zones incrementally increasing in speed until speed zone 6, which described the highest level of effort. Allocations of speed zones were those considered to be typical of varying locomotor categories during intermittent team sport (Suarez-Arrones *et al.,* 2012). Data were organized from the lowest to the highest speed so that the order of the speed zones from the lowest to the highest could be categorized for each training session and participant's data set. These data sets were paired with the time column and from there, the seconds or minutes were obtained for each speed zone. The average time spent at each speed zone from all training sessions and players for the different positions were then organized and recorded for data analysis**.**

ii. **Maximum speed (km/h)**

The obtained data were organized from the lowest to the highest speed, after which the highest value was recorded from all sessions and participants. An average maximum speed was calculated for both playing categories and used for the data analysis part of the study.

b. Total distance travelled (km)

The total distance travelled was obtained by taking the last value of total distance travelled recorded on the excel sheet used to organize the data. From all sessions, these values were collected for each participant and an average was calculated. The data was the presented according to all players, forwards, and backs.

c. Number of impacts in impact zones (n and g)

The number and intensity of impacts were gathered from accelerometer data and expressed as *g*-forces. The impact zones were categorized into six different zones, like Cunniffe *et al.* (2009) and Suarez-Arrones *et al.* (2014), and were as follows, impact zone 1: 5–6g: light impact, impact zone 2: 6–6.5g: light to moderate impact, impact zone 3: 6.5–7g: moderate to heavy impact, impact zone 4: 7–8g: heavy impact, impact zone 5: 8–10g: very heavy impact, and impact zone 6: 10+g: severe impact. Impact zone 1 indicates the lowest impact intensity, with zones incrementally increasing in intensity until impact zone 6, which describes the highest impact intensity. The player impact data was organized from the lowest to the highest impact zones. This was so that the order of impact zones could be easily tallied and extracted. Data containing impacts that were less than 5g were all excluded from the set as the scaling system only started from 5g. The frequency of impacts from each impact zone was summed up/added to calculate the total number of impacts for each impact zone.

3.3.4.3 Physiological variable

The most common physiological response (heart rate) as studied by several other Rugby union researchers (Cunniffe *et al.,* 2009; Smit, 2012; Virr *et al.,* 2014; Suarez-Arrones *et al.,* 2014; Nakamura *et al.,* 2016) was also included in the current study. This was done to provide insights on the heart rate responses that amateur women from Rugby union experience on the field during training.

a. Heart rate (bpm)

During data collection, measurements for heart rate were recorded every second for each participant in every training session. The heart rate responses were recorded using a BioHarness chest strap (figure 3) that contained a heart rate sensor that attaches directly on the skin, on the left-hand side of the participant's chest. The transmitting device intercepts heart rate signals from a heart rate monitor chest strap. The signal is received through an antenna connected to a computer (PC), where a digital reading of the heart rate of the participants can be seen.

Data collected for the demographic and anthropometric, physical, and physiological variables were transferred to an Excel spreadsheet for appropriate organisation and analysis. Only the data collected from when the participants were on the field (warming up and training) were analysed; data collected before and beyond field time from all sessions were discarded (Bradley *et al.,* 2020). This was to ensure that data from when the participants were off the field before and after training was not included in the data analysis.

3.3.3 Controlled variables

The controlled variables of the study were gender, age range and injury status. Due to the exploratory nature of the study aimed at women's Rugby union players, the study allowed only women as participants so that the data collected from the study could add to the little and much-needed knowledge on women's Rugby union. The age range included in the study was similar but not exclusive/limited to that mostly found in club Rugby which is commonly defined by players between the ages of 18 to '30s (Virr *et al.,* 2014). This age range was selected to paint the picture of the age range found in this type of context as realistically as possible.

The participants had to have had no recent injuries and have no symptoms or be infected with COVID-19 to ensure that they performed at their optimum levels. Therefore, players that were recently injured or had symptoms of illness that negatively affected their performance were excluded from participating in the study. Lastly, as per the equipment manufacturer's instructions, players with pacemakers were not allowed as participants in this study as the equipment used does not permit

(Zephyr technology, 2014). All this information was communicated to all players before participating in the study.

3.3.4 Confounding variables

Rugby union is an unpredictable sport, and the following variables could not be controlled or, in some cases, planned for; however, they could have affected the data collection process and sometimes the study's outcomes. Such variables included training environment, players' social and lifestyle, injuries, availability, and attitude to training (Baric and Bucik, 2009; Kruger and Smit, 2012). With regards to the players' social and lifestyle, it was common that because of their working hours, training often started later than scheduled, this was mainly because of commuting to the training field.

During the training sessions, six players withdrew from the study because of reasons such as minor injuries, moving towns and academic commitments. However, because the number of participants was initially 24 when the six participants pulled out from the study a total of 18 participants were still available to continue with the data collection. There was a positive availability and attitude from players towards training, the researchers had no difficulties as players always showed up.

3.4 Ethical aspects

The current study was approved on the 5th of May 2021 by the Rhodes University Ethical Standards Committee for human research (reference number: 3845, APPENDIX B). Before data collection, the student researcher through the Human Kinetics and Ergonomics department at Rhodes University met virtually with the chairperson of the Southern Eastern District Rugby Sub-Union (SEDRU) to recruit participants and verbally explain the aims and objectives of the study. This meeting was to obtain gatekeeper permission to identify and to recruit a club to participate in the study. The chairperson granted permission (APPENDIX C) for the researcher to approach one of the two existing clubs available in the district to participate in the study. The assigned club's management contacted the student researcher showing keenness to take part in the study. Subsequently, the aims and objectives of the study were explained to them while verbally requesting consent for their participation.

On 10 May 2021, a meeting was held between the research team, club's management, and players where all the potential volunteering participants were verbally informed about the purpose of the study, procedures, participant characteristics, risks and benefits, anonymity, and confidentiality of the data collected. Each player read and signed their copy of the "letter to participants and informed consent forms" (APPENDIX D) and provided written consent if they were willing to participate in the study. It was emphasized to the participants that should they wish to withdraw from the study for any reason; there will be no negative consequences. Should they wish to access their data for personal development, they will be allowed to do so. Participants were also allowed to ask questions or raise any concerns related to the study whenever they felt the need.

Due to the COVID-19 pandemic at the time of data collection, it was also essential to take the regulations from the South African government and World Rugby into account for the study. Therefore, throughout data collection, the research team strictly followed the COVID-19 protocols (APPENDIX D) published by World Rugby; they acted professionally and treated the participants and coaching staff respectfully.

3.4.1 Selection and context of selected Rugby union club

Context is an important component to building an understanding of women's Rugby in the Eastern Cape and to explain the shortage of women's Rugby union clubs in the Sarah Baartman region of the Eastern Cape. The participants for this study were recruited through one of the Eastern Cape's two sub-unions, SEDRU. This sub-union was formed in 1972 to promote Rugby union in the Black community and create an active and healthy community. The sub-union's affiliates are all situated in the Sarah-Bartman District, which includes Makhanda (where the research team and Rhodes University are from), Port Alfred (where the participants train), Alicedale, Alexandria, and Klipfontein (Figure 2).

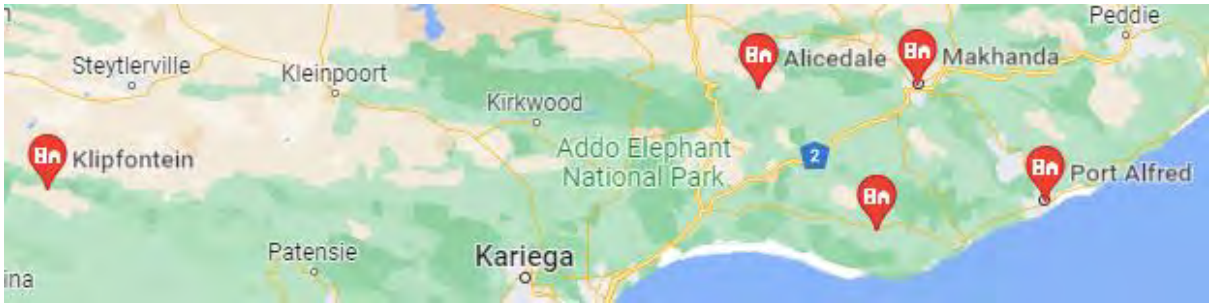

Figure 2: Map of towns/regions affiliated with SEDRU. (adapted from: https://www.google.co.za/maps/@-33.5864352,25.4899715,9z/data=!4m3!11m2!2svDCBeHaXSJu5-szPLy0e9Q!3e3?hl=en)

Participants were from a newly formed Rugby union club called Vixens, from a neighbouring town called Port Alfred, approximately 58 kilometres from Rhodes University in Makhanda. The research team consisted of the primary researcher and one research assistant who was the designated driver, who assisted in collecting data and unpacking and packing up the equipment before and after training. The team travelled approximately an hour from Rhodes University in Makhanda to the Station Hill stadium in Port Alfred three days a week at 17:00 to be ready for training after 18:00 due to the participants' work commitments. When the research team would get to the stadium, they would set up and sometimes wait for latecomers who would have been delayed from work or public transport. Training took 1 hour to 1 hour and 30 minutes each day. After training was completed, researchers would pack up all relevant equipment, leave the stadium (training ground) around 20:00 and get home around 21:00.

The South African context is unique because numerous political or economic factors may impact training schedules and data collection. For example, some days, because of the service-provision protests, and load-shedding that were happening in the country at the time, training would either start late or cancelled. Load-shedding is a way to distribute demand for electrical power across multiple power sources, it is used to relieve stress on a primary energy source when the demand for electricity is greater than the primary power source can supply (Courtemanche, 2016). As a result, training would sometimes be affected cancelling or starting training later that the set start time. Additionally, because it was in winter, and it would get dark earlier, load-shedding would affect training as it made it difficult to train with no lights.

3.5 Participants

A sample of convenience was chosen for the current study, this is because the amateur women's Rugby union club in Port Alfred, South Africa, was the only club in the region and closest club from Rhodes University where the researchers were from. A team of Rugby union consists of 15 positions; hence this was the minimum sample size for the study. Out of 24 participants who initially showed interest in taking part in the study, at the end there was a total sample of 18 (8 forwards and ten backs) women's Rugby union players between 18 and 36 years old. It must be noted that not all 18 participants were assessed on the same session, because of shortage in equipment they alternated. The number of participants decreased by six withdrawals due to several reasons such as going back to school, academic examinations, and work and social commitments other than Rugby.

3.5.1 Inclusion and exclusion criteria

The players had to be attending or willing to train with the Vixens Rugby union club in Port Alfred, South Africa. Additionally, the participants in the study had to be women as this was a strictly women's study. The players had to be in a COVID-19-free, non-injured state so that they were able to train optimally. Because of the use of bio-modules used to collect heart rate information, players who had pacemakers or automatic defibrillators were not allowed to take part in the study for medical reasons (Zephyr technology, 2014). Additionally, players with pre-existing skin irritation or trauma in the chest strap area could not participate (Zephyr technology, 2014). Lastly, players' data were excluded if the player was not on the field, or the recording devices did not record data on them for at least 45 minutes of each training session.

3.6 Data collection instruments

Below are the instruments, together with COVID-19 protocols and instrumentation in the collection of the study's demographic and anthropometric, physiological, and physical demands data.

3.6.1 COVID-19 preventive instruments

Information on the COVID-19 protocols for safe return to Rugby training and competitions was adapted from the World Rugby website (Falvey *et al.,* 2020. Below is a list of all the relevant equipment used for the study for COVID-19 adherence.

- **Disposable gloves** – These were used when handling equipment and assisting participants in wearing and taking off the vests.
- **Hand sanitizer** – This was used when handing over and taking back the vests and devices to the participants.
- **Disinfecting wipes** – These were used to wipe down the equipment after every training session.
- **Disposable face masks** – These were always worn by the research team when interacting with the participants.

3.6.2 Demographic and anthropometric data collection instruments

The following equipment was needed to collect the participants' demographic and anthropometric variables for the study. A KRUPS portable scale was used to measure the participants' body mass to the first decimal place. Secondly, an in-house-built portable stadiometer was used to measure the stature of the participants to two decimal places. A clipboard, recording sheet, and pen to record the participants' age (years), body mass (kg), and stature (m).

3.6.3 Physical and Physiological data collection instruments

Zephyr technology performance system devices paired with the GPS XT 10Hz unit devices were used to collect physiological and movement data. The Zephyr technology is compatible with the GPS device and can support GPS data transmission and storage through Bluetooth. The system is comprised of the following components:

1. **BioHarnessTM chest straps -** contain the heart rate sensor and are used to attach the module containing the accelerometer. The strap is worn so that the heart rate sensor is directly placed on the player's left side of the chest to measure heart rate accurately. The straps were available in three sizes: small, medium, and large.

2. **BioHarnessTM 3.0 ECHO modules -** This device was used to store and transmit heart rate and accelerometer data. The device collects and transmits measurements captured during standing and rigorous activity for heart rate and impacts (Zephyr technology, 2014).

3. **ZephyrTM ECHO gateway -** This was connected to the computer as a wireless receiver device for information transmitted from the bio harness module and GPS device.

4. **USB connector –** Personal computer (PC) hardware and ECHO gateway connection for data transfer.

5. **PC platform –** An HP ProBook 4540s Notebook PC was used for data visualization, organization, and analysis.

6. **OmniSense software -** Used for the storage and visual data display.

7. **Heart Rate (ECG) sensor locations -** Record heart rate between 25-240bt/min. heart rate was measured using the bio-harness chest strap, which can receive and record the heart rate signal transmitted from a heart rate sensor (Zephyr Technology, 2014).

8. **Breathing sensor location –** Used to record breathing rate.

9. **The device's accelerometer -** Used to record the participant's impact data.

10. **ZephyrTM compression shirts –** There were three different sizes (small, medium, and large) that the participants could choose from based on their body sizes. The vests were used to keep the GPS device safe and ensure it was permanently attached to the player's body whilst training, as they had a small pocket at the back between the left and right scapulae.

11. **Qstarz GPS XT 10Hz unit device**– Used for movement tracking of each player, records distance and speed. To date, no validity and reliability studies have been done on GPS technology.

12. **Notepad and pen** – were used to record players' daily information and notes on activities in that session.

Figure 3: Instrumentation used to collect physical and physiological data. (adapted from: *https://www.zephyranywhere.com/media/download/psm-training-user-guide.pdf*)

3.7 Data collection procedures

Before collecting demographic and anthropometric, physical, and physiological data, informed consent was obtained from the chairperson of the Sub-Union (APPENDIX C), the team's management, and the participants (APPENDIX D). After obtaining informed consent from the participants, data collection, which consisted of two consecutive phases, commenced. The first phase, intended for habituation, demographic and anthropometric data collection, and the equipment familiarisation, was started on 11 May 2021. The first meeting of this phase of the study, like all the meetings between the researchers and the participants, was held at the clubs' home field hall (Station Hill Stadium, Port Alfred). This is where the team had all their meetings and training sessions from Monday to Thursday of every week. The research team went to the stadium three times a week (Monday to Wednesday) because of financial constraints with regards to travelling and availability of the driver (research assistant) who also had academic commitments.

The demographic and anthropometric data (age, body mass, and stature) were collected during this habituation session The researchers started by welcoming and reminding the participants of what the purposes of the study were and that they could withdraw from the study at any time. This was followed by measuring and recording body mass, stature, and age. One researcher was responsible for measurements, while the other was the scribe recording the measurements on a data collection sheet. When measuring body mass, the participants were required to take off their shoes and jackets, stand upright on the KRUPS scale with their arms hanging on the sides, palms facing forward, and faces looking straight forward. For the measurement of stature, the stadiometer used was designed in a way that one researcher had to support it by pinning it against a straight wall to make sure it does not move forward when measuring the stature of a participant. Participants had to stand upright with their backs and heels touching against the wall where the measurements were being taken, arms on the sides, palms facing forward, and heads looking straight forward. The researcher would adjust the head plate for each participant to ensure an accurate reading. After body mass and stature were measured and recorded, each participant proceeded to tell their age to the scribe with all data recorded on a physical data collection sheet (APPENDIX E).

On 12 May 2021, the last meeting of phase one was held. Here the players were shown how the equipment used in the study is operated, including the BioHarnessTM 3.0 ECHO module, BioHarnessTM chest strap, ZephyrTM compression shirt, and Qstarz GPS XT 10Hz unit device. The session intended to allow them to practice how and when to switch the devices on and off, attach and detach the devices in their designated compartments, and take care of them. For further details, a short video (Hoosier Sports Report, 11 January 2017) was sent to the team's WhatsApp group chat demonstrating this information. This allowed the participants to familiarize themselves with how to operate the equipment and to help prevent the research team from touching the participants unnecessarily due to COVID-19 protocols. Additionally, the participants practiced with the equipment that day to become familiar with the equipment. Although this part was not intended for the actual data collection, it was important for the participants to familiarise themselves with the equipment before the study's second phase started.

The study's second phase for data collection of the physical and physiological demands started on 17 May 2021. When the researchers arrived at the stadium, they would lay out the equipment as a set/package for each participant. Each package consisted of a BioHarnessTM 3.0 ECHO module, BioHarnessTM chest strap, ZephyrTM compression shirt, and Qstarz GPS XT 10Hz unit device. These components were all uniquely coded so that the researchers knew which component went with them. As a result of having only seven ZephyrTM compression shirts coming in only three sizes (small, medium, and large), the researcher could only collect data on seven participants per session (APPENDIX F).

The seven participants scheduled to be monitored on each session were chosen according to playing categories, t-shirt and chest strap sizes available and based on the availability of participants that made it to training for each session (Table 3, APPENDIX F). In cases where the participants' bodies were smaller, and the BioHarnessTM chest straps (small, medium, and large) were a little bit big for the participants, an adhesive tape was used to secure the BioHarnessTM chest straps to the participant's body to make sure they do not become loose whilst on the field resulting in the participants being called out off the field to reattach them.

Table 3: Summarised training session schedule.

Pseudonym	**17/05**	**18/05**	**19/05**	**24/05**	**25/05**	**26/05**	**31/05**	**01/06**	**02/06**	**07/06**	**08/06**	**09/06**
Dark Green17	X	X	X									
Dark Green24				X	X	X						
Dark Green31							X		X	X		
Light Green17	X	X	X									
Light Green24				X	X	X						
Light Green31							X		X	X		
Yellow17	ER	X	A									
Yellow24				X	X	X						
Yellow31							X		X	X		
Red17	X	X	A									
Red24				X	X	X						
Red31							X		X	X		
Pink17	ER	X	A									
Pink24				X	X	X						
Pink31							X		X	X		
Orange17	X	ER	ER				X		X	A		
Orange24				X	X	X						
White17	ER	ER	ER	X	X	X	X		X	X		

X: Successful data collection, ER: Error in data collection, A: Absent for data collection, : No data collection.

Two to seven participants were monitored daily (Table 3), two participants were monitored only when other participants scheduled for the day did not show up, and seven participants would be monitored when all participants from the schedule showed up to training that day. The same group of participants was monitored together each week; this was done to minimize sharing of equipment before it was washed over the weekend and to ensure there was no mixing up of devices. Participants used the same set of uniquely coded equipment assigned each week to avoid inter-unit errors (Owen, 2019). As mentioned, to prevent different participants from using the same equipment before it was washed, if a participant did not show up, the equipment was not utilized by other participants; hence some days, only two participants were monitored.

When the researchers and participants arrived for practice, they were required to sanitize their hands, do a temperature check, and sign in for the club's protocol for COVID-19 regulations. Whoever was being monitored for that session would get their correctly sized and paired set of equipment. The participants would then go into the changing room, take off their shirts, secure the BioHarnessTM 3.0 ECHO module to the attachment space of the BioHarnessTM chest strap, wear the chest strap, secure it with tape if they needed to, secure the GPS device into the GPS vest's pocket located at the middle top part of the back of the vest, lastly, they would put the ZephyrTM compression shirt on.

The researchers would then check if the BioHarnessTM 3.0 ECHO module was working by powering the device on by depressing the front of the device, ensuring the heart rate's conductive pads were tight on the chest, and ensuring the device was detecting the heart rate signal. Following that, they would check if the Qstarz GPS XT 10Hz unit device was powered on and whether the device was recording at 10Hz. Lastly, they would check whether each device was showing on the live software of the computer by checking the designated slots on the software.

The participants would then go on to start with training which would start with a warm-up, followed by the workout of the day planned by the coaching staff (both included in the data analysis). The researchers sat on the side of the field to observe and monitor if all devices were still showing GPS, heart rate, and impact activity on the computer's software whilst also taking notes on the data collection sheet

regarding the type of training conducted and noting any injuries. Once training was over, the participants would switch off the devices to avoid recording unwanted data, then go into the changing rooms to take off the equipment and hand it over to the researchers. The equipment was wiped down and packed away. When phase two of the data collection ended, the data collected was extracted from the Zephyr OmniSense software, compiled in Microsoft Excel, and analyzed using different statistical tools mentioned below.

3.8 Statistical analysis

During data collection, the Zephyr OmniSense application software was used for data analysing, interpreting, and visualizing. This software enables end-to-end physiological and biomechanical load monitoring and analysis before, during, and after activities in real-time, anytime, and anywhere (Zephyr technology, 2014). After data collection of the physical and physiological demands, the files containing the data were downloaded from the software for storage in the Human Kinetics and Ergonomics, Rhodes University department's password-protected computer (HP ProBook 4540s notebook), as well as the student's online back-up through password-protected OneDrive cloud-based software to which only the researcher had access. Data were trimmed to remove unwanted data, then organized and summarised according to the whole sample, forwards, and backs. The data were described using Microsoft Excel using descriptive statistics (mean, standard deviation, and coefficient of variation).

Statistical analysis methods including the independent t-test, 1-way, and 2-way ANOVAs were used to analyse the data and check for differences between the two playing categories. A General linear model 2-way ANOVA through STATISTICA was used for statistical analysis of the time spent at different zones and impact data, followed by Fisher's Least Significant Difference (LSD) for post hoc testing to see precisely where the difference lay if there were any. The significance level was set at 95% ($P < 0.05$), with the symbols, ^{*abcdef} used to highlight significant differences in figures and tables.

3.9 Summary

This exploratory, descriptive, and observational study attempted to investigate and quantify the physical and physiological training demands of women's Rugby union players from the Sarah Baartman District, South Africa. This study had a comparative aspect in which the secondary aim of the study attempted to compare the training demands data obtained between forwards and backs. For the first phase of the study, demographic and anthropometric data were collected to inform the participants characteristics. Following that, GPS technology was used to collect the physical data of the study which included total distance travelled, maximum speed, time spent in speed zones and number of impacts in impact zones. Furthermore, Zephyr technology was also used to collect the physiological data aspect of the study, which only included heart rate data. The data collected from the study was organised and analysed using various statistical tools such as descriptive, Microsoft Excel, ANOVA etc. The following chapter called "Results" contains a presentation and analysis of data.

CHAPTER FOUR: RESULTS

4.1 Introduction

Chapter four of the current study contains a clear and comprehensive presentation of the results from the data collection conducted in chapter three above. The data are presented as descriptive and inferential statistics to highlight the demands experienced by players and to explore the differences between the forward and backline players. Similarly, to the previous chapter, the demographic and anthropometric variables are presented first, followed by the data collected on the physical variables which include speed (time spent in speed zones and maximum speed), total distance travelled, and the number of impacts in impact zones. Lastly, are the participants' physiological data collected on heart rate responses during amateur Rugby union training sessions. The current chapter then ends off with a summary of the overall study's findings.

4.2 Demographic and Anthropometric variables

18 out of 24 amateur women's Rugby union players from the Sarah Baartman District, Eastern Cape, South Africa, voluntarily participated in this study. The participants consisted of eight forward and ten backline players. Due to the relatively small sample size, it was deemed unnecessary to break down the playing positions further than forwards and backs (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2014). Furthermore, this allowed for the second aim of the study to be investigated (i.e., a comparison of forwards and backline players).

Table 4 details the participants' demographic and anthropometric characteristics, which include age, body mass, and stature. The table shows the overall data for the 18 players combined (i.e. forwards and backs together) as well as for just forwards and backs. When analysing the combined forward and backline players' data their averaged age equated to 25,44 years, the body mass was 68,7 kg, while stature was 1,60 meters. There was greater variability in age and body mass than for stature which had a very low coefficient of variation ranging between 2,01 and 4,11%.

Table 4: Rugby union player' demographic and anthropometric characteristics.

Positions	Age (years)	Body mass (kg)	Stature (m)
All players (n=18)	25,44 ±5,65 (22,20%)	68,7 ±14,3 (20,8%)	1,60 ±0,06 (3,62%)
Forwards (n=8)	23,38 ±5,42 (23,20%)	82,0 ±9,4 (11,4%) *	1,63 ±0,03 (2,01%)
Backs (n=10)	27,10 ±5,53 (20,39%)	58,0 ±5,8 (9,9%)	1,57 ±0,06 (4,11%)

*Mean, ±Standard Deviation and coefficient of variation in % in brackets, * denotes a significant difference between forwards and backs, ($p < 0,05$).*

In terms of the comparison between the two player categories, the body mass of forwards (82,0 ±9,4 kg) was significantly heavier than the backs (58,0 ±5,8 kg) with a difference of 24,0 kg between forwards and backs. Even though there was an almost 4-year difference in the mean age of the two player categories, this was found to be not significantly different with forwards (23,38 years) and backs (27,10 years). Furthermore, no significant differences were found for stature between forwards (1,63 m) and backs (1,57 m). The same was observed for the age variable between forwards (23,38 years) and backs 27,10 years).

4.3 Physical variables

This section presents the GPS data collected on the physical demands (movement and impacts) placed on participants during training. Table 5 contains the breakdown of the number and duration of the GPS files analysed according to all players, forwards, and backs.

Table 5: Number of players' GPS data files across all training sessions.

Positions	Number of GPS files	Training duration range per session
All players (18)	52	0:47:01 - 1:33:01
Forwards (8)	29	0:47:01 - 1:33:01
Backs (10)	23	0:48:58 - 1:33:01

Initially, before discarding the corrupt GPS files, over the four weeks of data collection, a total of 59 GPS data files were collected from the whole team for analysis. However, 52 GPS data files were analysed as seven files were corrupted and could not be used for further analysis. From the 52 remaining files, forwards and backs contributed 56% and 44% respectively, indicating that more data was collected on the forwards (even though they were a smaller sample). The GPS data files ranged from a minimum of 47 minutes and 1 second to a maximum of 1 hour, 33 minutes, and 1 second (Table 5) with similar training duration range for the forwards and backs. These durations give an indication of the average length of the training sessions conducted over the four weeks.

4.3.1 Speed

Speed-related variables were investigated and quantified for the movement demands' component of the study. The speed data were split into two categories: the time players spent in speed zones (giving an indication of the intensity of the training sessions) and the maximum speed players reached across all the training sessions. The results obtained on time spent in speed zones are presented first, followed by maximum speed. The data were summarised from raw form and presented as mean ±standard deviation (coefficient of variation in percentages in brackets) for all players combined, and then split into forwards, and backs allowing for the effective characteristics of training demands and comparison of the player categories.

a. Time spent in speed zones

Table 6 presents the time spent in speed zones for all players combined and then the differences in the time spent in speed zones between forwards and backs. Speed zone 1 indicates the slowest speed (0,0 to 5,9 km/h), with zones incrementally increasing in speed until speed zone 6 (20.0 km/h and higher), which describes the fastest speed intensity. As a whole group the participants spent on average 70,28 minutes (forwards = 69,28 and backs = 71,27 minutes) on the field for their training sessions, these values are further broken down according to the different speed zones in Table 6. To demonstrate statistical differences between speed zones in Table 6 the p value was set to be more than 0,05.

Table 6: Time spent in speed zones (mins) per training session.

Positions (n)	Speed zone 1 (0-5,9km/h) (mins)	Speed zone 2 (6-11,9km/h) (mins)	Speed zone 3 (12-13,99km/h) (mins)	Speed zone 4 (14-17,9km/h) (mins)	Speed zone 5 (18-19,9km/h) (mins)	Speed zone 6 (20km/h+) (mins)
All players (n=18)	62,02 ±13,21 (20,79) [bcdef]	6,22 ±2,06 (35,22) [acdef]	1,36 ±0,10 (10,42) [ab]	0,54 ±0,21 (38,89) [ab]	0,08 ±0,02 (25,00) [ab]	0,04 ±0,04 (100,00) [ab]
Forwards (n=8)	61,35 ±12,42 (20,38) [bcdef]	6,35 ±6,12 (96,13) [acdef]	1,22 ±4,32 (354,10) [ab]	0,31 ±0,42 (135,48) [ab]	0,04 ±0,15 (375,00) [ab]	0,01 ±0,02 (200,00) [ab]
Backs (n=10)	62,33 ±14,00 (22,46) [bcdef]	6,06 ±3,22 (49,56) [acdef]	1,08 ±1,51 (222,06) [ab]	1,20 ±2,25 (231,25) [ab]	0,12 ±0,23 (191,67) [ab]	0,08 ±0,21 (262,50) [ab]

Mean, ±Standard Deviation and coefficient of variation in % in brackets, [a] Significantly different to speed zone 1, [b] Significantly different to speed zone 2, [c] Significantly different to speed zone 3, [d] Significantly different to speed zone 4, [e] Significantly different to speed zone 5, [f] Significantly different to speed zone 6, ($p < 0,05$).

Regardless of playing position, all players spent a substantial amount of time (62.02 minutes, 88.25%) on speed zone 1 (standing and walking) which was defined to have the least demanding movement activities. While the least amount of time (0,04 minutes, 0,06%) was spent in the most demanding movement activities which is speed zone 6 (sprinting) for all players. Although no significant differences were found between playing positions, speed zone 1 and 2 were significantly different to all the other speed zones (1, 3-6), with a percentage of 88,55% and 9,17% for

respectively for forwards and 87,46% and 8,50% respectively for backs. Speed zones 3-6 were significantly different to speed zones 1 and 2 for both playing positions. The average time spent for all players in speed zone 3 equated to 1,94%, while for speed zone 4 it was 0,77%, 0,11% for speed zone 5 and 0,06% for speed zone 6. Speed zones 3-6 totalled a percentage of 2,28% for forwards and 3,48% for backs.

The statistical analysis showed no significant differences in the overall and individual time spent in speed zones between forwards and backline players. This is to say; both playing categories spent relatively the same time on each speed zone during training. All players and both playing positions, spent most of their time in speed zone 1, followed by speed zone 2 while the least amount of their time was spent in speed zones 6.

b. Maximum speed

Table 7: Maximum speeds reached per training session.

Positions	Maximum speed (km/h)
All players (n=18)	21,99 ±5,03 (22,87%)
Forwards (n=8)	21,35 ±5,72 (26,79%)
Backs (n=10)	22,85 ±3,88 (16,98%)

Mean, ±Standard Deviation and coefficient of variation in % in brackets.

On average, the combined group of players reached maximum speeds of 21,99 km/h per training session over a total of nine training sessions. The average maximum speed reached by players during training was similar between forwards and backs as there were no statistical differences between the two playing categories. The nonsignificant difference in the maximum speeds reached between forwards and backs was 1,5 km/h as the forwards obtained an average maximum speed of 21,35 km/h while the backs reached a maximum speed of 22,85 km/h. The coefficient of

variation also shows that there was more variability in the maximum speed reached in the forwards than the backline players.

4.3.2 Total distance travelled

Table 8: Average total distance travelled per training session.

Positions	Total Distance Travelled (km)
All players (n=18)	2,14 ±0,76 (35,51%)
Forwards (n=8)	2,22 ±0,73 (32,88%)
Backs (n=10)	2,05 ±0,80 (39,02%)

Mean, ±Standard Deviation and coefficient of variation in % in brackets.

Table 8 shows that the average total distance travelled by all players was 2,14 km per training session. No significant differences were detected between the two playing positions (forwards and backs). While forwards travelled an average total distance of 2,22 km, backs travelled an average total distance of 2,05 km. The coefficient of variation shows that there was a greater variability in the total distance travelled by backs than forward players during the training sessions observed.

4.3.3 Number of impacts in impact zones

The number and intensity of impacts the players experienced on the field during training have been presented in Table 9. The number and intensity of impacts were gathered from accelerometer data and expressed as *g*-forces.

Table 9: Total number of impacts in impact zones (n) across all training sessions.

Positions	Impact zone 1 (5-6g)	Impact zone 2 (6-6,5g)	Impact zone 3 (6,5-7g)	Impact zone 4 (7-8g)	Impact zone 5 (8-10g)	Impact zone 6 (10g+)	*Total (5-10g+)*
All players (n=18)	163,00 [bcdef]	16,00 [a]	9,00 [a]	14,00 [a]	7,00 [a]	4,00 [a]	***213,00***
Forwards (n=8)	94,00 [bcdef] (58,00%)	6,00 [a] (37,50%)	5,00 [a] (55,50%)	9,00 [a] (64,30%)	1,00 [a] (14,30%)	1,00 [a] (25,00%)	***116,00 (54,20%)***
Backs (n=10)	69,00 [bcdef] (42,00%)	10,00 [a] (62,50%)	4,00 [a] (44,40%)	5,00 [a] (35,70%)	6,00 [a] (85,70%)	3,00 [a] (75,00%)	***97,00 (45,30%)***

Total number, % compared to all players in brackets, [a] Significantly different to impact zone 1, [b] Significantly different to impact zone 2, [c] Significantly different to impact zone 3, [d] Significantly different to impact zone 4, [e] Significantly different to impact zone 5, [f] Significantly different to impact zone 6, ($p < 0,05$).

A total number of 213 impacts were recorded over the nine training sessions for all players combined. When comparing the number of impacts within the different impact zones, most impacts occurred in impact zone 1 while the least impacts were experienced in impact zone 6 for both playing positions. Impact zone 1 was significantly different to impact zones 2-6 for both playing positions. Impact zone 1 is defined in Table 9 as the least intense impact zone while the intensity of impacts increased from impact zone 1 to impact zone 6, being the most severe impact zone. No other significant differences were found (i.e., impact zones 2-6 were found to have a similar number of impacts) within the remaining impact zones.

A total of 163,00 impacts were reported in impact zone 1 (76,00% of the total number of impacts), while the other impact zones (2-6) decreased from a total of 16,00 to 4,00 impacts. Interestingly, the trend of the number of impacts, decreasing as impact zones increased for the majority of impact zones, the number of impacts in impact zone 4 increased from impact zone 3 for both playing positions. Meaning according to the trend, instead of impact zone 4 having less impacts compared to impact zone 3, there were more impacts reported for impact zone 4.

With regards to comparing playing positions, statistical analysis showed no significant differences between the two playing categories across all impact zones. A total of 116,00 impacts were recorded for forwards, and 97,00 impacts were recorded for backs across all training sessions. The greatest number of impacts were sustained in impact zone 1 for both playing positions, with forwards reporting 94,00 impacts while backs reported 69 impacts. Overall forwards reported 6, 5, 9, 1 and 1 impacts for impact zones 2-6 consecutively and backs on the other hand reported 10, 4, 5, 6 and 3 for impact zones 2-6 consecutively.

4.4 Physiological variables

Section 4.4 presents the descriptive statistics of the players' physiological data during across nine training sessions. Due to the availability of data collection resources, the physiological variable focused on in this study only included heart rate responses.

4.4.1 Heart Rate

Table 10: Average heart rate responses (bpm) per training session.

Positions	Heart Rate (bpm)
All players (n=18)	137 ±14 (10,22%)
Forwards (n=8)	139 ±15 (10,79%)
Backs (n=10)	134 ±13 (9,70%)

Mean, ±Standard Deviation and coefficient of variation in % in brackets,

The average heart rate responses reported per training session across nine training session for all players was recorded as 137 bpm. When comparing the heart rate responses between playing positions, the average heart rate was 139 bpm for forwards, and 134 bpm for backline players. These data show that forwards and backs had similar heart rate responses during training. This is supported by the fact that the statistical analysis showed no significant differences detected between the two playing categories.

4.5 Summary

This chapter provided the summarised overall data of the study and were presented as descriptive statistics, contrasted with inferential statistics that were used to highlight the differences between the playing categories. The data were presented from the demographic and anthropometric characteristics, followed by the results of the physical demands, and concluded with the data of the physiological demands. To summarize the findings obtained from this study, with regards to the physical demands data there were significant differences ($p<0,05$) in the time spent in various speed zones and no significant differences were detected between playing positions for all the speed zones. Significant differences ($p<0,05$) were also found in the number of impacts in impact zones while no significant differences ($p<0,05$) were detected between the playing positions. For all the physical and physiological demands, no significant differences were found between forwards and backs. In terms of the demographic and anthropometric characteristics that were studied through this study, the comparison between forwards and backs' body mass revealed significant differences ($p<0,05$). However, no significant differences ($p<0,05$) were detected for age and stature between forwards and backs.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

The findings of this study will be discussed in order of importance to highlight the key findings. From each sub-section, the discussion will be based on the corresponding hypothesis, research objectives, and the findings of relevant existing literature. Generalising and the ability to make inter-study comparisons to the existing literature and the current study is limited. This is because the current study is the first of its kind in the Sarah Baartman district of South Africa and there are several factors that make it difficult to compare. These factors amongst many include differing contexts, genders, levels of play, total time analysed, training or match-play and how the same variables have been studied differently (King *et al.,* 2019). Lastly, possible explanations will be provided to explain why some variables were statistically significant while others were not.

5.2 Physical variables

The Rugby union physical variables explored in the current study included time spent in speed zones, maximum speed, the number of impacts in impact zones and total distance travelled.

5.2.1 Speed

5.2.1.1 Time spent in speed zones

Players from this study spent 69,29 minutes (forwards, 68,48 and backs, 70,10) on average training for the duration of all the training sessions. Evidently, this duration was less than the standard 80 minutes of a Rugby union game (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Virr *et al.,* 2013; 2020; Cunningham *et al.,* 2016; Bradley *et al.,*). The difference (approximately 10 minutes) between this study and the duration of a match shows that the average time spent on training by the participants of this study may be inadequate for them to adapt to the demands that come with an actual match-play. Campbell *et al.,* (2017) states that greater demands are required from players during match-play compared to training because match-play usually includes unpredictable aspects that are different to training. However, with training there is a level of planning how the training will go on that particular session.

Lesser demands placed on players during training compared to match-play may be explained by the fact that coaches are reluctant to put players at a further risk of injury in the controlled setting of training (Dawson *et al.,* 2004; Campbell *et al.,* 2017). However, this does not dispute the need for a balance between risk (fatigue and injury) and reward (match performance) which must be well managed as the specificity of training practices in modern Rugby union may be inadequate to elicit optimal training adaptation (Higham *et al.,* 2016). This then means, even though coaches may be reluctant to train players to a point where they might get injured, coaches must also make sure players train optimally so that they are able to optimally meet the demands of match-play. Additionally, by optimally training players coaches are essentially reducing the risk of injury during match-play which is better than reducing risk of injury by undertraining players during training.

With regards to the time allocated to different training drills, coaches are ought to train players in a way that matches the time spent in such activities during match-play. However, although optimal training is beyond the time spent training but it also includes the appropriate intensity of the training, meaning the time spent in different speed zones is an important variable for gaining further insight into the quality of the training experienced in the current study.

Table 11: Time spent in speed zones across different Rugby union studies.

Author(s)	**Speed zones**	**Forwards (% or mins)**	**Backs (% or mins)**
Cunniffe *et al.,* 2009 (Men)	% Time standing/walking (0-6 km/h)	66,50	77,80
	% Time jogging (6-12 km/h)	24,30	13,00
	% Time cruising (12-14 km/h)	03,40	03,10
	% Time striding (14-18 km/h)	03,80	03,70
	% Time high intensity running (18-20 km/h)	01,10	00,90
	% Time sprinting (>20 km/h)	00,80	01,40
Coughlan *et al.,* (2011) (Men)	Time standing (0.0-1.8 km/h)	39,48	33,20
	Time walking (1.8-6.1 km/h)	31,43	38,09
	Time jogging (6.1-13.0 km/h)	17,05	16,59
	Time medium intensity running (13.0-18.0 km/h)	05,04	04,34
	Time high intensity running (18.0-24.1 km/h)	01,09	01,32
	Time maximal speed running (24.1-36.0 km/h)	00,02	00,15
Virr *et al.,* 2014 (Women)	Total time standing (speed zones unspecified)	21,09	19,00
	Total time walking (speed zones unspecified)	36,42	51,00

	Total time jogging (speed zones unspecified)	10,54	07,24
	Total time striding (speed zones unspecified)	04,06	03,30
	Total time sprinting (speed zones unspecified)	01,42	03,36
Tee and Coopoo, 2015 (Men)	% Time walking (0-2 m/s)	80,00	83,00
	% Time jogging (2-4 m/s)	17,00	13,00
	% Time striding (4-6 m/s)	03,00	04,00
	% Time sprinting (>6 m/s)	00,30	00,70
Bradley *et al.,* 2020 (Women)	%Time Walking (0-6 km/h)	79,80	82,30
	%Time Jogging (6,1-12 km/h)	13,50	10,80
	%Time Low Intensity Running (21,1-14 km/h)	02,00	01,70
	%Time Medium Intensity Running (14,1-18,1 km/h)	01,30	01,60
	%Time High Intensity Running (18,1-21 km/h)	00,10	00,40
	%Time Sprinting (>21,1 km/h)	00,00	00,10
Present study (Women)	% Time Standing and walking (0-5,9 km/h)	89,00	89,43
	% Time Jogging (6-11,9 km/h)	08,69	08,16
	% Time running at low intensity (12-13,9 km/h)	01,78	00,98
	% Time running at medium intensity (14-17,9 km/h)	00,45	01,15
	% Time running at high intensity (18-19,9 km/h)	00,06	00,17
	% Time sprinting (>20 km/h)	00,01	00,11

Six different studies from different contexts are presented in Table 11 showing the time spent in different speed zones between forwards and backs. Cunniffe *et al.,* (2009), Coughlan *et al.,* (2011), and Tee and Coopoo, (2015) conducted their studies on professional men's Rugby while Virr *et al.,* (2013), Bradley *et al.,* (2020) and the current study were conducted on professional and amateur women's Rugby respectively. Except for Virr *et al.,* (2013) who used time motion analysis all the other studies used GPS with different sampling rates that ranged from 5-10 Hertz. Existing research uses different methods as the speed classifications (Table 11) are divided differently with Cunniffe *et al.,* (2009), Bradley *et al.,* (2020) and the present study being the most similar. The selection of speed classifications is important as it can potentially impact the interpretation of the data, particularly in preparation for competition.

Therefore, the findings from different studies demonstrate clearly that caution is needed when adopting speed zones, and as such, they do not lend themselves to being used interchangeably. Except differences in speed classifications, the number

of participants also differed across these studies ranging from two to 129 participants. Lastly, these studies were conducted on varying number of games with Cunniffe *et al.,* (2009), Coughlan *et al.,* (2011) and Virr *et al.,* (2013) all observing one game each, Tee and Coopoo, (2015) observing the 2013 season and Bradley *et al.,* (2020) observing 14 games and the current study observing nine training sessions.

The findings of this study revealed that players spent 88,25% in the standing and walking zone, 8,85% jogging, 1,94% running on low intensity, 0,77% running on medium intensity, 0,11% running on high intensity and 0,06% sprinting. Hence, this study's second null hypothesis was rejected as it revealed that the time spent in speed zones significantly differed within speed zones. The amount of time spent in the speed zones decreased significantly from lower speed to higher speed zones. The findings from Table 11 are unanimous in the fact that both playing positions spend significantly different times in various speed zones. With the most amount of time spent standing and walking followed by jogging, running at low intensity, medium intensity, high intensity, and sprinting. During match-play, Cunniffe *et al.,* (2009), Tee and Coopoo, (2015), Bradley *et al.,* (2020) and during training, the present study presented their findings as time spent in speed zones in percentages, these studies combined reported that the time spent in the standing/walking speed zone was more than 70% of the time spent by players on the field.

When comparing the findings from this study to existing literature, it is clear that during both training and match-play, players spend more time in the lower intensity activities compared to the higher intensity activities. This implies that coaches should allocate training times accordingly to optimise performance in all activities performed during match-play. Additionally, as learnt in chapter two, forwards and backs have distinct roles for instance during contact and running activities. Therefore, it is important to train them in a way that depicts those differences. In a study by Smit, (2012) it was observed that when forwards and backs were allocated the same drills during training, no differences were found in their training responses. The same was observed in the current study, where all players were training identically, hence no significant differences have been found in their training responses.

With regards to the first null hypothesis, it was accepted, as it had stated that there would be no significant differences in the time spent in speed zones between forwards and backs. Indeed, forwards and backs spent similar times in all speed zones with both playing positions' times decreasing as speed zones went from speed zone 1 (standing and walking) to speed zone 6 (sprinting). As seen in Table 11, these findings agree with the findings from existing research, more time is spent in the standing and walking zones while a significantly least amount of time is spent in the sprinting zone. Although not always significant, research has also shown that forwards spend more time in lower-speed zones than backs while backs accumulate more time in high-speed zones due to their great speed traits and requirements for their role (Duthie *et al.,* 2005; Roberts *et al.,* 2008; Cunniffe *et al.,* 2009; Reid *et al.,* 2013; Suarez-Arrones *et al.,* 2014; Virr *et al.,* 2014; Tee and Coopoo, 2015; Bradley *et al.,* 2020). Which supports the idea of training forwards and backs sometimes differently as their roles on the field often differ, with forwards entering higher intensity running zones less than backs.

5.2.1.2. Maximum speed

Previous research shows that maximum speeds reached by Rugby union players during match-play varies, with most maximum speeds reached, going over the sprinting zone of 20+ km/h (Table 12). Table 12 shows a comparison of maximum speed reached between forwards and backs across different studies, including men's and women's Rugby union players. Except for the present study, all these studies have been conducted on match-play from a minimum of one game to a maximum of 14 games.

For the current study there were no significant differences in the maximum speeds reached between forwards and backs, although the top speed reached by the backline players was marginally higher compared to forwards. This study's forwards reached a maximum speed of 21,35 km/h and backline players reached 22,85 km/h. Research on men's Rugby union match-play has shown that backs usually reach significantly higher maximum speeds (Suarez-Arrones *et al.,* 2012; Tee *et al.,* 2015; Reardon *et al.,* 2016; Swaby *et al.,* 2016; Owen, 2019; Yamamoto *et al.,* 2020). For example, Cunniffe *et al.,* (2009) found that the backline players had a maximum

speed that was 2.4 km/h faster than the forwards, while Coughlan *et al.,* (2011) found an even greater difference of 4.7 km/h for studies on male players.

Table 12: Maximum speeds reached across different Rugby union studies.

Author(s)	**Forwards (km/h)**	**Backs (km/h)**
Cunniffe *et al.,* 2009 (Men)	26,30	28,70
Coughlan *et al.,* 2011 (Men)	26,10	30,80
Suarez-Arrones *et al.,* 2012 (Men)	24,60	28,20
Suarez-Arrones *et al.,* 2014 (Women)	22,00	24,40
Owen *et al.,* 2019 (Men)	25,50	30,10
Busbridge *et al.,* 2020 (Women)	22,00	26,00
Bradley *et al.,* 2020 (Women)	20,50	23,20
Present study (Women)	21,35	22,85

For the studies conducted on women's players there were unanimous results with Suarez-Arrones *et al.,* (2013), Bradley *et al.,* (2020) and Busbridge *et al.,* (2020) reporting backline players to be faster. Bradley *et al.,* (2020) argued that this was supported by the fact that backs are expected to perform more frequent and longer runs and sprints than forwards. This then suggests that during training backs should be allocated more sprinting drills, as high-speed movements often result in line breaks and scoring opportunities resulting in a high winning rate (Ortega *et al.,* 2009).

Apart from the differences between forwards and backs, women have also been reported to demonstrate slower speed when compared to men (King *et al.,* 2019). Table 12 shows that although women's Rugby maximum speeds reach over 20 km/h when compared to men's Rugby they are lower. This comparison must however be made with caution as women and men have different characteristics (King *et al.,* 2019). Therefore, unless the speed thresholds are allocated specifically to men's and women's capabilities, general speed allocation should be cautioned (Owen, 2019).

Tee *et al.,* (2015) found that there was a difference in the amount of high-speed running performed at the international level compared to lower levels (Tee *et al.,* 2015). This could be explained by the fact that different training programs and resources are available to the different levels of play with professional levels getting more quality training. Comparison between the current study and previous literature is however done with caution as these studies are of different contexts with some studies being conducted on men, professional level of play and match-play instead of training and from a minimum of two players up to 129 players.

5.2.2 Number of impacts in impact zones

213 impacts were recorded for all players across nine training sessions observed during this study's data collection period. Most impacts (163) were sustained in the lighter impact zone and the least impacts (4) were sustained in the severe impact zone. This would suggest that there was an average of 23 impacts per training session, approximately 12 impacts per player and 1 impact per play per training session. Although different studies use different methods, sample sizes, and time frames to collect data, it was found that the number of impacts from the current study is much lower compared to previous literature (figure 4) and does not reflect the demands of match-play seen in existing literature. Although there were no significant differences between playing positions Cunniffe *et al.,* (2009) recorded 1274 and 704 impacts for one game for forwards and backs respectively. Coughlan *et al.,* (2011) reported that forwards totalled 838 impacts while backs 573 impacts during one game between two players. Suarez-Arrones *et al.,* (2012) reported that forwards and backs sustained 1225 and 883 impacts respectively. This suggests that the participants of this study are not adequately preparing for match-play, as Ortega *et al.,* (2009) identified that winning teams complete more tackles than losing teams. Furthermore, Paul *et al.,* (2022) states that to ensure athletes are adequately prepared for match collision loads, training should be prescribed to meet the match demands.

The first null hypothesis of this study stated there would be no significant differences in the number of impacts between the different impact zones; this was rejected as impact zone 1 was significantly higher from all other impact zones. Similarly, to the current study, previous literature (figure 4) has shown that the number of impacts

decreases significantly as the impact zones increase from the lowest impact zone intensity to the highest. This is thought to result from the increasing intensity and hence more effort and risk required at higher intensity zones (Coughlan *et al.,* 2011). Additionally, higher impact intensities are likely to produce the highest proportion of injuries in Rugby union (Garraway *et al.,* 1999), resulting in five times more injuries than any other type of player impact (Coughlan *et al.,* 2011).

In terms of this study's first null hypothesis, it was accepted as there were no significant differences in the number of impacts in impact zones between forwards and backs. There is contention in the literature regarding the differences between forwards and backline players and the number of impacts. For example, Tee and Coopoo (2015) and Grainger *et al.,* (2018) found no significant differences in the number of impacts experienced during playing seasons between forwards and backs. Contrastingly several studies (Cunniffe *et al.,* 2009; Coughlan *et al.,* 2011; Suarez-Arrones *et al.,* 2012; Owen *et al.,* 2015; Lindsay *et al.,* 2015; Yamamoto *et al.,* 2020; Paul *et al.,* 2022) also conducted on match-play found differences in the number of impacts experienced between playing categories, with forwards often experiencing more impacts than backs. Hence, forwards are usually prescribed more contact training drills as they participate in mauls and scrums which require contact between forwards of opposition. Suarez-Arrones *et al.,* (2014) found that women's Rugby union backs experienced more impacts than forwards (figure 4).

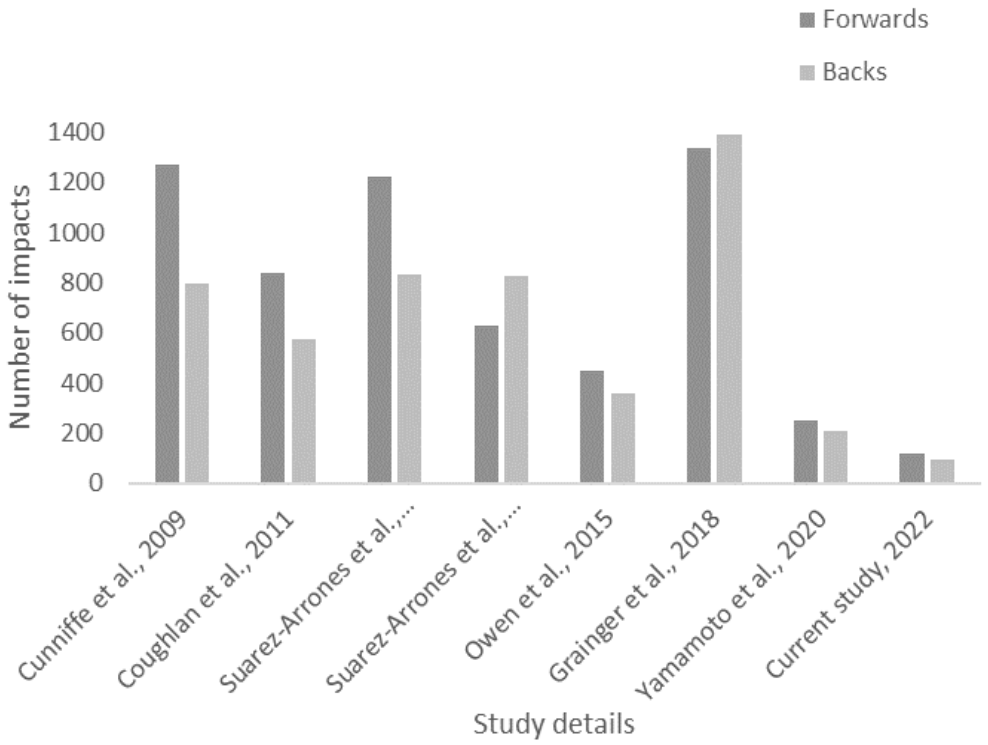

Figure 4: Comparison of the total number of impacts between different studies.

The above data have been collected on match-play on a range of 2-298 professional Rugby union players, except for the current study conducted on amateur players. It is also important to note that comparison between studies is made with caution, as data collection tools, sample size, gender, minutes played and focus (match-play vs training) in previous literature differ from those of this study. Additionally, it is difficult to compare the data collected from this study as there have been no studies conducted on similar contexts, such as women's amateur Rugby union players, as more research is conducted on men and professional players. This is evident in the fact a systematic review conducted by Paul *et al.,* (2022) revealed that out of 58 Rugby union studies looking at impact data only two had women participants, with Suarez-Arrones *et al.,* (2014) observing 8 players and Virr *et al.,* (2014) observing 38 players during match-play. From this study, Paul *et al.,* (2022) discovered that there was a lack of consistency on the definition of impacts which made it hard to compare.

The comparison between existing literature and current study findings suggest that the number of impacts experienced by forwards and backs from amateur women's Rugby union is not significantly different. Even though most research has reported

differences between the playing positions. Meaning the training intensity of amateur women's Rugby union players from this study does not differ in terms of playing positions. Evidently, from figure 4 it is also clear that the number of impacts sustained during training of the current study's participants are much lower compared to professional Rugby union match-play. Additionally, the different studies agree that the number of impacts experienced between the various impact zones differs significantly. From the above data it is evident that coaches should train players specific to their positional grouping for appropriate adaptations (Paul *et al.,* 2022).

5.2.3 Total distance travelled

Total distance travelled was, historically, one of the first GPS variables to be monitored and thus the most reported variable across different field team sports (Cummins *et al.,* 2013). Unfortunately, this was mainly applied to competition games and not training sessions, especially in Rugby union (Tee *et al.,* 2015). The average total distance travelled for the current study was 2135 m for all players over 9 training sessions. The total distances travelled from previous research (Table 13) which included men and women ranged from 4872 m to 7227 m during match-play. A comparison between the current study and previous research shows how short the distances travelled in this study were, showing that this study's participants were inadequately training to be able to match competition demands.

For the current study, the total distance travelled on the field during training showed no statistically significant difference between forwards and backs. The average total distance travelled by forwards and backs was 2220 m and 2050 m respectively. Most of the research conducted on Rugby union is conducted on match-play and it has found that backs travel significantly longer distances when compared to forwards (Roberts *et al.,* 2008; Cunniffe *et al.,* 2009; Cahill *et al.,* 2012; Suarez-Arrones *et al.,* 2014; Swaby *et al.,* 2016; Reid *et al.,* 2018; Yamamoto *et al.,* 2020; Callanan *et al.,* 2021). The total distances travelled from previous research which included men and women ranged from 4872 m to 7227 m during match-play.

Table 13: Total distance travelled across different Rugby union studies.

Author(s)	Forwards (m)	Backs (m)
Cunniffe *et al.,* 2009 (Men)	6680	7227
Suarez-Arrones *et al.,* 2012 (Men)	6162	6471
Suarez-Arrones *et al.,* 2014 (Women)	5498	6356
Callanan *et al.,* 2016 (Women)	5456	5964
Swaby *et al.,* 2016 (Men)	4872	6544
Reardon *et al.,* 2016 (Men)	5638	6172
Sheppy *et al.,* 2019 (Women)	5615	5925
Yamamoto *et al.,* 2020 (Men)	5731	6392
Bradley *et al.,* 2020 (Women)	5049	4908
Busbridge *et al.,* 2020 (Women)	5616	5829
Present study (Women)	2220	2050

Additionally, total distance travelled differs between levels of play, Stoop *et al.,* (2018) stated that because sub-elites and amateur Rugby union players have fewer, less intense training sessions they have lower physical capacity and therefore a smaller amount of total distance travelled during match-play. This may be explained by the fact that like the context of the current study, training in the amateur level of play may be different to training at professional level, this includes access to training equipment and availability of coaching staff. For example, from this study's participants the one volunteer coach who was responsible for all players and more often had to train everyone simultaneously without splitting the players into the playing groups. Additionally, except for the basic training equipment such as a field, balls, and cones the participants of this study, lacked. Hence, as mentioned, the comparison needs to be cautioned as previous research has different contexts to this study such as different levels of play.

5.3 Physiological variables

5.3.1 Heart Rate

Part of the aim of this study was to establish the physiological demands experienced by women's Rugby union players at an amateur level of play. The physiological demand investigated for this study was only heart rate because of the data collection equipment available to the researcher. Overall, the participants of this study had a heart rate response of 137 bpm per training session across nine training sessions. This average heart rate was lower compared to existing literature. Suarez-Arrones *et al.,* (2013) explored the mean heart rate responses of women's Rugby union players and on average the players combined reported 161 bpm during a professional game. While Suare-Arrones *et al.,* (2013) did not breakdown heart rate responses according to forwards and backs, Table 14 contains differences between the heart rate responses between forwards and backs.

Table 14: Heart rate responses (bpm) across Rugby union studies.

Author(s)	**Forwards (bpm)**	**Backs (bpm)**
Cunniffe *et al.,* 2009 (Men)	170	172
Virr *et al.,* 2014 (Women)	173	161
Portillo *et al.,* 2014 (Men)	158	156
Swaby *et al.,* 2016 (Men)	158	156
Present study (Women)	139	134

Similarly, to Cunniffe *et al.,* (2009). Portillo *et al.,* (2014) and Swaby *et al.,* (2016) who conducted their studies on men's Rugby union match-play, there were no significant differences between this study's forwards (139 bpm) and backs (134 bpm) during training. Kruger and Smit, (2012) argues that the roles of forwards and backs in a match are becoming more interrelated in modern-day Rugby (Kruger and Smit, 2012) hence there would be no significant differences. Possibly, the lack of position specific training methodologies could also contribute to players having similar heart rate responses (Campbell *et al.,* 2017).

Virr *et al.,* (2014) found that women's Rugby union' forwards had significantly higher heart rates than backs which indicated the overall higher cardiovascular stress placed on the forwards during match-play. Similarly, in a study conducted by Deutsch *et al.,* (1997) on men's Rugby union matches, the forwards had higher heart rate exertions than backs, explained by the fact that forwards' heart rate could be resulting from elevated catecholamine levels. Moreover, due to the contact nature of tackling and rucking/mauling, it is more likely that the continuous activity associated with forwards, interspersed with frequent bouts of static isometric work, could significantly result in an elevated heart rate (Deutsch *et al.,* 1997). Lower exertions of heart rate for backs can be explained as, the more intermittent nature of the backs, suggests that backs recover more quickly between bouts of high-intensity exercise (Deutsch *et al.,* 1997).

Kruger and Smit (2012) and Campbell *et al.,* (2017) compared men's heart rate between match-play and training. Both studies reported that there was a significant difference in the physiological demands experienced during match-play compared to training, with match-play resulting in higher heart rate responses. While Campbell *et al.,* (2018) did not explicitly report heart rate responses, Kruger and Smit, (2012) recorded 138,33 bpm during training and 154,40 bpm during match-play. Elevated heart rates during matches than in training may be an indication of the greater physiological, skill-demand, emotional and psychological stressors involved in decision-making scenarios occurring throughout competitive matches (Campbell *et al.,* (2017). Kruger and Smit, (2012) attributed these differences to individuality and individual effort made during the two different activities and to factors that influence performance in a match, such as applied game tactics and motivation to win the match. The low heart rate values in the training sessions were explained by the fact that training had more closed-skill drills than open-skill drills, which elicited significantly higher heart rate in players (Farrow *et al.,* 2008). Additionally, match-play circumstances impose a higher physiological load on athletes (Kruger and Smit, 2012). Coutts *et al.,* (2003) also indicated that a higher standard of Rugby can increase the intensity at which Rugby is played.

The different findings from Table 13 could also be attributed to by the fact that this study's participants primarily trained as a whole team instead of being split into

forwards or backs which was similar to Smit, (2012). Additionally, heart rate variables are determined by multiple influencing factors, such as environmental (e.g., noise, light, temperature), physiological (e.g., cardiac morphology, plasma volume, autonomic activity), pathological (e.g., cardiovascular disease), psychological (e.g., mood, emotions, stress) conditions, and non-modifiable factors (e.g., age, gender, ethnicity), as well as lifestyle (e.g., fitness, sleep, medication, tobacco, alcohol) and determinants of physical activity (e.g., intensity, duration, modality, economy, body position) (Nicholas, 1997; Sandercock *et al.,* 2005; Buchheit, 2014; Fatisson *et al.,* 2016; Sessa *et al.,* 2018). All these factors could have a contribution to the different findings obtained from different studies.

5.4 Demographic and anthropometric variables

Demographic and anthropometric characteristics were included in the current study to provide an overview of the participants' characteristics with the aim to explain and understand some of the finding's study. In men's Rugby it has been found that anthropometric characteristics are vital components of success in Rugby union; they differ and reflect the divergent demands of each position (Nicholas, 1997; Vaz *et al.,* 2014; Stoop *et al.,* 2018; Harty *et al.,* 2019; Posthumus *et al.,* 2020). However, these positional differences are less apparent at lower levels of play, especially in women's Rugby (Woodhouse *et al.,* 2021). This is perhaps due to the specialized training and selection processes at international standards (Hene and Bassett, 2013; Nyberg and Penpraze, 2016) and the popularity of men's Rugby compared to women's Rugby. The demographic and anthropometric measurements assessed at the beginning of the data collection of this study were age (yrs), stature (m), and body mass (kg) which will be discussed in that order.

5.4.1 Body mass

The findings from this study revealed that with regards to body mass there were significant differences between forwards and backs, with forwards weighing 82,0 kg while backs weighed 58,0 kg. This study's significant differences between the body mass of forwards and backs are unanimous with previous research conducted on women and men at semi-professional and professional playing levels (Quarrie *et al.,* 1995; Nicholas, 1997; Bell *et al.,* 2005; Hene and Bassett, 2013; Virr *et al.,* 2014; Bradley *et al.,* 2015; Harty *et al.,* 2019; Posthumus *et al.,* 2020). Skeletal factors may

account for the differences in body mass between forwards and backs as forwards have been observed to have greater limb girths and bone diameters (Kirby and Reilly, 1993; Quarrie *et al.,* 1995). Additionally, because of the requirements of forwards, they are expected to weigh more than backs because playing situations now require increased force; therefore, a heavier body mass has become essential to sustain these forces during activities such as scrums and mauls (Smart *et al.,* 2013; Nakamura *et al.,* 2016).

On the other hand, it is important to note that excess body mass may negatively impact performance by reducing speed and acceleration, which is an outcome that is likely across all positions (Duthie *et al.,* 2003). As such, it is forwards that are preferred to have a heavier body mass than backs, as backs cannot display significantly slower times in sprint and pro agility (Nyberg and Penpraze, 2016). Moreover, it is evident from the body mass' findings of this study that the physical demands data were not influenced by the participants' body mass. This is because according to the literature cited above, in virtue of forwards being heavier it would be expected that the physical demands differ between forwards and backs. For example, because forwards and heavier and backs are lighter it would be expected that there be a difference in the maximum speeds reached between the two playing positions. However, that was not the case in the current study. Which can be explained by the fact that, training for the participants of the current study was not split between forwards and backs, it was the same.

5.4.2 Stature

Although stature cannot be influenced by training (Sedeaud *et al.,* 2016), stature is an essential anthropometric characteristic because taller players are more likely to become elite Rugby athletes and win a more significant number of matches (Olds, 2001). No significant differences were detected in the stature between forwards and backs, with forwards and backs being as tall as 1,63 m and 1,57 m respectively. The findings from this study were inconsistent to previous research. In a systematic review conducted on men's Rugby union by Stoop *et al.,* (2018), it was found that regardless of level of play, the forwards were taller than the backs. Additionally, the findings from previous studies on both men's and women's studies (Quarrie *et al.,* 1995; Nicholas, 1997; Cunniffe *et al.,* 2009; Suarez-Arrones *et al.,* 2012; Suarez-

Arrones *et al.,* 2014) found that forwards are significantly taller than backs. Read (2017) conducted a study on men's Rugby union three different age groups which were under 16, 18, and 20, and found that the forward playing position was taller than the backs in all age groups.

With regards to women's Rugby union, the findings of the current study are also inconsistent with the results of studies conducted on schoolgirls (Quarrie *et al.,* 1995), college (Harty *et al.,* 2019), premier division (Bradley *et al.,* 2020), and elite (Callanan *et al.,* 2021) where it was found that forwards are significantly taller than backs.

5.4.3 Age

The average age for this study's participants was 25,44 years and the age range was 18-34 years which is similar to previous studies conducted on women's Rugby union players (Hene and Basset, 2013; Virr *et al.,* 2014; Suarez-Arrones *et al.,* 2014; Sheppy *et al.,* 2019; Bradley *et al.,* 2020; Busbridge *et al.,* 2020; Posthumus *et al.,* 2020; Woodhouse *et al.,* 2021; Callanan *et al.,* 2021). No significant differences were detected between the forwards' and backs' age. The finndings of this study are in agreement with the previous literature (Suarez-Arrones *et al.,* 2014; Harty *et al.,* 2019; Bradley *et al.,* 2020; Callanan *et al.,* 2021) which also found no significant differences in the age between forwards and backs. However, in a study conducted by Callanan *et al.,* (2021), the forwards were slightly older than the backs, while Harty *et al.,* (2019) found that backs and forwards were almost the same age.

CHAPTER SIX: CONCLUSIONS

6.1 Introduction

The current chapter aims to provide a conclusion based on the findings of the study. In this chapter mention will be given to the limitations and future recommendations that have been identified for future research. The aims of this study investigated and quantified the physical and physiological demands of amateur Rugby union players from the Sarah Baartman District in the Eastern Cape of South Africa using Global Positioning System. This investigation was conducted on training only and no matches were observed due to the COVID-19 regulations in South Africa at the time of data collection.

6.2 Hypotheses and outcomes

The first set of hypotheses focused on evaluating the differences between playing positions (forwards and backs).

1. Demographic and anthropometric characteristics

Null hypothesis: There will be no significant differences in the demographic and anthropometric characteristics between forwards and backs.

Alternative hypothesis: There will be significant differences in the demographic and anthropometric characteristics between forwards and backs.

Outcomes: Data on body mass showed that forwards were significantly heavier compared to backs, while no significant differences were detected between forwards and backs for stature and age.

2. Physical demands

Null hypothesis: There will be no significant differences in the physical characteristics between forwards and backs.

Alternative hypothesis: There will be significant differences in the physical characteristics between forwards and backs.

Outcomes: There were no significant differences observed between forwards and backs for time spent in speed zones, maximum speed, total distance travelled and number of impacts in impact zones.

3. Physiological characteristic

Null hypothesis: There will be no significant difference in the physiological characteristic between forwards and backs.

Alternative hypothesis: There will be a significant difference in the physiological characteristic between forwards and backs.

Outcomes: No significant differences were detected for heart rate between forwards and backs.

The second set of hypotheses focused on evaluating the differences within playing positions for two physical demands (time spent in speed zones and number of impacts in impact zones).

1. Time spent in speed zones

Null hypothesis: There will be no significant differences in the time spent between the speed zones.

Alternative hypothesis: There will be significant differences in the time spent between the speed zones.

Outcomes: For both forwards and backline players, there were significant differences detected in the time spent between speed zones. All players spent most of their training time in speed zones 1 and 2, while a significantly least amount of time was spent in speed zones 3-6.

2. Impact zones

Null hypothesis: There will be no significant differences in the number of impacts between the impact zones.

Alternative hypothesis: There will be significant differences in the number of impacts between the impact zones.

Outcomes: For both forwards and backs, there were significant differences detected in the number of impacts between impact zones. All players experienced a significant number of impacts in impact zone 1 and experienced the least and similar number of impacts in impact zones 2-6.

6.3 Limitations and future recommendations

The limitation of the current study includes firstly the period in which the study was conducted which was during an outbreak of a pandemic, Coronavirus (COVID-19). The nature of the disease made it difficult for the researchers to collect substantial data over a longer period. Therefore, the data obtained from this study must be interpreted and compared to existing literature with caution. The second limitation was the relatively smaller sample size and lack of women's Rugby union clubs that could have potentially participated in the study to provide more representation. The lack of women's Rugby union clubs is also what led to the lack of match-play data for the current study, as the participating club did not have clubs to potentially compete with. This is however understandable, due to the fact that women's Rugby union in the Sarah Baartman district is still struggling in terms of participation. The last limitation is with regards to the validity and reliability of the GPS devices used in the study. Currently the specific GPS devices used in the study lack validity and

Although the current study is not representative of all the amateur women's Rugby. The following recommendations can be drawn from the current study. Firstly, more women's Rugby union clubs and players needs to grow and be encouraged in the district. Secondly, coaches and players need to improve their education about physical and physiological demands of match-play, this is so coaches train players in a way that training demands match competition demands.

Future research should aim to further divide the forwards and backs playing categories into smaller or individual positions. This is because, although Rugby union generally has forwards and backs, there more specificity as the positions become smaller. Additionally, the author recommends that more research be done on amateur playing level, so that there is comparable data at all levels of play, to avoid comparing different contexts which might lead to false conclusions. Thirdly, it is recommended that researchers observe players over a longer period, instead of collecting data on a few sessions. Lastly, from this study it is recommended that researchers establish playing standard variables that are suitable to women Rugby union players, to avoid using men's standards that might be inappropriate for women.

6.4 Conclusions

Although most existing literature has been conducted on professional men and match-play, it has been encouraged that training simulates match-play. This is so players are adequately ready for match-play with a reduced risk of sustaining injuries as they would be familiar and capable of dealing with the demands of match-play. From the current study's findings, it can be concluded that the physical and physiological demands were much lower than those experienced in existing literature which was mostly obtained from men's professional Rugby union competitions.

Additionally, because the players of Rugby union are broadly split into two categories, they often require different characteristics and play different roles in a team. For the current study, the statistical analysis revealed no significant differences between forwards and backs. As learnt in chapter two, forwards and backs do possess different roles on the field as a result they have different characteristics. It is therefore suggested that forwards and backs get specific training drills tailored to their needs as they often perform different roles on the field during match-play. However, with regards to the demographic and anthropometric characteristics, significant differences between forwards and backs were reported for body mass while no significant differences were reported for age and stature.

Furthermore, as a result of the significant differences detected within the forwards and backs' time spent in speed zones and the number of impacts in impact zones. It can be concluded that firstly, the time spent in speed zones decreases as speed zones get more intense in terms of speed. Secondly, the number of impacts in impact zones also decreased as impact zones got intense. Therefore, from this it is suggested that coaches be specific with training and allocate training according to the amount of time spent in various activities.

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APPENDIX LIST

APPENDIX A: Table 1: Research conducted on women's Rugby union players.

Table 1: Scopus document search results for women's and female Rugby union studies globally.

Authors name	Title	Country	Research focus	Sample focus
1. Abdel-Salam, A., Eyres, K.S., Cleary, J. 1991	Internal fixation of closed tibial fractures for the management of sports injuries	United Kingdom	Sport injuries. Does not specify whether its talking about Rugby league or union	Group A, 42 men and three women, Group B, 41 men and four women,
2. Shewring, D.J., Matthewson, M.H. 1993	Injuries to the hand in Rugby Union Football	England	Rugby Union injuries	72 patients, two of whom were women
3. Gerrard, D.F., Waller, A.E., Bird, Y.N. 1994	The New Zealand Rugby Injury and Performance Project: II. Previous injury experience of a Rugby-playing cohort	New Zealand	Rugby injuries	Clubs & secondary school. Senior A, senior B, senior women and under 21 grades clubs, two schoolboy first XVs and three schoolgirl teams. 92 female and 258 male Rugby players.
4. Lewis, E.R., George, K.P. 1996	An initial investigation of injuries in women, men and youths playing Rugby Union football at the same club	Unspecified	Injury incidence rate	male (M), female (F) and youth (Y) Rugby Union players.
5. Nicholas, C.W. 1997	Anthropometric and physiological characteristics of Rugby union football players	Combination of data from different countries (Japan, South Africa, US, British)	Performance (Characteristics of players and demands of the game)	Rugby Union males and females
6. Bird, YN Waller, AE Marshall, SW Alsop, JC Chalmers, DJ Gerrard, DF.	The New Zealand Rugby injury and performance project: V. Epidemiology of a season of	New Zealand	incidence, nature, and circumstances of injury experienced	356 male and female Rugby players throughout the 1993 competitive club season

1998	Rugby injury			
7. Dietzen, C.J., Topping, B.R. 1999	Rugby football	United States	Safety knowledge	Women and Men
8. Gerrard, D.F. 1998	The use of padding in Rugby union. An overview	Southern Hemisphere	Injuries (prevention)	Women Rugby players
9. Marshall, W.S.W. 1998	The New Zealand Rugby Injury and Performance Project: V. Epidemiology of a season of Rugby injury	New Zealand	Injury and Performance	356 male and female Rugby players
10. Pringle, R.G. 1998	Incidence of sporting injury in New Zealand youths aged 6-15 years	New Zealand	Injuries	6-15 year olds playing Rugby union, Rugby league, and netball
11. Wilson, B.D., Quarrie, K.L., Milburn, P.D., Chalmers, D.J. 1999	The nature and circumstances of tackle injuries in Rugby union	New Zealand	Injuries	356 players. Male players from Senior A and B club teams, Under 21 teams, and Schoolboy First XV's (Under 18 and Under 19 grades). Female players from the Women's and Schoolgirl grades
12. Marshall, SW; Waller, AE Loomis, DP Feehan, M Chalmers, DJ Bird, YN; Quarrie, KL. 2001	Use of protective equipment in a cohort of Rugby players	New Zealand	To describe the level of usage of protective devices and equipment	Male and female players (N = 327)
13. Quarrie, K.L., Cantu, R.C., Chalmers, D.J. 2002	Rugby Union injuries to the cervical spine and spinal cord	Systematic review (Countries not all mentioned)	Injuries	Looked at both genders
14. Doyle, C; George, K. 2004.	Injuries associated with elite participation in women's Rugby over a competitive season: an	England	document and analyse injuries sustained over a competitive season	Thirty-five players in the England Women's Rugby elite squad 2001–2002.

	initial investigation			
15. Onyeaso, CO. 2004	Secondary school athletes: A study of mouthguards	Nigeria	to determine the extent of mouthguard awareness and use, amount and type of oro-facial trauma associated with and without mouthguard wear	Male and Female adolescent Nigerian contact sport athletes
16. Marshall, S.W., Loomis, D.P., Waller, A.E., (...), Quarrie, K.L., Feehan, M. 2005	Evaluation of protective equipment for prevention of injuries in Rugby union	Dunedin, New Zealand	injury prevention effectiveness of the protective equipment	304 players included 240 male and 87 female participants.
17. Comstock, RD); Fields, SK Knox, CL. 2005	Protective equipment use among female Rugby players	USA	to assess the prevalence of protective equipment use and the motivation for using protective equipment among a sample of US female Rugby players.	234 current US female Rugby players from 14 teams participating in a US women's Rugby tournament
18. Comstock, RD; Fields, SK. 2005	The fair sex? Foul play among female Rugby players	USA	to assess the players' perception of foul play and the referee response to foul play and to evaluate the association between players' perception of foul play and injury	258 females
19. Egan, E., Reilly, T., Giacomoni, M., Redmond, L., Turner, C. 2006	Bone mineral density among female sports participants	Unspecified	compare BMD and body composition measures and investigate differences from sedentary control subjects	female participants in three distinctly different sports. club and university level Rugby Union football players, netball players, distance runners, sedentary controls
20. Wilson, K.M., Hardy, L., Harwood, C.G. 2006	Investigating the relationship between achievement goals and process goals in Rugby union players	Unspecified	Performance	78 male and 72 female amateur club, professional club, country, national age group, and national level players.
21. Yard, Ellen Elizabeth;	Injuries sustained by Rugby players presenting to United	USA	Injuries	236539 Rugby players presented to US emergency departments.

Comstock, RD 2006	States emergency departments, 1978 through 2004			87.2% males
22. Walsh, M., Young, B., Hill, B., Kittredge, K., Horn, T. 2007	The effect of ball-carrying technique and experience on sprinting in Rugby union	Unspecified	Performance/Skills	52 Rugby players (34 males, 18 females
23. Dallalana, R.J., Brooks, J.H.M., Kemp, S.P.T., Williams, A.M. 2007	The epidemiology of knee injuries in english professional Rugby union	England	Injuries	Sample gender was not specified. 546 professional Rugby union players from 12 clubs
24. Fong, Daniel Tik-Pui; Hong, YL; Chan, LK; Yung, PSH; Chan, KM. 2007	A systematic review on ankle injury and ankle sprain in sports	38 countries	Injury reporting pattern	201600 athletes of different sport
25. Carter, A.F., Muller, R. 2008	A survey of injury knowledge and technical needs of junior Rugby Union coaches in Townsville (North Queensland)	Australia	Injury knowledge	registered coaches of junior Rugby Union teams with 11-19 year olds. 91% males and 9% females
26. Love, R.M., Ponnambalam, Y. 2008	Dental and maxillofacial skeletal injuries seen at the University of Otago School of Dentistry, New Zealand 2000-2004 (Rugby union was the most common sport associated	New Zealand	Injuries	16-25 year group with a male to female ratio of 2.01:1.
27. Fuller, C.W., Ward, C.J. 2008	An empirical approach for defining acceptable levels of risk: A case study in team sports	Unspecified	Safety	140 male athletes and 108 male and 100 female spectators associated with soccer and Rugby union teams
28. Kerr, H.A., Curtis, C., Micheli, L.J., (...), Kemp, S.P.T., Brooks, J.H.M. 2008	Collegiate Rugby union injury patterns in New England: A prospective cohort study	United States of America	Injury patterns	31 men's and 38 women's collegiate Rugby union teams prospectively recorded injuries during games and practice during the 2005-06 season.

29. Schick, D. M; Molloy, MG; Wiley, JP. 2008	Injuries during the 2006 Women's Rugby World Cup	All participating countries	Determine the rate of injury at the 2006 Women's Rugby World Cup	All participating teams in the 2006 WRWC were enrolled prospectively in this study
30. Gamble, Paul, 2008	Approaching physical preparation for youth team-sports players	Unspecified	Performance enhancement	young athletes competing in organized team sports
31. Nicol, A., Pollock, A., Kirkwood, G., Parekh, N., Robson, J. 2011	Rugby union injuries in Scottish schools	Scotland	incidence, pattern and severity of injuries	School Rugby union
32. Swain, M.S., Lystad, R.P., Pollard, H., Bonello, R. 2011	Incidence and severity of neck injury in Rugby union: A systematic review	Unspecified	Injuries	Rugby Union players, either male or female of any age
33. Williams, S., Hume, P.A., Kara, S. 2011	A review of football injuries on third and fourth generation artificial turfs compared with natural turf	Unspecified	compare the incidence, nature and mechanisms of injuries sustained on newer generation artificial turfs and natural turfs.	Rugby union, soccer, American football athle
34. Anastasi, S.M., Hamzeh, M.A. 2011	Does the eccentric Nordic Hamstring exercise have an effect on isokinetic muscle strength imbalance and dynamic jumping performance in female Rugby union players?	Unspecified	to test the effect of the NH based strength programme on hamstring muscle strength imbalance and maximal vertical jump performance	Female Rugby union players. The subjects were active participants in Rugby union at international and premiership club levels
35. Taylor, Aileen E; Fuller, CW Molloy, MG. 2011	Injury surveillance during the 2010 IRB Women's Rugby World Cup	Rugby World Cup	To assess and evaluate injuries sustained during the 2010 Women's Rugby World Cup.	285 women Rugby players.
36. Preatoni, E., Stokes, K., England, M., Trewartha, G. 2012	Forces generated in Rugby union machine scrummaging at various playing levels	Unspecified	scrummaging biomechanics (Performance)	34 forwards (women)
37. Bell, W., Colley, J.P., Evans, W.D., Darlington, S.E.,	ACTN3 genotypes of Rugby Union players: Distribution,	Unspecified	Biological/Physiological	Males and Females

Cooper, S.-M. 2012	power output and body composition			
38. Young, K., Kennedy, V., Kingsland, M., (...), Wiggers, J., Wolfenden, L. 2012	Healthy food and beverages in senior community football club canteens in New South Wales, Australia	South Wales and Australia	Food???	70 senior community football clubs (Australian Rules Football, Soccer, Rugby League and Rugby Union)
39. PONSETÍ, ROSA CALAFAT. 2012	Correlation of Tackle Ability in High Performance Spanish Women's Rugby Union Player.	Spanish	investigates the tackling ability of players	17 players at the highest level in Spain and 12 junior players who are in the Catalan High - Performance group. Spanish women's Rugby union.
40. Gevat,; Taskin, H; Arslan, F Larion, A Stanculescu, G. 2012	The Effects of 8-Week Speed Training Program on the Acceleration Ability and Maximum Speed Running at 11 Years Athletes	Unspecified	to examine the effects of an 8-week speed training program on the acceleration ability and maximum speed	30 healthy female athletes
41. Pogliaghi, S., Da Lozzo, G., Ceradini, V., De Roia, G.F. 2013	Physiological and anthropometric characteristics of elite women's Rugby union players (Book Chapter)	Unspecified	Performance	elite women's Rugby union players
42. Barié, A., Grossner, T., Streich, N. 2013	Injuries in Rugby union - Review of the current literature and epidemiology of medical reported injuries at the olympic trainings centre Rhein-Neckar Heidelberg	Heidelberg, Germany	Injuries	94 Rugby union players (15% women)
43. King, D., Brughelli, M., Hume, P., Gissane, C. 2013	Concussions in amateur Rugby union identified with the use of a rapid visual screening tool	New Zealand	Injuries and technology	premier club level amateur Rugby union team
44. Brown, J.C., Lambert,	The incidence of Rugby-related	South Africa	Injuries	amateur and professional Rugby-

M.I., Verhagen, E., (...), Van Mechelen, W., Viljoen, W. 2013	catastrophic injuries (including cardiac events) in South Africa from 2008 to 2011: A cohort study			playing population. 529 483 Junior and 121 663 Senior Rugby union ('Rugby') players (population at risk). Males and females
45. Cummins, C., Orr, R., O'Connor, H., West, C. 2013	Global positioning systems (GPS) and microtechnology sensors in team sports: A systematic review	Unspecified	Performance enhancement through technology use	male and female; age 12-50 years. Australian football league (AFL; n = 8), soccer (n = 7), Rugby union (n = 6), and Rugby league (n = 6), with limited representation in other team sports: cricket (n = 3), hockey (n = 3), lacrosse (n = 1), and netball (n = 1).
46. Zietsman, B.B. and McCarthy, P.W. 2013	Position played affects cervical spine range of motion of elite female Rugby union players.	Wales	to determine if playing a contact sport such as Rugby union decreases cervical (neck) active flexion/extension in the elite female game.	Female Welsh international Rugby Union players in the 2011 pre-season training camp squad were invited to participate (age 24 ±4yrs)
47. Hene, N. M.; Bassett, S. H. 2013	Changes in the physical fitness of elite women's Rugby union players over a competitive season.	South Africa	Performance/ Physical characteristics	Thirty-two elite women's Rugby union players, all members of the South African Rugby Union High Performance Squad, were sub-divided into 2 positional categories of 17 forwards and 15 backs
48. Agel, J and Schisel, J. 2013	Practice Injury Rates in Collegiate Sports	Unspecified	to explore the differences in practice injury rates for select National Collegiate Athletic Association (NCAA) sports within and across sport by preseason, in-season, and postseason.	Agel, J and Schisel, J. 2013
49. Fraas, M.R.,	Concussion history and	Ireland	Injuries and reporting	four professional Irish Rugby

Coughlan, G.F., Hart, E.C., McCarthy, C. 2014	reporting rates in elite Irish Rugby union players			union clubs. Not clear whether there were females
50. King, D., Gissane, C., Brughelli, M., Hume, P.A., Harawira, J. 2014	Sport-related concussions in New Zealand: A review of 10years of Accident Compensation Corporation moderate to severe claims and costs	New Zealand	Injuries, Costs retrospective review of injury entitlement claims	Seven sport codes from 2001 to 2011, Including Rugby union. Genders were both looked at
51. Robertson, G.A.J., Wood, A.M., Heil, K., Aitken, S.A., Court-Brown, C.M. 2014	The epidemiology, morbidity and outcome of fractures in Rugby union from a standard population	United Kingdoms	Injuries	Males and females
52. Kodama, N., Takemura, Y., Ueba, H., Imai, S., Matsusue, Y. 2014	Operative treatment of metacarpal and phalangeal fractures in athletes: early return to play	Unspecified	Injuries	6 Rugby football players, 2 soccer goalkeepers, 3 American football players, 3 handball players, 2 baseball players and 4 who participated in other sports. (Not mentioned is whether there were males or females)
53. Virr, J.L., Game, A., Bell, G.J., Syrotuik, D. 2014	Physiological demands of women's Rugby union: time-motion analysis and heart rate response	Canada	Performance improvement	Thirty-eight premier club level female Rugby players, ages 18-34 years
54. Suarez-Arrones, L., Portillo, J., Pareja-Blanco, F., (...), Sánchez-Medina, L., Munguía-Izquierdo, D. 2014	Match-play activity profile in elite women's Rugby union players	"International"	Performance improvement (using GPS)	8 international female Rugby union players
55. Gardner, A.J., Iverson, G.L., Williams, W.H., Baker, S., Stanwell, P. 2014	A systematic review and meta-analysis of concussion in Rugby Union	Unspecified	Injuries (concussion)	Men's 7s and 15s Women's 7s and 15s

56. Venter, R.E. 2014	Perceptions of team athletes on the importance of recovery modalities	Unspecified	Performance knowledge	A total of 890 athletes who volunteered to participate in the study were team players from field hockey, netball, Rugby union and soccer. 507 (57%) men and 383 (43%) women
57. Doherty, Cailbhe; Delahunt, E Caulfield, B Hertel, J Ryan, J Bleakley, C. 2014	The Incidence and Prevalence of Ankle Sprain Injury: A Systematic Review and Meta-Analysis of Prospective Epidemiological Studies	Unspecified	to provide an up-to-date account of the incidence rate and prevalence period of ankle sprain injury unlimited by timeframe or context activity	Males and Females
58. Bohu, Y., Klouche, S., Lefevre, N., (...), Ribaut, A., Herman, S. 2015	The epidemiology of 1345 shoulder dislocations and subluxations in French Rugby Union players: A five-season prospective study from 2008 to 2013	French Rugby union	Injuries (Shoulder)	1317 men and 28 women, mean age 22.5±5.9 years from senior professionals, senior amateurs, juniors, cadets and Rugby school players
59. Kirkwood, G., Parekh, N., Ofori-Asenso, R., Pollock, A.M. 2015	Concussion in youth Rugby union and Rugby league: A systematic review	United Kingdom	Injuries	Genders unspecified. child and adolescent Rugby union and Rugby league (under 20 years)
60. Freitag, A., Kirkwood, G., Scharer, S., Ofori-Asenso, R., Pollock, A.M. 2015	Systematic review of Rugby injuries in children and adolescents under 21 years	United Kingdoms	Injuries	Rugby union and league injuries among players under the age of 21 years
61. King, D., Hume, P.A., Brughelli, M., Gissane, C. 2015	Instrumented mouthguard acceleration analyses for head impacts in amateur Rugby union players over a season of matches	America	Studying of injuries through the use of technology	38 premier amateur senior Rugby players participating in the 2013 domestic season of matches.
62. Broad, M., Welbury, R. 2015	CLUB POLICIES FOR MOUTH PROTECTORS AND DENTAL EMERGENCY COVER IN	Scotland	Injuries and safety	SRU affiliated clubs with junior playing members. Gender unspecified

	SCOTTISH RUGBY UNION (SRU) AFFILIATED JUNIOR TEAMS			
63. Guzzini, M., Vadalà, A., Agrò, A., (...), Lanzetti, R.M., Ferretti, A. 2016	Nonsurgical treatment of Mason type II radial head fractures in athletes. A retrospective study	Unspecified	Injuries	52 patients (31 males, 21 females). bicyclists, or baseball, boxers, basketball, Rugby, tennis or football players.
64. Mathema, P., Evans, D., Moore, I.S., Ranson, C., Martin, R. 2016	Concussed or Not? An Assessment of Concussion Experience and Knowledge Within Elite and Semi professional Rugby Union	Wales	Injury knowledge	international, professional and semiprofessional players, coaches, medical staff, and referees within Rugby Union
65. Kim, S.Y., Chan, C.L., Hyam, D.M. 2016	Facial fractures in football: incidence, site, and mechanism of injury	Australia	Injuries	Rugby league, Rugby union, Australian rules, and soccer matches.
66. Lemez, S., Macmahon, C., Weir, P. 2016	Relative Age Effects in Women's Rugby Union from Developmental Leagues to World Cup Tournaments	Canada and New Zealand	Prevalence of relative age effects	Player data (age range = 4-21+ years) were gathered from the 2006 and 2010 Rugby World Cups (n = 498) and from Canadian (n = 1,497) and New Zealand (NZ; n = 13,899) developmental Rugby leagues.
67. Heffernan, S.M., Kilduff, L.P., Erskine, R.M., (...), Pitsiladis, Y.P., Williams, A.G. 2016	Association of ACTN3 R577X but not ACE I/D gene variants with elite Rugby union player status and playing position	Unspecified	Medical, Physiological or biological	710 Caucasian men and women, forwards and backs.
68. Jones, T.W., Smith, A., Macnaughton, L.S., French, D.N. 2016	Strength and conditioning and concurrent training practices in elite Rugby union	International	Performance	elite men's and women's Rugby Union
69. Pfister, K Hagel, B	The incidence of concussion in youth sports: a systematic	Systematic review	overall risk of concussion in youth sports and compare sport-specific	Males and female over 18 years of different sports

Ghali, WA Ronksley, PE. 2016	review and meta-analysis		estimates of concussion risk.	
70. Hughes, A., Barnes, A., Churchill, S.M., Stone, J.A. 2017	Performance indicators that discriminate winning and losing in elite men's and women's Rugby union	Unspecified	Performance	elite men's and women's Rugby Union
71. Pollard, R., Prieto, J., Gómez, M.-Á. 2017	Global differences in home advantage by country, sport and sex	Unspecified	use a multivariate approach to investigate variations in home advantage between different team sports and between different countries	men's and women's competition
72. Balasundaram, A.P., Athens, J., Schneiders, A.G., McCrory, P., Sullivan, S.J. 2017	Do post-concussion-like symptom responses change following exercise or sports participation in a non-concussed cohort?	Unspecified	to determine the reliable change in post-concussion-like symptoms reported following self-selected exercise or sports activities and, to explore the potential influence of gender and exercise parameters on post-concussion-like symptoms reported by a non-concussed cohort following exercise	sample of students aged 18–30 years who visited a university recreation center to engage in their chosen exercise activity and a purposeful sample of men's and women's Rugby union players engaged in their regular training sessions
73. Dobbs, I.J., Watkins, C.M., Barillas, S.R., Wong, M.A., Brown, L.E. 2017	Assessing knee strength ratios and bilateral deficit via dynamic vs. static tests in amateur Rugby union players	Unspecified	Performance	male and female amateur Rugby union players
74. Jones, T.W., Smith, A., Macnaughton, L.S., French, D.N. 2017	Variances in strength and conditioning practice in elite Rugby union between the Northern and Southern Hemispheres	Northern and Southern Hemisphere	Performance	Forty (20 NH, 20 SH, 38 males, 2 females; 33.0 6 5.5 years) of 52 (77%) coaches
75. Kearney, P.E., See, J. 2017	Misunderstandings of concussion within a youth Rugby population	Hertfordshire and Sussex in the south of England	Knowledge on injuries	255 players, male (n = 238) and female (n = 17) aged 11–17 years

76. Hill, D.M., Carvell, S., Matthews, N., Weston, N.J.V., Thelwell, R.R.C. 2017	Exploring choking experiences in elite sport: The role of self-presentation	Unspecified	Injuries	9 elite athletes (6 male and 3 female. netball, Rugby union, golf, tennis, and cricket
77. Clacy, A., Goode, N., Sharman, R., Lovell, G.P., Salmon, P.M. 2017	A knock to the system: A new sociotechnical systems approach to sport-related concussion	Australia	Injuries	118 members of the community Rugby union
78. Balasundaram, A.P., Athens, J., Schneiders, A.G., McCrory, P., Sullivan, S.J. 2017	Do post-concussion-like symptom responses change following exercise or sports participation in a non-concussed cohort?	Unspecified	Injuries	260 participants (146 males and 114 females. Including Rugby union players
79. Watkins, Casey M 2017	DETERMINATION OF VERTICAL JUMP AS A MEASURE OF NEUROMUSCULAR READINESS AND FATIGUE	Unspecified	Performance	11 males and 7 females (from Rugby league and Rugby union)
80. Green, B Pizzari, T 2017	Calf muscle strain injuries in sport: a systematic review of risk factors for injury	Systematic review	review the literature to identify risk factors for calf strain injury	5397 Australian football, Rugby union, basketball and triathlon athletes
81. Chow, GCC; Chung, JWY; Ma, AWW Macfarlane, DJ Fong, SSM. 2017	Sensory organisation and reactive balance control of amateur Rugby players: A cross-sectional study	Unspecified	compared the sensory organisation and reactive balance control of amateur Rugby players	22 males: 19 females;
82. Dobbs, I.J. Watkins, CM Barillas, SR Wong, MGA Brown, LE. 2017	Assessing knee strength ratios and bilateral deficit via dynamic vs. static tests in amateur Rugby union players	Unspecified	Performance	6 male and 11 female amateur Rugby union players
83. Viviers, P.L., Viljoen, J.T., Derman, W. 2018	A Review of a Decade of Rugby Union Injury Epidemiology: 2007-2017	Unspecified	injury trends across the spectrum of various Rugby union subpopulations, highlight gaps that may influence future injury	Studies on 15-a-side Rugby union (men and women)

			prevention tactics.	
84. Bowes, A., Bairner, A. 2018	England's proxy warriors? Women, war and sport	England	to 'give a voice' to women whose experiences have often been ignored by both the popular press and academics alike. both on the field of play and more broadly	female athletes (cricket, netball, association football and Rugby union)
85. Curtis, C., Russell, M., Ranchordas, M.K. 2018	Enhancing dietary practices, general nutrition knowledge and body composition of a female International Rugby Union player incorporating smartphone application technology	England	Health and technology incorporation to improve performance	2 19-year-old female Rugby Union players,
86. Fuller, G.W., Govind, O., Tucker, R., Raftery, M. 2018	Sport concussion assessment tool—Third edition normative reference values for professional Rugby Union players	national and international professional competitions	Injury assessment	3611 professional Rugby Union players
87. Armstrong, R., Greig, M. 2018	The Functional Movement Screen and modified Star Excursion Balance Test as predictors of T-test agility performance in university Rugby union and netball players	Unspecified	Performance	Thirty-two female Rugby players, 31 male Rugby players and 39 female netballers
88. Brown, J.C., Boucher, S.J., Lambert, M., (...), Hendricks, S., Kraak, W.J. 2018	Non-sanctioning of illegal tackles in South African youth community Rugby	South Africa	Safety	99 South African Rugby Union U18 Youth Week tournament matches were coded between 2011 and 2015
89. Schneuer, F.J., Bell, J.C., Adams, S.E., (...), Finch, C., Nassar, N. 2018	The burden of hospitalized sports-related injuries in children: an Australian population-based study, 2005–2013	Australia	Injuries	children 5 to 15 years of age Rugby league/union and soccer

90. Le Flao, Enora Brughelli, M Hume, PA King, D. 2018	Assessing Head/Neck Dynamic Response to Head Perturbation: A Systematic Review	Unspecified	to compare methodologies utilised to assess head/neck dynamic response to perturbation	Le Flao, Enora Brughelli, M Hume, PA King, D. 2018
91. Armstrong, Ross; Greig, Matt 2018	INJURY IDENTIFICATION: THE EFFICACY OF THE FUNCTIONAL MOVEMENT SCREEN (TM) IN FEMALE AND MALE RUGBY UNION PLAYERS	United Kingdoms	development of effective injury prevention strategies is required.	Sixty-four female university Rugby union players (age: 20.39 ± 1.91 years) and 55 male university Rugby union players
92. Cross, Matt R 2018	Training at maximal power in resisted sprinting: Optimal load determination methodology and pilot results in team sport athletes	Finland and France	Performance	Soccer [n = 15 male] and Rugby [n = 21; 9 male and 12 female] club-level athletes
93. King, D., Hume, P.A., Hardaker, N., (...), Pearce, A.J., Gissane, C. 2019	Female Rugby union injuries in New Zealand: A review of five years (2013–2017) of Accident Compensation Corporation moderate to severe claims and costs	New Zealand	Injuries/Business	women's Rugby union
94. King, D., Hume, P., Cummins, C., (...), Foskett, A., Barnes, M. 2019	Match and Training Injuries in Women's Rugby Union: A Systematic Review of Published Studies	Unspecified	Injury incidence	Women's Rugby- 7s and 15s
95. Kirkwood, G., Hughes, T.C., Pollock, A.M. 2019	Results on sports-related injuries in children from NHS emergency care dataset Oxfordshire pilot: an ecological study	England	Injuries	Children and adolescents aged 0–19 years. Several sports including Rugby union
96. Bussey, M.D., McLean, M., Pinfold, J., (...), Romanchuk, J., Salmon, D.	History of concussion is associated with higher head acceleration and reduced	Unspecified	Performance and history of injury	7female with no-concussion history, 10 3female within 12-months of concussion and 7

2019	cervical muscle activity during simulated Rugby tackle: An exploratory study			3female with 24 + months since last concussion. 27 male and female Club Rugby union players
97. Morgan, R., Wright, S.L., Noon, M., Robertson, P., Price, M. 2019	Cervical range of motion in school age Rugby union players: A cross sectional study	English National 3 North	Performance	59 school age Rugby union players
98. King, D., Hume, P.A., Hardaker, N., (...), Gissane, C., Clark, T. 2019	Sports-related injuries in New Zealand: National Insurance (Accident Compensation Corporation) claims for five sporting codes from 2012 to 2016	New Zealand	Injuries	cricket, netball, Rugby league, Rugby union and football male and female players
99. Clacy, A., Goode, N., Sharman, R., Lovell, G.P., Salmon, P. 2019	A systems approach to understanding the identification and treatment of sport-related concussion in community Rugby union	Australia	Injury knowledge	118 members of the amateur (community) Rugby union. players, parents, medics, coaches, club managers, administrators, and volunteers
100. Yeomans, C., Comyns, T.M., Cahalan, R., (...), Glynn, L.G., Kenny, I.C. 2019	The relationship between physical and wellness measures and injury in amateur Rugby union players	Ireland	Performance and injury	Male (n = 113) and female (n = 24) amateur Rugby union players from 5 of the top 58 amateur clubs
101. Holmes, G., Clacy, A., Salmon, P.M. 2019	Sports-related concussion management as a control problem: using STAMP to examine concussion management in community Rugby	Australia	Injury management	community level Rugby union (n = 12) management or organisational roles 72% male and 28% female
102. Brown, J.C., Cross, M., England, M., (...), Verhagen, E., Fuller, C.W.	Guidelines for community-based injury surveillance in Rugby union	Australia, New Zealand, South Africa,	Injury surveillance	all age groups; male /female players; and all formats of the game, such as 15s, 7s and tag Rugby

2019		The Netherlands and the United Kingdom.		
103. Moore, Emma; Chalmers, Samuel; Milanese, Steve; et al. 2019	Factors Influencing the Relationship Between the Functional Movement Screen and Injury Risk in Sporting Populations: A Systematic Review and Meta-analysis	Unspecified	association between the Functional Movement Screen (FMS) and sports injury risk	Range of athlete populations including Rugby union
104. Petrakos, G; Tynan, NC Vallely-Farrell, AM Kiely, C Boudhar, A Egan, B. 2019	RELIABILITY OF THE MAXIMAL RESISTED SPRINT LOAD TEST AND RELATIONSHIPS WITH PERFORMANCE MEASURES AND ANTHROPOMETRIC PROFILE IN FEMALE FIELD SPORT ATHLETES	Unspecified	Performance	female field sport athletes.
105. Bradley, E.J., Board, L., Hogg, B., Archer, D.T. 2020	Quantification of Movement Characteristics in Women's English Premier Elite Domestic Rugby Union	English	Performance improvement (using GPS)	English domestic women's Rugby union
106. Sheppy, E., Hills, S.P., Russell, M., (...), McNarry, M., Kilduff, L.P. 2020	Assessing the whole-match and worst-case scenario locomotor demands of international women's Rugby union match-play	International	Performance	Twenty-nine international women's Rugby union players
107. Escobar, J.A., Álvarez, P.J.R., Da Conceição, F.A., Fuentes García, J.P. 2020	Does the Initial Level of Horizontal Force Determine the Magnitude of Improvement in Acceleration Performance in Rugby?	Unspecified	Performance	31 female amateur Rugby union players

108. Valenzuela, P.L., McGuigan, M., Sánchez-Martínez, G., (...), Pereira, L.A., Loturco, I. 2020	Reference power values for the jump squat exercise in elite athletes: A multicenter study	Madrid, Spain; and São Paulo, Brazil	Performance	684 elite athletes (458 male and 226 female) of 16 different sports (boxing, judo, karate, fencing, taekwondo, wrestling, basketball, soccer, futsal, handball, Rugby union, badminton, tennis, long distance running, triathlon, and sprinting
109. Black, A.M., Miutz, L.N., Warriyar, V., (...), Yeates, K.O., Emery, C.A. 2020	Baseline performance of high school Rugby players on the sport concussion assessment tool 5	Canada	Performance and injury assessment	High school Rugby union players. n = 380, males = 210, females = 170
110. Quarrie, K., Gianotti, S., Murphy, I. 2020	Injury Risk in New Zealand Rugby Union: A Nationwide Study of Injury Insurance Claims from 2005 to 2017	New Zealand	Injury and business	Rugby union players aged 5–40 years.
111. Brisbine, B.R., Steele, J.R., Phillips, E., McGhee, D.E. 2020	Breast injuries reported by female contact football players based on football code, player position and competition level	Australia	Injuries AND Safety	297 female Australian Football, Rugby League, Rugby Union (XVs) and Rugby 7s players. 242 coaching and medical staff
112. Little, J.-A., Eckert, F., Douglas, M., Barrett, B.T. 2020	Eyewear for Rugby Union: Wearer Characteristics and Experience with Rugby Goggles	Twenty-three Rugby Unions took part in the trial.	Safety	11 females and 177 males
113. Martin, E., Beckham, G. 2020	Force production during the sustained phase of Rugby scrums: A systematic literature review	Unspecified	Performance	Both genders
114. Sasaki, K., Sato, H., Nakamura, A., (...), Katsuta,	Clarifying the structure of serious head and spine injury in	Japan	cause of Rugby head and spinal cord injuries	Both genders

T., Kono, I. 2020	youth Rugby Union players			
115. Brisbine, B.R., Steele, J.R., Phillips, E.J., McGhee, D.E.	Breast and torso characteristics of female contact football players: implications for the design of sports bras and breast protection	Australia	Injury prevention/protection	female contact football players. 117 AFL, Rugby League, Rugby Union and Rugby 7s players
116. Salmon, D.M., Mcgowan, J., Sullivan, S.J., (...), Clacy, A., Romanchuk, J. 2020	What they know and who they are telling: Concussion knowledge and disclosure behaviour in New Zealand adolescent Rugby union players	New Zealand	survey players ethnic, geographic and socioeconomic backgrounds to gain an understanding of concussion knowledge, awareness of NZ Rugby's (NZR) guidelines and attitudes towards reporting behaviours	Male and female high school Rugby players (n= 416)
117. Posthumus, L., Macgregor, C., Winwood, P., (...), Driller, M., Gill, N. 2020	The physical characteristics of elite female Rugby union players	New Zealand	Performance	30 elite female Rugby union players
118. Leahy, Therese M.; Kenny, Ian C.; Campbell, Mark J.; et al. 2020	Injury surveillance and prevention practices across Rugby schools in Ireland	Ireland	Injuries	Ninety-three Rugby playing schools (97% male, 3% female) school Rugby teams.

APPENDIX B: Rhodes University's Ethical Clearance

RHODES UNIVERSITY
Where leaders learn

Rhodes University Human Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
t: +27 (0) 46 603 7727
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e: s.manqele@ru.ac.za
NHREC Registration number: RC-241114-045

https://www.ru.ac.za/researchgateway/ethics/

05/05/2021

Peni Mbane

Email: g14M2339@campus.ru.ac.za

Review Reference: 2021-3845-6030

Dear Mr. Andrew Todd

Title: Investigating and quantifying the physical and physiological demands of amateur women's rugby union players using Global Positioning System (GPS).

Principal Investigator: Mr. Andrew Todd

Collaborators: Ms. Nomabhelu Mbane,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Ethics Committee (RU-HEC). Your Approval number is: 2021-3845-6030

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying you when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated.

Sincerely,

Prof Arthur Webb

Chair: Rhodes University Human Ethics Committee, RU-HEC

cc: Mr. Siyanda Manqele - Ethics Coordinator

APPENDIX C: SEDRU Ethical Clearance:

SOUTH EASTERN DISTRICTS RUGBY SUB-UNION
SEDRU

All correspondence / enquiries to:

The Chairperson
Cell No.: 083 403 1017
Deon Hilpert

47 Middle Terrace, Grahamstown 6139
email: HilpertDX@saps.gov.za
email:

TO : THE CHAIR:RHODES UNIVERSITY HUMAN ETHICS COMMITTEE: PROF. A. WEBB

CC : ETHICS COORDINATOR

: RHODES UNIVERSITY

FROM : SOUTH EASTERN DISTRICTS RUGBY SUB-UNION

ENQUIRIES : **Chairperson – Deon Hilpert**

Dear Professor

Re : **INVESTIGATING AND QUANTIFYING THE PHYSICAL AND PHYSIOLOGICAL DEMANDS OF AMATEUR WOMEN`S RUGBY UNION PLAYERS USING GPS SYSTEM**

DATE : **MONDAY, 26 APRIL 2021**

The above-mentioned Sub-Union, an affiliate of Eastern-Province Rugby Union hereby grant permission for the study to be done within the boundaries of SEDRU Sub-Union.

Our affiliates are situated in Makhanda, Alicedale, Alexandria, Klipfontein and Port-Alfred. We have two active womens teams, situated in Makhanda and Porty-Alfred.

We trust that both parties will benefit from this study and also that the results will benefit the rugby fraternity beyond the borders of SEDRU Sub-Union.

Yours in the promotion of grassroots sports

Many Thanks.

Kind Regards.

Deon Hilpert (Chairperson- SEDRU)

APPENDIX D: Letter to participants and informed consent forms

DEPARTMENT OF HUMAN KINETICS AND ERGONOMICS

INFORMATION LETTER TO PARTICIPANTS

Researcher - 076 707 2736 | g14m2339@campus.ru.ac.za

Supervisor - 046 603 8469 | a.todd@ru.ac.za

Dear ……...

Thank you for showing interest towards the research project titled: **"Investigating and quantifying the physical and physiological demands of amateur women's Rugby union players using Global Positioning System (GPS)."** This study (tracking number 3845) has been approved by the Rhodes University Ethical Standard Committee. Please read this information letter carefully as it contains all the necessary information you need to know before consenting to participate in the study. Please note that participation is absolutely voluntary, no one will be pressurized to take part in the study.

PURPOSE OF THE STUDY

Recently there has been a rapid increase of women's participation in Rugby union. However, this participation has not been matched with an increase in scientific research. The lack of research is an area of concern as it makes it difficult for coaches to design effective training programs for athletes since there is not enough data to base decision making on. Particularly in the Sarah Baartman district, Eastern Cape, grassroots Rugby dominates in terms of the number of players and tournaments, yet there is little data providing coaches and players with information on appropriate training techniques and levels. To improve performance and prevent injury in this large population of Rugby, it is necessary to gain information on training demands so that appropriate training loads can be implemented. This need is even more in women's Rugby in the Sarah Baartman region, on which there has been no research conducted to date.

Therefore, the purpose of the current study is to investigate the training or match play demands of women's Rugby players in the Sarah Baartman district in the Eastern Cape. To achieve this objective, modern technology available in GPS tracking, commonly used across multiple sporting codes, will be used to monitor the physical and physiological demands.

PROCEDURES

Overview:

In addition to 2 familiarization sessions, you will be required to attend 21 training sessions which will be split into 3 sets of 7 sessions each. 15 participants will be split into 3 groups of 5 and training demands will be collected up to 7 times on each group of 5. You will be required to attend all 21 sessions as data collection will be done randomly on each group. All sessions will take place at the Station hill sport field, Monday to Thursday from 18:00. During training, please make sure to adhere to all covid19 protocols as explained below.

Covid19 Protocols (https://playerwelfare.worldRugby.org/covid-19)

1. *Respect government rules and guidelines.*
2. *Bring and use your own clothing and water bottle.*
3. *Clean and disinfect hands and equipment before, during and after training.*
4. *Respect social distancing before, during and after training.*
5. *Keep tackling low to avoid transmission.*
6. *Avoid spitting and clearing your nose.*
7. *Have fun but do not celebrate with or high five other teammates.*
8. *Return home immediately after training.*

Introductory session:

You will be introduced to the researcher(s), they will take you through the everything you will need to know about the study. This session will also be used to answer questions that you may have, you will also be asked for a verbal and written consent to take part in the study.

Demographic data collection:

Your age, body mass and stature will be measured and recorded, this is to inform details of the participants characteristics. Your body mass and stature will be measured using a weighing scale and stature scale, respectively. During this session you will also be taken through the equipment, how it works, worn, switched on and off etc. A demonstration video will be provided to you to have and watch when you need to. NOTE! This is to limit unnecessary physical contact between you and the researcher(s). However, the researcher(s) will be present at every session to deal with any technical difficulties that may arise.

Physical and Physiological data collection:

You will be given a clean and disinfected GPS XT 10Hz tracking device, bioharness module, chest strap and a vest. Following the instructions from the video you will attach the bioharness module in its place and turn it on, you will then turn on the GPS and place it in the pocket at the back of the vest. You will then wear the chest strap followed by the vest and follow the coach's instruction for warmups. You will wear the vest under your playing shirt for the whole duration of the training session. For all the 7 sessions you will be required to wear the same vest and use the same GPS device unit. If you get an injury during a session or are being substituted switch the device off at that time. When the session has ended you will take off the vest and

the chest strap and switch off the 2 devices and return them to the researcher(s) for data analysis.

PARTICIPANT CHARACTERISTICS

The current study will require women's Rugby union players from an amateur club around the Eastern Cape, South Africa. The participants must be over the age of 18 years. Participants must be in good health, injury free, comfortable with equipment (especially because it will be strapped to their bodies).

POTENTIAL RISKS AND BENEFITS

This study will not interfere with the participants performance as it will only record their performance. The equipment used is regularly used to monitor match play workloads and provides no additional risks to participation in Rugby. The purpose of the study is to monitor workload that is experienced during match play and therefore does not add any additional workload or risk. The participants will be free and are encouraged to play as they would have in their normal training sessions or competitive games. Possible risks will be the equipment possibly causing discomfort as players might feel like they are being watched however because they are used to being watched by an audience this should not be a problem. Another possible risk might be the transmission of covid19, however South African Rugby Union has allowed players to go back to training following covid19 protocols.

Benefits derived from this study will include exposure to new and high-tech equipment such as GPS trackers and accelerometers which may otherwise be difficult to come across. Participants will also contribute to the improved understanding of the physical and physiological demands placed on players during a game. Other benefits will include seeing their objectified and quantified performance and capability allowing them the opportunity to maintain or improve their performance.

ARCHIVED DATA, ANONIMITY AND FEEDBACK

The data collected from this study will be stored until the study has been completed and the researcher has received feedback from the examiners, signifying the completion of the degree. Following that the data will be stored at the Human Kinetics and Ergonomics departments archives and can be used for publication purpose as group's summary data. Any personal information collected from the participants will be stored and accessed by only the main researcher or supervisor. The data collected from the participants will be stored using a coding system to ensure anonymity. At an appropriate time for the researcher and participants a feedback session will be organized with the gatekeeper(s) to thank and present the outcomes of the study.

Thank you for showing an interest in our study. We hope you will learn a lot from it and that you will enjoy the experience. If you have any further questions, please feel free to contact us directly.

Researcher: Nomabhelu Mbane, g14m2339@campus.ru.ac.za, 076 707 2736

Co-researcher and Supervisor: Andrew Todd, a.todd@ru.ac.za, 046 603 8469

Ethics Coordinator: Siyanda Manqele, s.manqele@ru.ac.za, 046 603 7727

PARTICIPANT: _____

(Print name) **(Signed)** **(Date)**

WITNESS: _____

(Print name) **(Signed)** **(Date)**

RESEARCHER: _____

(Print name) **(Signed)** **(Date)**

Yours sincerely

Nomabhelu Mbane

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

DEPARTMENT OF HUMAN KINETICS AND ERGONOMICS

INFORMED CONSENT AND INDEMNITY FORM

Researcher - 076 707 2736 | g14m2339@campus.ru.ac.za

Supervisor - 046 603 8469 | a.todd@ru.ac.za

I.....

have been fully informed of the research project titled: **"Investigating and quantifying the physical and physiological demands of amateur women's Rugby union players using Global Positioning System (GPS)."**

I have read the information sheet and understand the data collection process that will take place. All data collection procedures, associated risks and the benefits from partaking in this study have been verbally explained to me as well as in writing [information letter appended to this document]. I have had ample opportunity to ask questions and to clarify any concerns or misunderstandings. I am satisfied that these have been answered satisfactorily. I understand that all data collected for publication purposes will be kept anonymous and all information gained in this regard will be treated confidentially. Furthermore, I consent to photographs, knowing that these will be altered to ensure my anonymity. I understand that I can withdraw from the study at any point, irrespective of external influences placed on me by the researcher.

In agreeing to participate in this research study I waive any legal recourse against the researchers from the Department of Human Kinetics and Ergonomics, Rhodes University, from claims resulting from personal injuries sustained whilst participating in the above-mentioned research. I am aware and fully understand that the Department of Human Kinetics and Ergonomics is not responsible for any injuries due to my personal negligence and non-compliance with instructions. This waiver shall be binding upon my heirs and personal representatives.

I have read and understood the above information, as well as the information provided in the letter accompanying this form. I therefore consent to voluntarily participate in this research project.

PARTICIPANT: _____

(Print name) **(Signed)** **(Date)**

WITNESS: _____

(Print name) **(Signed)** **(Date**

RESEARCHER: _____

(Print name) **(Signed)** **(Date)**

APPENDIX E: Anthropometric data collection sheet

Women's Rugby Union Demographic Data:

Pseudonym	**Age (years)**	**Body mass (kg)**	**Stature (m)**
1. Pink/17	18	55	1.661
2. Red/24	18	90	1.650
3. Red/17	18	83	1.650
4. Orange/17	20	92	1.631
5. Yellow/24	21	55	1.499
6. Yellow/31	22	80	1.647
7. Light Green/24	23	91	1.658
8. Pink/24	26	66	1.506
9. White/17	27	65	1.565
10.Dark Green/17	27	51	1.564
11.Light Green/31	27	62	1.633
12.Dark Green/24	28	69	1.573
13.Yellow/17	29	64	1.679
14.Red/31	30	68	1.621
15.Orange/24	31	51	1.530
16.Light Green/17	31	57	1.592
17.Dark Green/31	30	83	1.581
18.Pink/31	36	54	1.520

APPENDIX F: Daily training session's schedule for data collection.

Date: 17 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green17	Backline	MODULE: Dark Green STRAP: Small	Dark Green	Small
Light Green17	Backline	MODULE: Light Green STRAP: Small	Light Green	Small
Orange17	Forward	MODULE: Orange STRAP: Large	Orange	Large
Yellow17	Backline	MODULE: Yellow STRAP: Medium	Yellow	Medium
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink17	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red17	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 18 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green17	Backline	MODULE: Dark Green STRAP: Small	Dark Green	Small
Light Green17	Backline	MODULE: Light Green STRAP: Small	Light Green	Small
Orange17	Forward	MODULE: Orange STRAP: Large	Orange	Large
Yellow17	Backline	MODULE: Yellow STRAP: Medium	Yellow	Medium
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink17	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red17	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 19 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green17	Backline	MODULE: Dark Green STRAP: Small	Dark Green	Small
Light Green17	Backline	MODULE: Light Green STRAP: Small	Light Green	Small
Orange17	Forward	MODULE: Orange STRAP: Large	Orange	Large
Yellow17	Backline	MODULE: Yellow STRAP: Medium	Yellow	Medium
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink17	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red17	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 24 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green24	Forward	MODULE: Dark Green STRAP: Medium	Dark Green	Medium
Light Green24	Forward	MODULE: Light Green STRAP: Large	Light Green	Large
Orange24	Backline	MODULE: Orange STRAP: Small	Orange	Small
Yellow24	Backline	MODULE: Yellow STRAP: Small	Yellow	Small
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink24	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red24	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 25 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green24	Forward	MODULE: Dark Green STRAP: Medium	Dark Green	Medium
Light Green24	Forward	MODULE: Light Green STRAP: Large	Light Green	Large
Orange24	Backline	MODULE: Orange STRAP: Small	Orange	Small
Yellow24	Backline	MODULE: Yellow STRAP: Small	Yellow	Small
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink24	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red24	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 26 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green24	Forward	MODULE: Dark Green STRAP: Medium	Dark Green	Medium
Light Green24	Forward	MODULE: Light Green STRAP: Large	Light Green	Large
Orange24	Backline	MODULE: Orange STRAP: Small	Orange	Small
Yellow24	Backline	MODULE: Yellow STRAP: Small	Yellow	Small
White17	Backline	MODULE: White STRAP: Medium	White	Medium
Pink24	Backline	MODULE: Pink STRAP: Small	Pink	Small
Red24	Forward	MODULE: Red STRAP: Large	Red	Large

Date: 31 May 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green31	Forward	MODULE: Dark Green	Dark Green	Large
		STRAP: Large		
Light Green31	Forward	MODULE: Light Green	Light Green	Small
		STRAP: Small		
Orange17	Forward	MODULE: Orange	Orange	Large
		STRAP: Large		
Yellow31	Backline	MODULE: Yellow	Yellow	Medium
		STRAP: Medium		
White17	Backline	MODULE: White	White	Medium
		STRAP: Medium		
Pink31	Backline	MODULE: Pink	Pink	Small
		STRAP: Small		
Red31	Forward	MODULE: Red	Red	Small
		STRAP: Small		

Date: 01 June 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green31	Forward	MODULE: Dark Green	Dark Green	Large
		STRAP: Large		
Light Green31	Forward	MODULE: Light Green	Light Green	Small
		STRAP: Small		
Orange17	Forward	MODULE: Orange	Orange	Large
		STRAP: Large		
Yellow31	Backline	MODULE: Yellow	Yellow	Medium
		STRAP: Medium		
White17	Backline	MODULE: White	White	Medium
		STRAP: Medium		
Pink31	Backline	MODULE: Pink	Pink	Small
		STRAP: Small		
Red31	Forward	MODULE: Red	Red	Small
		STRAP: Small		

Date: 02 June 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green31	Forward	MODULE: Dark Green	Dark Green	Large
		STRAP: Large		
Light Green31	Forward	MODULE: Light Green	Light Green	Small
		STRAP: Small		
Orange17	Forward	MODULE: Orange	Orange	Large
		STRAP: Large		
Yellow31	Backline	MODULE: Yellow	Yellow	Medium
		STRAP: Medium		
White17	Backline	MODULE: White	White	Medium
		STRAP: Medium		
Pink31	Backline	MODULE: Pink	Pink	Small
		STRAP: Small		
Red31	Forward	MODULE: Red	Red	Small
		STRAP: Small		

Date: 07 June 2021

PSEUDONYME	POSITION	BIOHARNESS MODULE & CHESTSTRAP	GPS DEVICE	SHIRT NUMBER
Dark Green31	Forward	MODULE: Dark Green	Dark Green	Large
		STRAP: Large		
Light Green31	Forward	MODULE: Light Green	Light Green	Small
		STRAP: Small		
Orange17	Forward	MODULE: Orange	Orange	Large
		STRAP: Large		
Yellow31	Backline	MODULE: Yellow	Yellow	Medium
		STRAP: Medium		
White17	Backline	MODULE: White	White	Medium
		STRAP: Medium		
Pink31	Backline	MODULE: Pink	Pink	Small
		STRAP: Small		
Red31	Forward	MODULE: Red	Red	Small
		STRAP: Small		