Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA:

Empirical [1]

Student name: Jade Newman	***Student ID:*** 10001819
Programme: SCRAM	
Dissertation title: A Physiological Profile of Female Rugby Union	
Supervisor: Dr Jeremy Moody	

Comments	Section
	Title and Abstract (5%) Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.
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CARDIFF METROPOLITAN UNIVERSITY
Prifysgol Fetropolitan Caerdydd

CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

SPORT CONDITIONING, REHABILITATION AND MASSAGE

2013-4

A PHYSIOLOGICAL PROFILE OF FEMALE RUGBY UNION

Dissertation submitted under the discipline of:
Sports Conditioning, Rehabilitation and Massage

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A PHYSIOLOGICAL PROFILE OF FEMALE RUGBY UNION

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Table 1. Ages of individual participants

Player	Position	Age (years)
1	FR	21
2	FR	19
3	FR	20
4	SR	19
5	SR	20
6	BR	19
7	BR	22
8	BR	18

Table 2. Ages of position groups (mean ± *s*)

Position	Age (years)
FR	20 ± 1.00
SR	19.5 ± 0.50
BR	19.7 ± 2.30

1.2 Body Mass

Table 3. Body mass of individual participants

Player	Position	Body Mass (kg)
1	FR	85.00
2	FR	101.20
3	FR	96.60
4	SR	81.00
5	SR	75.20
6	BR	75.00
7	BR	75.00
8	BR	71.90

Table 4. Body mass of position groups (mean ± *s*)

Position	Body Mass (kg)
FR	94.3 ± 16.20
SR	78.1 ± 2.90
BR	74 ± 2.10

1.3 Stature

Table 5. Stature of individual participants

Player	Position	Stature (cm)
1	FR	155.00
2	FR	168.00
3	FR	169.00
4	SR	180.00
5	SR	170.00
6	BR	170.00
7	BR	165.00
8	BR	178.00

Table 6. Stature of position groups (mean ± *s*)

Position	Stature (cm)
FR	164.00 ± 9.00
SR	175.00 ± 5.00
BR	171.00 ± 7.00

1.4 Ball in Play

Table 7. Ball in play (BIP) count and percentage of match time

	Count	BIP time (minutes)	Match length (minutes)	% of match time BIP
Ball In Play	60	00:39:30.12	00:85:10.00	46.06

1.5 Movement Analysis

Table 8. Movement analysis data for individual participants' percentage match time spent in each activity

Player	Position	Standing Still	Walking	Jogging	Running	Sprinting	Utility movements	Jumping	Rucking/mauling	Scrummaging
1	FR	35.44%	21.15%	19.54%	4.41%	0.12%	1.88%	0.00%	10.23%	6.94%
2	FR	36.39%	33.76%	12.42%	2.57%	0.29%	1.12%	0.00%	7.28%	5.88%
3	FR	39.02%	25.42%	20.08%	1.65%	0.15%	0.67%	0.00%	7.24%	5.52%
4	SR	38.13%	24.94%	17.56%	2.95%	0.37%	0.99%	0.00%	9.58%	5.30%
5	SR	38.12%	22.11%	14.35%	3.60%	1.14%	2.22%	0.00%	12.78%	5.21%
6	BR	36.77%	25.47%	15.31%	4.45%	0.91%	2.38%	1.00%	9.13%	4.98%
7	BR	39.74%	22.08%	16.37%	5.66%	0.66%	1.77%	0.00%	8.97%	4.39%
8	BR	39.34%	24.12%	15.81%	4.32%	0.68%	1.63%	0.00%	9.27%	4.52%

Table 9. Movement analysis data for position groups' percentage match time spent in each activity

Position	Standing Still	Walking	Jogging	Running	Sprinting	Utility movements	Jumping	Rucking/mauling	Scrummaging
FR	36.95%	26.78%	17.35%	2.88%	0.19%	1.22%	0.00%	8.25%	6.11%
SR	38.13%	23.53%	15.96%	3.28%	0.76%	1.61%	0.00%	11.18%	5.26%
BR	38.62%	23.89%	15.83%	4.81%	0.75%	1.93%	0.00%	9.12%	4.63%

1.6 Work to Rest Ratio

Table 10. Work to rest ratios of individual participants

Player	Position	Low intensity activity (rest)	High intensity activity (work)	Rest to work	Work to rest ratio
1	FR	56.59%	43.12%	57:43	1:1.3
2	FR	70.15%	29.56%	70:30	1:2.3
3	FR	64.44%	35.31%	65:35	1:1.9
4	SR	63.07%	36.75%	63:37	1:1.7
5	SR	60.23%	39.30%	60:40	1:1.5
6	BR	62.24%	37.66%	62:38	1:1.6
7	BR	61.82%	37.82%	62:38	1:1.6
8	BR	63.46%	36.23%	64:36	1:1.8

Table 11. Work to rest ratios of position groups

Position	Low intensity activity (rest)	High intensity activity (work)	Rest to work	Work to rest ratio
FR	63.73%	36.00%	64:36	1:1.8
SR	61.65%	38.03%	62:38	1:1.6
BR	62.51%	37.24%	63:37	1:1.7

1.7 Heart Rate

Table 12. Heart rate data for individual participants' percentage match time spent in each zone

Player	Position	Zone 1 0-60% max HR	Zone 2 60-70% max HR	Zone 3 70-80% max HR	Zone 4 80-90% max HR	Zone 5 90-95% max HR	Zone 6 95-100% max HR
1	FR	0.00%	5.13%	12.30%	25.35%	31.97%	24.51%
2	FR	13.58%	16.46%	16.77%	21.71%	19.55%	11.52%
3	FR	0.094%	8.76%	19.21%	38.14%	24.86%	7.82%
4	SR	0.091%	1.19%	7.42%	19.71%	41.52%	29.33%
5	SR	0.96%	5.08%	10.64%	41.51%	33.65%	7.77%
6	BR	0.00%	1.18%	8.51%	22.10%	36.50%	30.98%
7	BR	0.00%	0.19%	12.32%	24.83%	35.17%	27.49%
8	BR	0.28%	2.26%	14.51%	31.10%	31.57%	19.13%

Table 13. Heart rate data for position groups' percentage match time spent in each zone

Position	Zone 1 0-60% max HR	Zone 2 60-70% max HR	Zone 3 70-80% max HR	Zone 4 80-90% max HR	Zone 5 90-95% max HR	Zone 6 95-100% max HR
FR	4.56%	10.12%	16.09%	28.40%	25.46%	14.62%
SR	0.53%	3.14%	9.03%	30.61%	37.59%	18.55%
BR	0.00%	1.21%	11.78%	26.01%	34.41%	25.87%

Table 14. Average heart rate of individual participants during match time

Player	Position	Average HR ($beats \cdot min^{-1}$)
1	FR	181.00
2	FR	159.00
3	FR	163.00
4	SR	176.00
5	SR	168.00
6	BR	182.00
7	BR	173.00
8	BR	173.00

Table 15. Average heart rate of position groups during match time

Position	Average HR ($beats \cdot min^{-1}$)
FR	168.00 ± 13.00
SR	172.00 ± 4.00
BR	176.00 ± 6.00

Table 16. Average heart rate of all positions during match time

Pack average HR ($beats \cdot min^{-1}$)	172.00

1.8 Anaerobic Threshold

Table 17. Percentage time spent below and above anaerobic threshold of position groups during match time

Position	Below anaerobic threshold (0-80% max HR)	Above anaerobic threshold (80-100% max HR)
FR	30.77%	68.48%
SR	12.69%	86.75%
BR	13.08%	86.29%

Table 18. Percentage time spent below and above anaerobic threshold of all positions during match time

	Below anaerobic threshold (0-80% max HR)	Above anaerobic threshold (80-100% max HR)
All Players	18.85%	80.50%

1.9 Summary

Table 19. Summary of heart rate data and movement pattern analysis for position groups during match time

	Heart Rate Data			Movement Analysis
Position	Below threshold (0-80% max HR)	Above threshold (80-100% max HR)	HR zone used most	Work to rest ratio
FR	30.77%	68.48%	80-90% Max HR	1:1.8
SR	12.69%	86.75%	90-95% Max HR	1:1.6
BR	13.08%	86.29%	90-95% Max HR	1:1.7

ACKNOWLEDGEMENTS

I would like to thank my dissertation supervisor, Dr Jeremy Moody, for his continuous support throughout my university career and for always challenging my ideas. His academic guidance, constructive suggestions and willingness to give his time so generously have been of constant help. Without the aforementioned support, this study would not have been possible.

I would like to express my appreciation to the eight participants from Cardiff Metropolitan University Women's Rugby 2nd XV, who gave up their personal time and allowed me to concentrate my study on them.

Finally, I am extremely grateful to my friends and family, in particular my Mother, for the support and encouragement throughout my study.

ABBREVIATIONS

BUCS – British University and Colleges Sport

FR – Front row

SR – Second row

BR – Back row

BIP – Ball in play

HR – Heart rate

Max – Maximum

Bpm = Beats per minute

beats·min^{-1} = Beats per minute

GPS = Global Positioning Software

ABSTRACT

Rugby union is a full contact team sport combining physical elements of strength, speed and skill. Participants are expected to possess high levels of physical fitness as the game is famously characterised by the components of short bursts of high intensity interposed by periods of recovery or low intensity activity. The game is a combination of aerobic and anaerobic endurance, during which participants often rely upon multiple energy systems.

The aim of this study was to provide a profile of the physiological demands experienced by female rugby union players during game play. Eight (8) female rugby players who were members of Cardiff Metropolitan University Women's 2nd XV Rugby Squad were analysed. The players were sub-divided into three (3) categories; front row, second row, and back row. Each player undertook inclusive pre-game tests (age, stature, body mass, and maximum heart rate), followed 24 hours later by heart rate and movement pattern analysis during match play. Each heart rate reading was allocated into one (1) of six (6) zones, in correspondence to the individual's maximum heart rate (0-60%, 60-70%, 70-80%, 80-90%, 90-95%, and 95-100% of maximum heart rate). Movement patterns were coded as one (1) of nine (9) activities (standing still, walking, jogging, running, sprinting, utility movements, jumping, rucking/mauling, and scrummaging).

The results indicated that all players on average spent over 80% of game time working above the anaerobic threshold at 80-100% maximum heart rate, alongside displaying an average work to rest ratio of 1:1.7. Positional group analysis indicated the front row engaged in long duration, continuous bouts of exercise. Second row forwards tended to play a high ruck and maul role whereas the back row were more involved in high intensity sprinting and fringe work around the breakdown. The results provide a full physiological profile of the demands of female rugby union. The data provided could influence the alteration of training approaches for coaches and individual players.

CHAPTER 1
INTRODUCTION

It has been suggested that, as the men's game has developed, so too has the women's game (International Rugby Board, 2009). As the female game is continuously evolving, it is progressively imperative that the database of information follows suit. At present there is an inadequate volume of data available to represent the female game of rugby union. The current database focuses on injury epidemiology, feminism, sexuality and levels of participation within the sport. There is a sizeable gap in current literature, alongside a vast amount of discrepancy, when exploring the continuously expanding game of female rugby union. At present there is no comprehensive empirical data to represent the physiological demands of rugby union in the female game. A complete profile to refer too is not available.

It is important to explore this subject area, as the male game of rugby union cannot be compared to the female due to vast physiological disparities between genders. 2014 and 2015 will see two (2) of the most prominent competitions within the female rugby union schedule: the 2014 World Cup and 2015 Six Nations. Both competitions are of paramount importance to international rugby union governing bodies that will be aiming to place high, in order to increase funding and participation in the sport. Increased media coverage has prompted greater interest of non-participants who could aim to take part in the sport, further strengthening the requirement to expand the data available.

This study intends to collect physiological data from a group of female rugby union players during live match play. Collecting heart rate data and movement patterns for a full 80 minutes will enable the collation of figures to provide a physiological profile database of the demands experienced during game play. Additionally, position specific analysis will take place to provide training suggestions and requirements.

The main aim of this study is to provide a complete profile of the various physiological requirements of individual playing positions, collective position groups and a full forward pack. The profile of data provided will also make available information for planning and devising training programmes for competition or simply to use as a reference for the qualities required of aspiring participants.

This study will contribute to current literature by the addition of an overall profile of the female game. Distinctive components of the game that have not been covered previously such as the scrum, ruck and maul will be provided, alongside position specific demands.

CHAPTER 2
LITERATURE REVIEW

It is apparent that there is limited literature available on the female game of rugby union. Previous research distillates on injury, ethical issues and participation levels rather than the importance of the physical qualities female rugby union participants may or may not require to possess in order to excel. As a male dominated sport, it could be suggested there is inadequate research into whether there is a difference between the physical demands of male and female rugby union. With women's rugby intensifying in popularity there is an ever-growing need for data to become available. This need is emphasised when considering that squad selection and planning for the 2014 World Cup and 2015 Six Nations will be the main concentration for coaching and management staff around elite teams at present. The data is not only useful to players and coaches but arguably it could provide a vast contribution to the knowledge of outsiders to the sport such as non-athletes, spectators, potential sponsors and local businesses. This knowledge could in turn increase participation numbers and understanding of the sport alongside helping to expand the profile of women's rugby with the aid of sponsors, supporters and media. At present, as Howe (2001, p.85) identified, 'attracting the attention of sponsors to a sport such as women's rugby is tremendously difficult'.

Recent statistics collected from the 2010 Women's Rugby World Cup, by the International Rugby Board (2010, p. 2) suggest that 'the shape of the game is now similar in almost all respects to that seen at the highest levels of men's rugby'. With this statistic in mind, alongside the recent 2013 Six Nations tournament data, it is arguable that the women's game has evolved even further in the last two (2) years. Hence, studies compiled in the future could show even greater similarities to the men's game. Such a study has the potential to highlight areas of the women's game that restrict it from becoming as successful and high profile as the men's game.

Physical demands could be defined as exertion placed upon the body by an activity that requires total physiological body systems to be placed under stress. With this in mind the most effective method of measuring the physical demands of rugby union is to collect heart rate (HR) data alongside movement pattern analysis. This method would provide data on what is occurring within the body; alongside observing from the outside what the body is able to perform, recorded on video footage. The main advantage of using video footage is that it enables the calculation of work to rest ratios, which is important when 'investigating the physiological demands of intermittent sports such as rugby' (Deutsch *et al.,* 2007, p.1). Work to rest ratios can give insight into how hard or how often a player is working during a game, which can influence types of training methods that could be employed to improve performance in the future.

Prior to 2003, there had been no movement pattern analysis data published following the 'significant rule changes and emergence of southern hemisphere professional rugby in 1995' (Deutsch *et al.,* 2007, p.9). There have since been further rule changes, in 2010, 2012 and 2013 suggesting that once again there is limited knowledge of the current physical demands of rugby union, especially within the female game.

In a time motion analysis of professional rugby union players, Deutsch *et al.,* (2007) made the assumption that whist the ball was in play all 15 athletes were working, and otherwise in a state of rest. Thus, questioning the reliability of the data collected due to the assumption made. The same study did not provide any individual data for players or positions as only four (4) position categories were used, perhaps limiting its contribution to knowledge. It is appropriate to provide position specific data as 'in team sports, the physical, technical and tactical demands of different playing positions vary greatly' (Vänttinen *et al.,* 2007, p.2). Due to the lack of depth in the data collected by Deutsch *et al*., (2007) this study has major disadvantages, hence providing an opportunity for a study to be completed that can provide the missing elements such as knowledge of key aspects of the game requirements.

A later study conducted by Roberts *et al.,* (2008) concentrated on the physical demands of English rugby union and displayed vast limitations, as the data did not contain any heart rate monitoring. This was a huge limitation of the study as the phrase 'physical demand' suggests the demand of an activity being placed upon the body and how the body deals or responds too it. With this in mind, it is not possible to measure a demand without collecting data to represent the response of the body too that demand. Therefore, without heart rate monitoring or an alternative measure of physiological body response, this study cannot be seen as reliable or accurate. Furthermore, the same study did not record certain movements that were observed during time motion analysis. Backwards running was not classed as a movement and was therefore omitted during analysis, arguably leaving the study with considerable limitations.

Cunniffe *et al.,* (2009) used just two (2) subjects competing in just one (1) game for research into the physiological demands of elite rugby union. The study used Global Positioning Software (GPS) to record and track player movements alongside the intensity and duration of activity. This method of classification lacks reliability as the GPS technology recorded intense static activities such as scrummaging, rucking and mauling as low intensity activities. Arguably, this factor limited the validity of the data as the classification of the intensity could be seen as incorrect. Scrummaging, rucking and mauling are often some of the highest intensity activities experienced, especially within the elite game. Habka *et al*., (2007, p.1) stated that the 'rugby union scrum is considered as an important phase of the game and it epitomizes [sic] the games physical nature', perhaps suggesting that the study completed by Cunniffe *et al.,* (2009) was not as accurate as it could have been. The intensity and duration of work periods were used in this study to calculate work to rest ratios; hence the aforementioned limitation could affect the work to rest ratios detrimentally. The authors identified this as a limitation, stating that the ratios may not provide a true reflection of player work rates, in particular for forwards. Furthermore the authors proposed that 'combining objective GPS data with qualitative analysis of time spent in non-running exertion and utility movements may help in establishing more defined work to rest ratios and setting of fitness goals' (Cunniffe *et al.,* 2009, p.8). This study used heart rate transmitter belts situated on the players' chest throughout the data collection and hence also produced heart rate results alongside GPS tracking, compiling a complete set of physiological profile results. This method of data collection is an important strength of the research and an essential part of further research into the physiological profiling of sport.

The most recent study conducted by Hene *et al*., (2011) attempted to document the contemporary demands of elite female rugby union and is currently the leading research in the subject area. The study provides new and innovative data into the demands of elite female rugby union during the 2010 World Cup, using the 32 member South African squad. The article brought to light that there are vast statistical differences between positional groups, and suggests, 'back line players…have a lean physique, unlike forward players who are heavier, taller and have a greater proportion of body fat' (Hene *et al*., 2011, p.2). This research does have limitations, the main being that although containing new findings, a large percentage of the findings were repeats of previous studies, perhaps restricting the study to merely repeated findings rather than new findings overall. Although this approach helps to reinforce important results and statistics that have been previously proven, it does confine the study to simply repeating previous authors. This suggestion is reinforced in that similar results can be found in a number of previous studies including Kirby and Reilly, 1993; Quarrie *et al*., 1995; and Schick *et al.,* 2008.

There have been a number of research studies that have looked at the same population and level of players that produce conflicting findings, perhaps as a result of game evolution or more worryingly the accuracy of the studies. An area of variability in results has been the calculation of work to rest ratios between forward and backline players. Deutsch *et al.*, (2007) concluded that work to rest ratios of forwards and backs were 1:7.4 and 1:21.8 respectively. Just three (3) years later Cunniffe *et al.,* (2009) found the work to rest ratios of forwards and backs to be 1:5.8 and 1:5.7 respectively. This difference in results could be due to changes in the way rugby union has been played within the three (3) year gap between studies. However, with such a dramatic change in results it could be due to validity complications. This suggests that either one (1) or both studies may have made errors during data collection if the variability in results is not due to game evolution. Due to the conflicting results between the two (2) studies there is a need for new data. This data could clarify any misinterpretations or miscalculations of previous research, or even prove that within such a short space of time the game of rugby union can change as dramatically as it appears to have.

Rule changes within rugby union have made the play 'more open, faster and more attractive' (Duthie *et al*., 2003, p.11). Alongside the tactical changes teams employ to give themselves the upper hand in competition, recent rule changes are aimed at speeding up the game, specifically within the contact area. With previous literature and present game structure taken into consideration it is expected that the work to rest ratio would further revolutionise.

The distance covered by elite rugby union players has also been a common factor chosen to investigate. This has similarly been an area of speculation with regards to accuracy between separate studies. Roberts *et al.,* (2008) concluded that in an 80-minute game the forwards and backs covered 5581m and 6127m respectively. In a more recent study, Cunniffe *et al.,* (2009) found that in the same time bracket, forwards and backs covered

6680m and 7227m respectively; over 1km more for each group than the previous study. A potential reason for this could be that Roberts *et al.,* (2008) used 14 forwards and 15 backs over five (5) separate matches, whereas Cunniffe *et al.,* (2009) used just one (1) forward and one (1) back during just one (1) match. The latest findings from 2009 could be classed as unreliable due to the lack of participant data. Therefore, it would be appropriate to conduct further studies using more than two (2) participants and during more than one (1) game. Although this would require an increased amount of data analysis time, it would ensure that the data collected was far more reliable.

The majority of previous studies have used GPS tracking or time motion analysis of players to analyse the physiological demands of rugby union, including the work of Roberts *et al*., 2006; Vänttinen *et al*., 2007; Deutsch *et al*., 2007; Roberts *et al*., 2008; Cunniffe *et al*., 2009; and Hene *et al*., 2011. However, only a minority of these studies, mainly the most recent, also compiled heart rate data alongside GPS tracking or time motion analysis. It is these few studies that arguably provided the most in depth and reliable results, suggesting that for future studies to further contribute to knowledge it is imminent to include heart rate data alongside GPS tracking or time motion analysis.

There is limited literature on the reliability and accuracy of the current heart rate monitoring systems. A study conducted by Weippert *et al.,* (2010) is the only current research into the validity of heart rate monitoring systems. The study compared the validity of three separate instruments (Ambulatory ECG, Polar S810i and Suunto t6) and concluded that all three instruments can be used interchangeably. Weippert *et al.,* (2010, p.7) suggests that the Suunto t6 system provides an accuracy of 1ms and can hold a total of '10,0000 R-R intervals'. This statement suggests that the Suunto monitoring system is trustworthy, and an appropriate piece of instrumentation for a future study. When collecting heart rate data, 'cardiac ultrasound is the initial diagnostic tool of choice in the assessment of cardiac structure and function in humans' (Shave *et al.,* 2014, p.2). However, due to the nature of the study it is not appropriate to conduct ultrasound measurements, therefore the simpler method of heart rate monitoring using the Suunto t6 system is suitable.

Prusak *et al.,* (2010) conducted a study on the reliability of 'Studicode', the software most commonly employed during data analysis of studies aiming to look at player movement and activity during game play. Prusak *et al.,* (2010, p.1) concluded, 'with less than two hours of training and three practice attempts, students are moderately reliable in their coding ability and highly accurate in their content analysis'. Therefore, it is possible to state that, with practice, the 'Studiocode' software can be used effectively and accurately to produce a sound set of results.

With previous literature in mind, the overall findings and conclusions have suggested that rugby union is of a highly intermittent nature requiring intense physical demands from the body. Current theories suggest that 'the contemporary rugby union player runs longer and harder than previously thought' (Cunniffe *et al*., 2009, p.8). Thus, with consideration that the game of rugby union is continuously evolving due to rule changes and tactical decisions, further research could present new findings and contribute to current knowledge. It has been documented by Deutsch *et al.,* (2007, p.11) that 'various positions in rugby are markedly different in terms of metabolic demand, and even more so in terms of kinematics'. This statement suggests that there is a need for future research to consider player positions to provide an in depth analysis of the differing demands. With limited data available on the physiological requirements of female rugby union it is not possible to compare past findings with future studies, however there is a gap within current knowledge to explore the physical demands of female rugby union.

With female rugby union expanding and becoming ever more popular it is imperative for research to be conducted into this area to provide the academic world with data that can be applied in the field. There has been very recent research into elite female rugby union (Hene *et al*., 2011). However, this study was compiled using the South African female squad, which has not been overly successful. In the last World Cup (2010) the final standings saw South Africa take 10th place with Wales finishing just ahead in ninth (9th) place (International Rugby Board, 2010, p. 6). With this statistic in mind it would be appropriate to complete a future study on participants within a country finishing further up the table than South Africa, such as Wales.

From critiquing previous literature it is evident that there is a need for 'A Physiological Profile of Female Rugby Union'. This study is important to conduct in order to provide a profile of the physiological demands of female rugby union. There has been little research into this area hence contribution to knowledge of this study could be vast. It has previously been suggested by Carson *et al.,* (1999) that within the female game, data is scarce. Not only would this study provide an overall analysis and profile of female rugby union, it would also highlight specific areas of the forwards game such as scrummaging, rucking and mauling. Duthie *et al.,* (2003, p.15) concluded that ‘further analysis of the demands of rugby is required, with researchers focusing on specific components of the game’.

CHAPTER 3
METHODOLOGY

3.1 Participants

All participants monitored in this study were part of the same playing team, Cardiff Metropolitan University Women's 2nd XV, competing in the British University and Colleges Sport (BUCS) Western 1A Division. The match selected for monitoring was played at Cardiff Metropolitan University School of Sport, Pitch 2, during the season 2013-2014.

The participants were selected if they met the following criteria:

1. Training and competing regularly for Cardiff Metropolitan Women's 2nd XV
2. Playing in a forward position (either prop, hooker, lock, flanker or number eight)
3. Previous playing experience of at least 3 years

The criteria set out above ensured that the participants were appropriate to monitor through 80 minutes of game play alongside securing the reliability and validity of data collected from each participant. The third (3rd) criteria requirement specifically ensured that the game environment did not expose the participant to physical demands that had not been previously experienced.

A full forward pack, consisting of eight (8) players, was used for the monitoring. This group of players were divided and identified as one of five (5) main positions including props (2), hooker (1), locks (2), flankers (2), and number eight (1). These individual playing positions were further divided into front row (FR) for props and hooker, second row (SR) for locks, and back row (BR) for flankers and number eight. The selection of participants was aimed at providing in-depth data into the physiological demands of a rugby union game whilst playing in the forwards. All eight (8) members of the scrum were monitored so that every position was analysed and could therefore provide the broadest results possible.

Within an 80-minute game it has been shown that 'forwards perform high-intensity activities for longer periods than backs' (Roberts *et al.,* 2008, p.6). This statement suggests that the forwards may provide a more compact profile containing less rest periods and therefore higher physical demands than the backs. Similarly Duthie *et al.,* (2003, p.11) earlier documented that whilst 'the forwards are engaged in intense activity, the backs are typically walking, standing, running in support play or covering in defence'. Hence, both statements alongside a vast number of alternative literatures suggested a profile concentrated on the forward playing positions would provide a far more valuable study. This profile could be compared to previous research conducted on backs or forwards within the female game or may even present a new research problem to be addressed.

3.2 Instrumentation

To collect heart rate HR data from the participants the instrumentation used was the Suunto T6 Team monitoring system. Weippert *et al.,* (2010, p.2) stated, the Suunto T6 breast belt system is a 'widely used instrumentation for physical exercise monitoring'. With this statement in mind, the Suunto T6 system was an appropriate instrument to use in order to gather the measurements required.

To collect movement pattern data a similar method to Deutsch *et al*., (2007) was employed. A camera was used to record the game and the footage was then put into the software 'Studicode' to be analysed. Training or usage of the 'Studiocode' software over the recommended 2 hours (Prusak *et al.,* 2010) ensured that the analysis of the data collected was accurate and reliable. During analysis each player was tagged and measured for time spent within each movement category. This method is very similar to the work of Deutsch *et al.,* (2007), however it added female data to the information already available.

3.3 Procedure

To begin the data collection, participants gave their informed consent following reading a participant information sheet. Their stature and weight were then recorded before issuing each participant with a heart rate monitor, situated on the left hand side of their chest underneath a sports bra. All participants took part in a thorough warm up, stretching, and foam rolling period led by the 2nd XV Captain.

The participants then completed a measure of maximum heart rate in the form of the 'Yo-Yo' test, performed whilst wearing the heart rate monitor. The 'Yo-Yo' test was selected as an appropriate measure of maximum heart rate as it is 'tailored specifically for intermittent-based activities, is ideal for team sports more than the continuous motion of the multi-stage fitness test' (Clarke *et al.,* 2014, p.1).

Within 24 hours of the completion of preliminary data collection, the participants were exposed to a full 80-minute rugby union competitive game whilst wearing the heart rate monitor and being video recorded. If a maximum heart rate value during the game was seen to be higher than a value that pre-testing produced then the highest value was used. Although the 'Yo-Yo' test is an appropriate measure of maximum heart rate and game specific aerobic fitness, it was expected that psychological factors would prevent the participants from gaining a fully maximum value as it had been documented that 'gender is a factor in aerobic fitness performance' (Winborn *et al.,* 1988, p.7).

The match data was collected during a BUCS Western 1A Division fixture. The full starting forward pack was monitored throughout the 80 minutes of game time. If a player came off the pitch injured their data was automatically discounted from the study. This was to ensure the data collected was reliable and valid for analysing.

3.4 Data Analysis

Before commencement of monitoring, each participant had their maximum heart rate recorded in order to calculate their individual heart rate zones. The maximum heart rates were easily measured using the 'Yo-Yo' test as all participants completed the test at the same time and were arguably motivated to beat their position competition within the team and gain a better result. This provided an accurate measure of the maximum heart rate achieved for each participant.

The aim of the heart rate data analysis was to calculate each individual's percentage of match time spent in each heart rate zone. In order to complete this statistical procedure each individual was analysed separately. To commence the statistical analysis each player's max HR was documented. Succeeding this, each individual heart rate reading, collected every 10 seconds through match play, was then allocated into a heart rate zone as a percentage of the maximum heart rate. This allocation provided an occurrence value to show how many times each heart rate zone was visited. As heart rate readings were collected at 10 second intervals it was assumed that for every occurrence in a particular heart rate zone, this correlated to 10 seconds spent within the zone. Therefore, a time value was made available for each occurrence, leading to a total time value spent in each heart rate zone for each individual. If a player entered a heart rate zone 96 times this represented 960 seconds spent within the zone, the equivalent of 16 minutes. To present the data it was appropriate to display the time values as a percentage of match time, therefore providing a representative figure of the proportion of the match that each heart rate zone was utilised by individual players. Collective data was determined by taking an average of individual player's results, that was then grouped according to whether they were playing in a front row, second row or back row position.

There were six categories of heart rate zones:

1. Zone 1: 0-60% max HR

2. Zone 2: 60-70% max HR

3. Zone 3: 70-80% max HR

4. Zone 4: 80-90% max HR

5. Zone 5: 90-95% max HR

6. Zone 6: 95-100% max HR

The aim of movement pattern analysis was to calculate each individual's percentage of match time spent performing different activities. This enabled the calculation of work to rest ratios alongside the percentage of time spent in each movement pattern zone. Each player was analysed separately by observing the entire match and allocating a movement pattern zone in accordance to what they were doing on the pitch. The statistical analysis of this data began with observing the total time spent in each zone, which was then converted into a percentage of the whole match time. When determining the calculation of work to rest ratios, standing still and walking were classed as low intensity, whereas all other activities were classed as high intensity. The work to rest ratio values represented that for every one (1) period of work each individual rested for a certain period of time. The lower the rest value, the harder the individual worked throughout match play. Individual results were then collated into position groups in accordance to whether they played in a front row, second row or back row position.

The nine (9) categories that were used for the analysis of movement patterns were:

1. Standing still = standing or lying on the ground without being involved in pushing or any game activities (Deutsch *et al*., 2007, p.3).

2. Walking = walking forwards or backwards slowly with purpose. One foot is in contact with the ground at all times (Deutsch *et al*., 2007, p.3).

3. Jogging = running forwards slowly to change field position, but with no particular haste or arm drive (Deutsch *et al*., 2007, p.3).

4. Running = manifest purpose and effort, accelerating with long strides, yet not at maximal effort (3/4 pace) (Deutsch *et al*., 2007, p.3).

5. Sprinting = running with maximal effort (Deutsch *et al*., 2007, p.3).

6. Utility movements = shuffling sideways or backwards to change field position. Usually a defensive or repositioning movement (Deutsch *et al*., 2007, p.3).

7. Jumping = jumping in a line out or to catch a ball in play (Deutsch *et al*., 2007, p.3).

8. Rucking/mauling = attached to an active ruck or maul (Deutsch *et al*., 2007, p.3).

9. Scrummaging = attached to an active scrum (Deutsch *et al*., 2007, p.3).

The data collection and analysis of the data was expected to be very labour intensive, taking approximately '8 hours to produce data for one player for a whole match' (Roberts *et al*., 2006, p.10). With this information in mind, it was expected data analysis for one (1) game involving eight (8) forward playing position individuals could take approximately 64 hours to complete.

CHAPTER 4
RESULTS

4.1 General Statistics

4.1.1 Age

In this study the forward pack showed a very close age range with the SR the youngest (19.5 ± 0.5) and the FR the oldest (20 ± 1.00), as shown in table two (2).

Table 2. Ages of position groups (mean ± *s*)

Position	Age (years)
FR	20 ± 1.00
SR	19.5 ± 0.50
BR	19.7 ± 2.30

4.1.2 Body Mass

The results of this study show that the FR had significantly higher body mass (94.30kg ± 16.20) than either the SR (78.10kg ± 2.90) or BR (74.00kg ± 2.10). Table four (4) shows that the SR and BR share similar figures in body mass, the BR showing the lowest body mass.

Table 4. Body mass of position groups (mean ± *s*)

Position	Body Mass (kg)
FR	94.3 ± 16.20
SR	78.1 ± 2.90
BR	74 ± 2.10

4.1.3 Stature

As expected, the SR displayed the greatest height of the forwards pack (175.00cm ± 5.00), often required by the position characteristics. This study showed the FR (164.00cm ±

9.00) to have the stature, with the BR (171.00cm ± 7.00) again showing similar results to the SR. Table six (6) displays the grouped results for stature of the participants.

Table 6. Stature of position groups (mean ± *s*)

Position	Stature (cm)
FR	164.00 ± 9.00
SR	175.00 ± 5.00
BR	171.00 ± 7.00

4.1.4 Ball in play

The results from this study, found in table seven (7), show that the ball was in play for 46.06% of the match time, a relatively high percentage, especially considering the playing standard of the participants. This moderately high percentage could be as a result of recent rule changes. Williams *et al.,* (2005, p.9) stated that 'the significant increase in ball in play time may have been due to rule changes that were introduced to improve continuity'.

Table 7. Ball in play (BIP) count and percentage of match time

	Count	BIP time (minutes)	Match length (minutes)	% of match time BIP
Ball in Play	60	00:39:30.12	00:85:10.00	46.06

4.2 Movement Analysis

Tables eight (8) and nine (9) show a summary of the movement analysis data. Table eight (8) contains all individual data collected, showing the percentage of match time that each player spent in the different activity categories. Table nine (9) displays collative data for the three (3) position groups.

Table 8. Movement analysis data for individual participants' percentage match time spent in each activity

Player	Position	Standing Still	Walking	Jogging	Running	Sprinting	Utility movements	Jumping	Rucking/mauling	Scrummaging
1	FR	35.44%	21.15%	19.54%	4.41%	0.12%	1.88%	0.00%	10.23%	6.94%
2	FR	36.39%	33.76%	12.42%	2.57%	0.29%	1.12%	0.00%	7.28%	5.88%
3	FR	39.02%	25.42%	20.08%	1.65%	0.15%	0.67%	0.00%	7.24%	5.52%
4	SR	38.13%	24.94%	17.56%	2.95%	0.37%	0.99%	0.00%	9.58%	5.30%
5	SR	38.12%	22.11%	14.35%	3.60%	1.14%	2.22%	0.00%	12.78%	5.21%
6	BR	36.77%	25.47%	15.31%	4.45%	0.91%	2.38%	1.00%	9.13%	4.98%
7	BR	39.74%	22.08%	16.37%	5.66%	0.66%	1.77%	0.00%	8.97%	4.39%
8	BR	39.34%	24.12%	15.81%	4.32%	0.68%	1.63%	0.00%	9.27%	4.52%

Table 9. Movement analysis data for position groups' percentage match time spent in each activity

Position	Standing Still	Walking	Jogging	Running	Sprinting	Utility movements	Jumping	Rucking/mauling	Scrummaging
FR	36.95%	26.78%	17.35%	2.88%	0.19%	1.22%	0.00%	8.25%	6.11%
SR	38.13%	23.53%	15.96%	3.28%	0.76%	1.61%	0.00%	11.18%	5.26%
BR	38.62%	23.89%	15.83%	4.81%	0.75%	1.93%	0.00%	9.12%	4.63%

4.2.1 Standing Still

Table eight (8) shows that individually the loose-head prop spent the least percentage time standing still (35.44%) whilst the open-side flanker showed the largest percentage (39.74%). As positional groups the FR forwards spent less percentage time standing still (36.95%) than the SR (38.13%) and BR (38.62%), who showed similar properties to one another. The BR spent the greatest percentage time standing still at 38.62% of the match time as shown in table nine (9).

4.2.2 Walking

This study shows that the loose-head prop again spent the least percentage time walking (21.15%) whilst the hooker spent the greatest (33.76%). The FR collectively showed the highest value spent walking (26.78%) with the SR and BR again showing very similar results with 23.53% and 23.89% respectively.

4.2.3 Jogging

The hooker displayed the lowest percentage of time spent jogging (12.42%) whereas the tight-head prop spent the greatest percentage time (20.08%) closely followed by the loose-head prop (19.54%), all shown in table eight (8). As a result, the FR pooled data showed the highest reading (17.35%) with the BR (15.83%) displaying the lowest value.

4.2.4 Running

This study showed the tight-head prop exhibited the lowest percentage time spent running (1.65%) with the open-side flanker engaged in the most running activity (5.66%), displayed in table eight (8). Collectively, as expected the BR revealed the greatest percentage time running (4.81%) and the FR spent the least (2.88%).

4.2.5 Sprinting

Individually the right lock (5) spent a particularly greater time sprinting (1.14% of game time) in comparison to any other position. The loose-head prop exhibited the lowest value (0.12%). Table nine (9) shows that collectively the FR demonstrated a very low value at 0.19% compared to the SR and BR at 0.76% and 0.75% respectively.

4.2.6 Utility Movements

The blind-side flanker spent a significantly greater percentage of time (2.38%) making utility movements than any other position, whereas the tight-head prop demonstrated the lowest value (0.67%). The pooled data showed that the FR spent the least percentage time performing utility movements (1.22%) with the BR spending the greatest (1.93%), arguably as a characteristic of the position.

4.2.7 Jumping

Within the forward pack there was just one (1) jumper in the lineout on every occasion. This player was the blind-side flanker, spending 1.00% of their time jumping or being lifted. As a result there is no collective position data shown in table nine (9).

4.2.8 Rucking/mauling

Individually the greatest percentage of time rucking/mauling was shown by the right lock (5) with 12.78% of their game time engaged in the activity. The least active in the ruck/maul area were the tight-head prop and hooker, spending 7.24% and 7.28% respectively, as shown in table eight (8). Within positional groups the SR presented a significantly greater percentage time rucking/mauling (11.18%), followed by the BR (9.12%), leaving the FR at the least active (8.25%).

4.2.9 Scrummaging

As collective groups, table nine (9) shows the FR spent the greatest time scrummaging at 6.11% of game time. The SR were active in the scrum for 5.26% of game time and the BR who detached immediately after the ball had been played showed 4.63% of their time was spent scrummaging.

4.2.10 Work to Rest Ratio

The work to rest ratio results found in tables ten (10) and 11 show that individually the loose-head prop demonstrated the highest quantity of work efforts in comparison to rest efforts (1:1.3). The position with the least active work to rest ratio was the hooker (1:2.3). As collective positional groups (table 11) the FR showed the least active ratio (1:1.8) whereas the SR gained the most active (1:1.6). The BR placed in between the two groups at 1:1.7.

Table 10. Work to rest ratios of individual participants

Player	Position	Low intensity activity (rest)	High intensity activity (work)	Rest to work	Work to rest ratio
1	FR	56.59%	43.12%	57:43	1:1.3
2	FR	70.15%	29.56%	70:30	1:2.3
3	FR	64.44%	35.31%	65:35	1:1.9
4	SR	63.07%	36.75%	63:37	1:1.7
5	SR	60.23%	39.30%	60:40	1:1.5
6	BR	62.24%	37.66%	62:38	1:1.6
7	BR	61.82%	37.82%	62:38	1:1.6
8	BR	63.46%	36.23%	64:36	1:1.8

Table 11. Work to rest ratios of position groups

Position	Low intensity activity (rest)	High intensity activity (work)	Rest to work	Work to rest ratio
FR	63.73%	36.00%	64:36	1:1.8
SR	61.65%	38.03%	62:38	1:1.6
BR	62.51%	37.24%	63:37	1:1.7

4.3 Heart Rate Analysis

Tables 12 and 13 show a summary of heart rate data analysis. Individually, table 12 shows the percentage of match time that each player spent within different heart rate zones. All individual data was collated into positional groups, as shown in table 13.

4.3.1 Zone 1: 0-60% max HR

The loose-head prop, blind-side and open-side flanker all spent the least percentage of time in zone one (1) at 0%, whereas the hooker spent a large percentage of time at 13.58%. Within positional groups the BR spent an average of 0.00% in zone one (1) closely followed by the SR at 0.53%, whereas the FR spent far greater time at 4.56%.

4.3.2 Zone 2: 60-70% max HR

Zone two (2) results show that individually the open-side flanker spent the least time at 60 – 70% max HR with a low percentage time of 0.19%. Again, the hooker spent the largest proportion at 16.46%, as shown in table 12. Collectively the BR spent the least percentage time in zone two (2) (1.21%) whereas the FR showed the greatest time (10.12).

4.3.3 Zone 3: 70-80% max HR

Within zone three (3) the left lock (4) showed the lowest percentage of time (7.42%) at 70-80% of their max HR whereas the tight-head prop showed the greatest percentage with a result of 19.21%. Table 13 displays the positional group results, which highlight that the FR spent the greatest percentage of time (16.09%) in zone three (3) whereas the SR spent the least (9.03%).

4.3.4 Zone 4: 80-90% max HR

In table 12, zone four (4) results showed that interestingly the left lock (4) again spent the least percentage of time at 80-90% of their max HR (19.71%), whereas the right lock (5) more than doubled this value (41.51%). Jointly the positional groups showed very close results with the SR spending the greatest percentage of time (30.61%) in zone four (4), while the BR spent the least (26.01%).

4.3.5 Zone 5: 90-95% max HR

Individually the percentage time spent in zone five (5) showed fairly similar results. The hooker spent the least amount of time (19.55%) at 90-95% of their max HR whilst the left lock (4) spent the greatest percentage time (41.52%), both shown in table 12. When considering positional groups table 13 shows the FR spent the least time (25.46%) in zone five (5) whereas the SR spent the greatest with a value of 37.59%.

4.3.6 Zone 6: 95-100% max HR

Zone six (6) presents a very high intensity sector for any player. As individuals, the right lock (5) and tight-head prop spent the least percentage of time in zone six (6), with values of 7.77% and 7.82% respectively, observed in table 12. The greatest percentage of time spent in zone six (6) was presented by the blind-side flanker with a result of 30.98%. Collectively, table 13 shows that the FR spent the least percentage time (14.62%) in zone six (6) whilst the BR spent the greatest (25.87%).

Table 12. Heart rate data for individual participants' percentage time spent in each zone

Player	Position	Zone 1 0-60% max HR	Zone 2 60-70% max HR	Zone 3 70-80% max HR	Zone 4 80-90% max HR	Zone 5 90-95% max HR	Zone 6 95-100% max HR
1	FR	0.00%	5.13%	12.30%	25.35%	31.97%	24.51%
2	FR	13.58%	16.46%	16.77%	21.71%	19.55%	11.52%
3	FR	0.094%	8.76%	19.21%	38.14%	24.86%	7.82%
4	SR	0.091%	1.19%	7.42%	19.71%	41.52%	29.33%
5	SR	0.96%	5.08%	10.64%	41.51%	33.65%	7.77%
6	BR	0.00%	1.18%	8.51%	22.10%	36.50%	30.98%
7	BR	0.00%	0.19%	12.32%	24.83%	35.17%	27.49%
8	BR	0.28%	2.26%	14.51%	31.10%	31.57%	19.13%

Table 13. Heart rate data for position groups' percentage time spent in each zone

Position	Zone 1 0-60% max HR	Zone 2 60-70% max HR	Zone 3 70-80% max HR	Zone 4 80-90% max HR	Zone 5 90-95% max HR	Zone 6 95-100% max HR
FR	4.56%	10.12%	16.09%	28.40%	25.46%	14.62%
SR	0.53%	3.14%	9.03%	30.61%	37.59%	18.55%
BR	0.00%	1.21%	11.78%	26.01%	34.41%	25.87%

CHAPTER 5
DISCUSSION

To the author's knowledge, this study is the first to assess and build a physiological profile of female rugby union, combining two (2) methods of on field software – heart rate data, alongside movement pattern analysis. Previously, when analysing the male game, Duthie *et al.,* (2003, p.10) suggests that researchers have used movement analysis and measurements of physiological parameters such as heart rate to establish the physiological responses to rugby. However, there is no current data on the female game. The results of this study show that:

5.1 General Statistics

The FR is collectively the oldest, contrasting previous research by Fuller *et al.,* (2013, p.6) who documented that in the male game the FR has seen a significant age reduction observed at prop. This could be due to the nature of the female game in comparison to the male game. In the male game players are often younger due to a commonly shorter playing career in comparison to a female career, reinforced by Gabbett (2007, p.4) who implied that this is due to the fact that unlike elite male rugby players, elite women competitors are amateurs.

Similar to previous research, the FR is where the players with the greatest body mass are recorded. This finding concurs with earlier observations of rugby union players (Fuller *et al.,* 2013; Hene *et al.,* 2011). The BR is collectively the lightest position within the pack. This finding is arguably a characteristic of the BR position as a 'loose forward' demonstrating similar properties to that of a backline player, analogous to previous research (Cahill *et al.,* 2013). A heavy pack of forwards can prove vital in high contact areas of the game such as scrummaging, rucking and mauling due to forces required to move an opposition. In these circumstances it has been suggested that excessive body fat may act as a protective buffer in contact (Duthie, 2006). However, it is detrimental to a player's work rate and speed if the excess body fat acts as a dead weight.

Results show that the SR is the position with the greatest stature results. This is parallel to past literature, as the SR position is where the tallest players will often be found, due to the nature and roles of the position. Specifically, in the lineout a height advantage is a common factor in success rate. Greater height is also utilised in the scrum as a power source. As a general statement within rugby union, more competitive teams are taller and bigger (Duthie *et al.,* 2003). The height advantage and being larger allows the second row to generate and tolerate greater impacts, alongside providing strength and power during the phases of scrums, rucks and mauls, as reinforced by Sedeaud *et al.,* (2012, p.4).

During the match used for analysis, the ball was in play for 46.06% of the match time. The ball in play (BIP) time shows the exact amount of time that the ball was active on the field and excludes time periods in which the ball was off the field of play, or the referee ceased play due to an injury or foul. Although a rugby union match is played for a minimum of 80 minutes, it is very rare to observe a match that has a BIP time above 60%. However, previous literature shows that there has been an increase of approximately 20% in ball in play time (Quarrie and Hopkins, 2007, p.4). This is mainly due to a decrease in the number of set plays such as lineouts and scrums as a result of errors such as knock-ons.

5.2 Movement Analysis

Standing still and walking were activities both classed as resting or low intensity, whereas the remaining activities were seen as working or high intensity. Interestingly the FR spent the least time standing still, however the greatest time walking, contrary to previous research stating that the FR spend less time walking than any other positional group (Deutsch *et al*., 2007, p.4). The FR also spent the most time jogging whereas the BR showed the least percentage time of the positional groups within the activity of jogging. This result complies with similar results gained by Deutsch *et al.,* (2007) and Duthie *et al.,* (2005).

As a moderately high intensity activity, it was expected that running would show a change in dynamics with regards to the collective position ranking in comparison to jogging, walking and standing still. As anticipated, the FR spent the least time engaged in the activity, whereas the BR spent the greatest. Likewise, sprinting showed similar results. The FR spent the least percentage time sprinting whereas the SR spent the greatest. These results comply with the work of Roberts *et al.,* 2008.

Utility movements were classed as sideways or backwards shuffling efforts, in order to change field position. Deutsch *et al.,* (2007, p.3) classed utility movements as a defensive or repositioning movement. Due to the nature of the movement it was expected that the greatest amount of utility movement would be observed on the fringes of rucks, mauls and tackles. The results of this study show that unsurprisingly the BR used utility movements the most, arguably as a characteristic of the position. The BR positions are commonly seen on the fringes of a breakdown in order to place immediate pressure upon an opposition following play of the ball. This statement is supported by Hendricks *et al.,* (2013, p.1) who recommended that a faster defensive speed, in response to an attacking line, was a statistically significant predictor of breakdown wins and preventing the attacking team from advancing towards the gain line.

Interestingly the FR spent the least time performing utility movements as well as the least time rucking or mauling, posing uncertainty as to what their involvement was at the breakdown. This result contrasts with work from Deutsch *et al.,* (2007, p.6), who found that front row forwards were involved in significantly more rucks and mauls than players in other positional groups. On the contrary, the SR were by far the most active in the ruck and maul zone, identifying the position within the female game as a high contact area.

As expected, within the scrum there were very small differences seen between individual positions with regards to the percentage time spent scrummaging, dependent only on when they were classed as detached from the scrum. Within positional groups it was anticipated that the FR would spend the greatest time engaged in the activity, followed by the SR, then the BR. This anticipation was confirmed, arguably as a result of the nature of the scrum. These results strengthen an argument by Quarrie *et al.,* (2013, p.5) who found that the FR are engaged within the scrum for longer as a result of it being more difficult for front row players to remove themselves from scrums and move to subsequent activities than it is for loose-forwards.

The work to rest ratio provided valuable information on the physiological loads of rugby union, calculated by analysing the relationship between the percentages of time spent performing work and the percentage of time spent performing rest, as suggested by O'Donoghue *et al.,* (2005, p.11). The nature of the game allows work to rest ratios to assess player efforts, due to the game of rugby union displaying intermittent periods of moderate to high intensity activities (both stationary and locomotor), interspersed with periods of lower intensity activity or rest, similarly identified by Quarrie *et al.,* (2013, p.6).

In this study the work to rest ratio values indicated that for every one (1) period of work performed by a participant, there was a certain period of rest. To the author's knowledge, this study is the first to consider activities such as rucking, mauling and scrummaging as high intensity whereas in previous studies these activities were classed as low intensity. This has previously been as a result of GPS technology categorising the activities as static. Cunnieffe *et al.,* (2009, p.7) reinforced this limitation of past literature, stating:

> Although the above [work to rest] ratio provides information on the intermittent nature of elite rugby union, it may not provide a true reflection of player work rates, in particular for forwards…combining objective GPS data with qualitative analysis of time spent in non-running exertion and utility movements may help in establishing more defined work to rest ratios and setting of fitness goals.

The results of this study show that the position group with the shortest rest period over the full game was the SR (1:1.6). The FR displayed the longest rest periods as a whole (1:1.8). These results echo that of Quarrie *et al.,* (1996, p.3) who suggested that in current studies, the props were the heaviest, slowest, and least aerobically fit players.

5.3 Heart Rate Analysis

Throughout the game the mean HR and peak HR observed were 172 beats per minute (beats·min^{-1}), as shown in table 16, and 206 beats·min^{-1} respectively. This is similar to the results found by Cunnieffe *et al.,* (2009, p.4) who recorded that players showed mean and peak HR of 172 and 200 beats·min^{-1}, respectively, during a game.

Table 16. Average heart rate of all positions during match time

Pack average HR (beats·min^{-1})	172.00

Heart rate was used to measure individually how hard a player was working. In order for this to be accurate, each player's results were calculated in relation to their own maximum (max) heart rate. Collected either in pre-testing or during match time, the highest value observed was used. Six (6) heart rate zones were used in this study labelled as zones one (1) to six (6). When debating whether a player is working aerobically or anaerobically it has been stated that the percentage of maximum heart rate thresholds are ‘1) maximal (>95% of MHR), 2) supra-threshold (85-95% of MHR), 3) anaerobic threshold (75 - 84% of MHR) and 4) sub-threshold (<74% of MHR)’ (Deutsch *et al.,* 1998, p.3). Therefore, it could be suggested that within this study, zones one (1) and two (2) are sub-threshold (0-70% max HR), zone three (3) is on the anaerobic threshold (70-80% max HR), zones four (4) and five (5) are supra-threshold (80-95% max HR) and zone six (6) is maximal (95-100% max HR). This proposal is supported by previous research from McMillan *et al.,* (2005, p.1) who suggested that the anaerobic threshold is close to 80-90% of maximal heart rate.

In both zones one (1) and two (2), 0-60% max HR and 60-70% max HR respectively, the FR were found to be within these zones the greatest percentage of time. Similarly, the BR spent the least percentage time within both heart rate zones. These results suggest that the FR remained at a comfortable level of exertion for a greater amount of time in comparison to any other positional group. When considering work to rest ratio outcomes, the FR showed the longest rest periods, arguably reinforcing the result that the FR worked below their anaerobic threshold for the greatest time in comparison to any other positional group.

The FR was also seen to be the most active within the range 70-80% max HR, situated marginally below the anaerobic threshold. Overall, the percentage times spent in this zone, and below, were small due to the detail that, evoked by Duthie *et al.,* (2003, p.15), rugby is primarily anaerobic, although the aerobic system is utilised during rest periods and down time, to replenish energy stores. For the periods of time spent in zones one (1) to three (3) (0-80% max HR), it could be supposed that these were times when a player was recovering, hence the use of the aerobic system to replace glycogen stores. Despite the FR being the most active in this zone out of all positional groups, the time spent in this zone was just 30.77% of game time. Working at a level of 0-80% max HR meant the participants benefited from increased capillarisation, providing a sufficient oxygen supply to respond to the increased oxygen demand. Kano and Sakuma (2013, p.1) reported that working below 80% of maximum heart rate may benefit athletes, as the employment of an active recovery promotes a greater capillary supply to skeletal muscle, which is important for delivery of oxygen and substrates to muscle cells. Therefore, when working at 0-80% max HR it is appropriate to state that the participants were recovering in an attempt to increase glycogen levels and decrease lactate in order to allow for an anticipated increased workload. Tables 17 and 18 show the percentage of match time spent below and above the anaerobic threshold for position groups, and all players, respectively.

Table 17. Percentage time spent below and above anaerobic threshold of position groups during match time

Position	Below anaerobic threshold (0-80% max HR)	Above anaerobic threshold (80-100% max HR)
FR	30.77%	68.48%
SR	12.69%	86.75%
BR	13.08%	86.29%

Table 18. Percentage time spent below and above anaerobic threshold of all positions during match time

	Below anaerobic threshold (0-80% max HR)	Above anaerobic threshold (80-100% max HR)
All Players	18.85%	80.50%

Interestingly, when observing the most active positional group in zones four (4) and five (5), the SR were predominant in both, with significantly higher readings than either the FR or BR. Working at 80-95% max HR is highly stressing for any individual however McInnes *et al*., (1995, p.111) indicated that on average players spent 65% of total match time at a heart rate of 85% maximum or above. Results from this study, as shown in table 12, indicate that the FR spent 68.48% of game time above 80% max HR, whilst the SR and BR spent 86.75% and 86.29% respectively. In this study all players as an average spent 80.50% of game time above 80% of their max HR. In comparison to the results observed by McInnes *et al.,* (1995) this is an increase of 15%. Arguably, a predominant reason for this rise in figures may be as a result of the numerous rule changes, all intended to increase the pace of rugby union.

When considering maximal effort it was anticipated that all players would spend a significant period of time within zone six (6), in the expectation that they would all be exerting themselves maximally. This expectation was met as the results show that all players collectively as a forwards pack spent on average 19.68% of match time working at maximal levels. This finding is reinforced by work from Deutsch *et al*., (1998, p.7) who found that props, locks and back row forwards spend up to 20% of match time above 95% of their maximum heart rate. When considering position specific values, it was observed that the FR spent the least time within zone six (6) at 14.62% whereas the BR almost doubled this value at 25.87%. When functioning at such a maximal effort it is arguable that a large percentage of time was spent working on anaerobic energy pathways. However, results from this study suggest otherwise from examining the movement pattern results alongside heart rate data. The large percentage of time spent standing still and walking, alongside the sporadic nature of rugby in the tackle, ruck and maul area, suggests that the players experienced spells of static exertion combined with spells of high velocity exertion, causing elevated heart rate values at instants throughout match play rather than for long periods of time. The FR players as a group spent more of the match in zone four (4), than any other zone with a value of 28.40% of game time. Therefore, the FR spent over a quarter of the match with their HR situated at 80-90% of their maximum. The SR and BR equally spent the majority of their game time in zone five (5) (90-95% max HR) at 37.59% and 34.41% respectively, than any other zone. The results of this study show that the SR and BR both exerted themselves at a higher level and for a longer period of time, than the FR. This result, coupled with the work to rest ratio results suggests that the SR were the hardest working position, followed by the BR and then the FR, as shown in table 19.

Table 19. Summary of heart rate data and movement pattern analysis for position groups during match time

	Heart Rate Data			Movement Analysis
Position	Below threshold (0-80% max HR)	Above threshold (80-100% max HR)	HR zone used most	Work to rest ratio
FR	30.77%	68.48%	80-90% Max HR	1:1.8
SR	12.69%	86.75%	90-95% Max HR	1:1.6
BR	13.08%	86.29%	90-95% Max HR	1:1.7

5.4 Summary

Table 19 provides an important conclusion of the significant heart rate and movement analysis data collected. In summary this study observed that the BIP time was 46.06% of match time. On average the players spent 80% of their game time working above their individual anaerobic threshold of 80-100% max HR. It could be suggested that as a result of the data observed, when planning training for female rugby union participants, an intensity that keeps players heart rate at around 90-100% of their maximum for short durations, interspersed with active recovery periods would be appropriate.   This approach to training would elicit a replication of the physiological demands of game play. Therefore, players would be required to work under fatigue in training, leading to an increased work quality during match time. However, when ensuring players are working above threshold it is vitally important that each player has an individual assessment of maximum HR and will therefore work above their personal threshold rather than a generalised value for the team. This recommendation is appropriate, as similarly suggested by Clarke *et al.,* (2014, p.4); working above or below a critical velocity elicits different physiological responses in each individual.

The average work to rest ratio of all players throughout match time was seen to be 1:1.7, therefore, in training aiming for a work to rest ratio of 1:1.5 to 1:1.7 would provoke a work rate comparable too, or better than, match play. As this suggestion is concentrated on sport specific findings focusing on rugby union, it may also be appropriate to deploy other training strategies in order to gain the greatest training results possible. It is important to consider traditional aerobic conditioning methods to develop a level of aerobic fitness in order to maintain repeated high intensity efforts and to recover sufficiently between activities, as suggested by Stone and Kilding (2009, p.23). It is appropriate to employ sport specific conditioning methods alongside traditional aerobic conditioning methods to promote increases in levels of fitness alongside skill levels. This approach is made possible by engaging in combined skill and fitness conditioning such as small-sided games and circuits. These activities can be manipulated by a variety of condition or rule changes, for instance, pitch dimensions, rest periods, participant numbers or rule restrictions, in order to elicit the desired physiological responses. Stone and Kilding (2009, p.23) identified that as a result of combining traditional and sport specific conditioning training it is possible to increase sport performance substantially.

In view of position specific requirements, it was observed that the BR spent the greatest amount of game time working at 95-100% max HR than any other position group. However the SR out-rucked and mauled both the FR and BR. These results alongside the work to rest ratios imply that the SR were more active as a continuous work force, hence the work to rest ratio results observed. The SR spent short amounts of time resting and a large amount of time rucking, mauling and jogging. Contrariwise, the BR appeared to perform the greatest amount of utility movements perhaps around the base of rucks and mauls as well as a high occurrence of sprints. These results, alongside observing the highest percentage of game time spent at 95-100% max HR, suggest the BR completed short, sharp bursts of high intensity activities throughout the game, a concept useful to take into training plans.

The FR as a collective did not appear to stand out from the other position groups in certain activities. The FR spent a large percentage time walking, jogging, and as expected, scrummaging. The results show that the FR spent the least percentage time rucking and mauling, arguably posing the question of what were they were doing at the breakdown? It could be proposed that the FR were utilised as ball carriers. This activity was not recorded within movement analysis, perhaps meaning that the FR were not adequately represented in their movement patterns throughout match play.

5.5 Implications

As previously stated, this study aimed to provide a profile of the physiological demands of female rugby union. This study was intended to analyse and profile the insufficiently researched game of female rugby union, alongside highlighting specific areas of the forwards game previously overlooked such as scrummaging, rucking and mauling. The results from this study expose the latest findings of the physiological demands and requirements of female rugby union. This information is important for players and coaches in order to further understand the game and hence plan training and prepare for future competitions such as the 2014 World Cup and 2015 Six Nations. The data from this study could in turn provide a vast contribution to knowledge of non-participants, aspiring participants, potential sponsors, and local businesses. Thus, in turn, increasing the profile of women's rugby through media, sponsors and supporters. When initially conducting this study it was important that the end result was not only valuable and significant to academic researchers, but also to other professionals and persons interested in the topic.

The results from this study make available programming and training perspectives that can positively affect performance if utilised correctly. In order to gain the best results possible it is appropriate to apply the training recommendations previously mentioned. The recommendations aim to increase skill and fitness levels by employing traditional and sport specific conditioning methods. The outcomes of this approach are beneficial to the increase of performance and standards of female rugby union. By applying study results to on field training and programming perspectives, it is possible for recent relative data to be utilised to its full potential. Therefore, the contribution to knowledge of this study could prove to be vastly advantageous to participants, coaches and management staff within female rugby union.

5.6 Limitations and Future Research

The data in this study is limited to one (1) match with eight (8) participants. It is therefore fair to say that it is restricted in terms of subject numbers alongside the standard of participation level. Further research should concentrate on increased subject numbers, match volumes and higher playing standards. This suggestion would help to provide greater detail of the physiological demands of female rugby union. Despite the aforementioned limitation it is important to note that this study provides baseline data, previously unavailable, of the physiological demands required of, and experienced by, participants competing in female rugby union. It would be appropriate in future research to collect additional data such as body composition to decipher the percentage of lean tissue mass and fat tissue mass found in female rugby union participants in comparison to previous research.

Upon commencement of data collection, each participant partook in a measurement of maximum heart rate in the form of a 'Yo-Yo' test. Results show that just one (1) participant out of eight (8) gained their highest heart rate value when completing the 'Yo-Yo' test, whereas the remaining seven (7) participants showed their highest reading during the match. Therefore it is questionable as to whether the 'Yo-Yo' test is an appropriate measure of maximum heart rate, especially when considering the psychological behaviours of females in sport. Future research should aim to carry out a more accurate measure of maximum heart rate.

When collecting pre-testing results, this study completed the aforementioned 24 hours before game analysis. Although a short turnaround is beneficial in data collection due to the limited amount of time for external factors to affect participants, this time frame could be considered too short and did not allow for full recovery. Post match, in extreme cases it has been documented by Gill *et al.,* (2006, p.2) that individuals may experience just 88.2% recovery after 84 hours. However, it is not possible to allow a recovery period suited to every participant as players who are well conditioned have faster recovery times compared to players who are less conditioned, supported by similar suggestions from Cihan *et al.,* (2012, p.7).

When examining the results produced from movement analysis data, it became apparent that the FR might not have been fully represented at the breakdown. Therefore, future research should include a ball carrying option when providing a profile of movement patterns executed throughout game play. Additionally, when concentrating on the line-out it would be appropriate to include a lifting option due to the detail that during the line-out every player that was not considered to be jumping was recorded as standing still, therefore negatively affecting individual work to rest ratio statistics.

With the equipment available it was extremely difficult to ensure all heart rate monitors were running on the same time frame due to the set up of the individual monitors. Therefore, it was necessary to individually adjust each monitor to the same timings during analysis. Due to this limitation it was not possible to link the heart rate data to the movement analysis data in real-time. Future research should aim to link heart rate data to movement analysis in order to assess whether certain heart rate zones correlate to a particular movement pattern.

In future research, in order to assess whether individuals are working aerobically or anaerobically it would be appropriate to take a measure of blood lactate concentration levels at periods throughout game play. However, it has previously been stated by Coutts *et al.,* (2003, p.5) that this is very difficult to achieve due to the logistical and invasive nature of collecting samples at irregular periods during match play.

CHAPTER 6
CONCLUSION

In summary, the current data from this study provides a position specific physiological profile of female rugby union. The research concentrates on the demands required of female participants competing in a forward playing position. Present evidence suggests that with the game of rugby union continuously evolving it would be appropriate to consider the findings of this study when planning and devising training programmes for competition or simply as a reference for the qualities required of aspiring participants.

Current data makes evident the detail that each playing position requires different qualities and it is inappropriate to suggest that all forward playing positions require similar characteristics or training methods. To achieve maximal training results and to emulate game conditions, the results of this study show that it is suitable to ensure participants spend 80% of training time working above 80% max HR. Alongside this suggestion it would also be appropriate to ensure a work to rest ratio of 1:1.7 or below. Additionally it is appropriate to recommend a combination of sport specific and traditional conditioning methods such as small-sided games with rule constraints in order to elicit game accurate environments. These recommendations would make certain that training efforts replicate the physiological demands of game play and therefore require performance under fatigue. Training and performing under fatigue forces errors that may otherwise occur in match play.

To attain position specificity the FR should employ a large amount of long duration activities at the aforementioned training levels. The SR position is better suited to a large amount of contact and body position training due to high ruck and maul occurrences. Additionally the SR would benefit from repeated bursts of high intensity activity with short rest periods. The BR requires short sharp bursts of high intensity work, spending a large amount of time working at 95-100% max HR.

In respect to total working time throughout a match, current results show that the ball is in play 46.06% of match time. This value equated to 39 minutes and 30 seconds of game time, therefore it would be acceptable to suggest that training should aim to be continuous workloads for 40 minutes or more.

The current data makes evident the various physiological requirements of individual positions within the forwards pack as well as collective position groups. The data shows how the kinematics and demands of each position vary greatly and how physiological characteristics of individuals could decipher which position an individual is most suited too and would excel at. It had been formerly suggested by Nicholas, C., (1997, p.19), that future research should provide a set of normative values for different playing positions, together with recommendations for training and programming approaches; a demand that this study has met. However, with female rugby union continuously evolving, it would be appropriate to further expand the physiological profile and hence provide additional information in order to increase growth and standards of the sport.

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APPENDICIES

8.1 Appendix A – Ethics Status

PART ONE

Name of applicant:	Jade Newman
Supervisor (if student project):	Dr Jeremy Moody
School:	School of Sport
Student number (if applicable):	10001819
Programme enrolled on (if applicable):	Sports Conditioning, Rehabilitation & Massage
Project Title:	A Physiological Profile of Female Rugby Union
Expected Start Date:	16/10/2013
Approximate Duration:	5 months
Funding Body (if applicable):	N/A
Other researcher(s) working on the project:	N/A
Will the study involve NHS patients or staff?	If yes, attach a copy of your NHS application to this form
Will the study involve taking samples of human origin from participants?	Choose an item.

In no more than 150 words, give a non technical summary of the project
This project will begin with all participants completing basic fitness testing (height, weight, resting heart rate and maximum heart rate); all completed wearing a heart rate monitor. They will then be tracked (heart rate and video analysis) throughout game play. Following data collection I will analyse their work rate, heart rate and time spent doing certain movements or activities, building a profile for individual players and position groups. To conclude I will provide a physiological profile of the loading that female rugby union players can expect to experience throughout game play. Data collected will be available in an area that has not yet been studied or researched before, enabling elite female rugby union to have a set of normative data that can be used for comparison. Alongside, this study will provide coaching staff with data personal to their squad that could be used to influence training and selection in future.

Does your project fall entirely within one of the following categories: No	
Paper based, involving only documents	Choose an item.

in the public domain	
Laboratory based, not involving human participants or human tissue samples	Choose an item.
Practice based not involving human participants (eg curatorial, practice audit)	Choose an item.
Compulsory projects in professional practice (eg Initial Teacher Education)	Choose an item.
If you have answered YES to any of these questions, no further information regarding your project is required. If you have answered NO to all of these questions, you must complete Part 2 of this form	

DECLARATION: **I confirm that this project conforms with the Cardiff Met Research Governance Framework**	
Signature of the applicant: J.E.Newman	Date: 19/09/2013
FOR STUDENT PROJECTS ONLY	
Name of supervisor:	Date:
Signature of supervisor:	

Research Ethics Committee use only	
Decision reached:	Project approved ☐ Project approved in principle ☐ Decision deferred ☐ Project not approved ☐ Project rejected ☐
Project reference number: Click here to enter text.	

Name: Click here to enter text.	Date: Click here to enter a date.
Signature:	
Details of any conditions upon which approval is dependant: Click here to enter text.	

A RESEARCH DESIGN	
A1 Will you be using an approved protocol in your project?	Choose an item.
A2 If yes, please state the name and code of the approved protocol to be used[3]	
Click here to enter text.	
A3 Describe the research design to be used in your project	

Research method:

The data will be collected during British University & Colleges Sport fixtures, held on a Wednesday afternoon. All eight of the starting forward pack will be monitored throughout the 80 minutes of game time. If a player comes off the pitch injured their data will be automatically discounted from the study. This is to ensure the data collected is reliable and valid for analysing. The collection of video data will also be completed at the same time so that the heart rate data matches up to the video footage gained.

Recruitment of participants:

All players monitored in this study will be part of the same team, Cardiff Metropolitan University Women's 2nd XV, competing in the British University and Colleges Sport Western 1A Division. Match data collection will be taken on Cardiff Metropolitan School of Sport, Pitch 2 during the season 2013-2014.

The participants will be selected if they meet the following criteria:

7. Training and competing regularly for Cardiff Metropolitan Women's 2nd XV
8. Playing in a forward position (either prop, hooker, lock, flanker or number eight)
9. Have had previous playing experience of at least 3 years

[3] An Approved Protocol is one which has been approved by Cardiff Met to be used under supervision of designated members of staff; a list of approved protocols can be found on the Cardiff Met website here

Analytical Techniques:

Analysis of HR rata – Before commencement of monitoring, each participant will have their maximum heart rate recorded to calculate the heart rate zones for each participant. The maximum heart rate value will be gained from participants completing the Yo-Yo test within two (2) weeks prior to the game play. This test will also provide a measure of game specific aerobic fitness. The heart rate data collected during match play from each individual participant is split into six (6) separate heart rate zones, which I can then use to measure the time spent within each heart rate zone for individual players and for player positions. These zones are:

1. Zone 1: 0-60% max HR
2. Zone 2: 60-70% max HR
3. Zone 3: 70-80% max HR
4. Zone 4: 80-90% max HR
5. Zone 5: 90-95% max HR
6. Zone 6: 95-100% max HR

Analysis of time motion data – Once the time motion data has been collected it will be uploaded to 'StudioCode' and each players movements throughout the game will be separated into nine (9) categories which will enable the calculation of work to rest ratios and percentage of time spent in each speed zone. This will provide a profile of individual players and position specific movement activities over 80 minutes of game play including time spent in each category alongside frequency that each category is being used. The nine (9) categories are:

1. Standing still
2. Walking
3. Jogging
4. Running
5. Sprinting
6. Utility
7. Jumping

8. Rucking/mauling
9. Scrummaging

A4 Will the project involve deceptive or covert research?	Choose an item.
A5 If yes, give a rationale for the use of deceptive or covert research	
Click here to enter text.	

B PREVIOUS EXPERIENCE
B1 What previous experience of research involving human participants relevant to this project do you have?
None
B2 **Student project only** What previous experience of research involving human participants relevant to this project does your supervisor have?
10. UKSCA Accreditation Lead Assessor 2005 – To date SCW S&C Internship Mentor Mentor 2006 - 2007 Gateshead Thunder Rugby League Head of Performance 2005 - 2007 UK Sport Fast Track Practitioner Programme Lecturer/Mentor 2005 – 2007 United Kingdom Strength & Conditioning Association Non-Executive Board Director 2005 - 2007 Great Britain Wheelchair Rugby Association (GBWRA) Performance Director 2002 - 2005 FSAD Wales Sports Science Support Sports Science 2002 - 2003 GBWRA Development Unit Head Coach 2001 - 2003 GBWRA Head Coach 1999 - 2002 Welsh Judo Association Sports Science 1999 - 2003 GBWRA Sport Science 1998 - 2005 Tennis Wales Sport Science 1999 - 2001 GBWRA Head Coach 1998 - 2001 Welsh Squash Racquets Association Sport Science 1995 - 1998

C POTENTIAL RISKS
C1 What potential risks do you foresee?
Participants: Physical exertion whilst recording pre-game statistics (maximum heart rate) and during the game could be of discomfort, however this will not be out of the normal for participants. There is a risk of injury occurring during the max heart rate testing due to the area or surroundings. **Researcher:** Participants may not want to be involved in the study before it begins or during the collection of data, thus leaving me with inadequate data to complete the study. Due to the availability of the data to coaches the results could inform team selections, putting the researcher in a situation that may not be appropriate.
C2 How will you deal with the potential risks?
Participants: This will be normal for the participants who usually train every day and compete at least once a week. If a participant appears to be struggling, injured or requests to stop they will be removed from the testing or measurement and discounted from the study. Injuries will be avoided as much as possible by ensuring the area is clean and safe with a registered first aider on site. **Researcher:** To prevent dropouts, a squad of players, rather than the bare minimum, will be used. Hence there will be a back – up set of players of the same position who have also been tested pre-game that can provide additional data for the study in case of participants dropping out. With regards to data being available to coaches, it will only be possible for them to access it if the participants or individuals give full consent.

8.2 Appendix B – Participant Information Sheet

Cardiff Metropolitan School of Sport Ethics Committee
Research Participant Information Sheet

Project Title: A Physiological Profile of Female Rugby Union

This document provides a run through of:

1) The background and aim of the research
2) My role as the researcher
3) Your role as a participant
4) Benefits of taking part
5) How data will be collected
6) How the data/research will be used

The purpose of this document is to assist you in making an *informed* decision about whether you wish to be included in the project, and to promote transparency in the research process.

1) Background and aims of the research

The aim of this study is to provide a profile for the physical demands of female rugby union. There is currently very little information of the demands of female rugby union. Hence I wish to collect and analyse data to provide a comprehensive profile of the physiological demands of female rugby union.

2) My role as the researcher

The project involves me (Jade Newman), the researcher collecting weight, stature, heart rate and video analysis data from a full forwards pack, containing eight (8) players. This group of players will consist of five (5) main positions including Props (2), Hooker (1), Locks (2), Flankers (2), and Number Eight (1). The selection of participants is to provide in-depth data into the physiological demands of a game whilst playing in the forwards.

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3) Your role as a participant

Your role is to train and compete with Cardiff Metropolitan Women's Rugby Union team throughout season 2013/2014 and be monitored and recorded in selected matches. You will be regularly informed of any monitoring or recordings taking place. You do not have to take part in this study if you do not wish, and you have the right to withdraw from the study at any point.

During the first meeting you will be given an Informed Consent to be completed. This form is to ensure you understand what is expected of you as a participant, myself as a researcher and the process you will experience throughout the study, alongside giving your consent for data to be collected, analysed and presented.

During the second meeting you will be expected to complete a number of pre-study tests to attain peak values for your heart rate during exercise. This will consist of the completion of height, weight, and maximum heart rate ('Yo-Yo' test – a 20 metre shuttle test with 10 second active recovery). Throughout the testing you will be required to wear a heart rate monitor strap.

The final part of the study will involve you as the participant being measured for heart rate values during live match play. You will also be video recorded which will be used for analysis of your movements throughout the match.

4) Benefits of taking part

The information obtained from this study will provide a comprehensive profile of the physiological demands of female rugby union. There is currently no data available in this area at present; therefore any data collected will contribute to knowledge vastly. The data will allow for a better insight into the female game and could provide findings that help to expand the game. Your personal data will be available to only yourself should you wish to access it. If you give consent for your coaches and management staff to access your results they will have access also.

5) How data will be collected

All eight of the starting forward pack will be monitored throughout the 80 minutes of live game time using the Suunto T6 Team monitoring system to record heart rate data and a video camera to record game footage.

6) How the data / research will be used

In agreeing to become a *voluntary* participant, you will be allowing me to use your recorded data and include it within a larger data set that includes the data of other participants. This will provide a physiological profile of women's rugby union, aiding training and potentially increasing support and participation within the women's game.

Your rights

Your right as a *voluntary* participant is that you are free to enter or withdraw from the study at any time. This simply means that you are in full control of the part you play in informing the research, and what *anonymous* information is used in its final reporting.

Protection to privacy

Concerted efforts will be made to hide your identity in any written transcripts, notes, and associated documentation that inform the research and its findings. Furthermore, any personal information about you will remain *confidential* according to the guidelines of the Data Protection Act (1998).

Contact

If you require any further details, or have any outstanding queries, feel free to contact me on the details printed below.

Jade Newman
Cardiff School of Sport
Cardiff Metropolitan University
Cardiff
CF23 6XD
E: st10001819@outlook.cardiffmet.ac.uk

8.3 Appendix C – Participant Consent Form

CARDIFF METROPOLITAN PARTICIPANT CONSENT FORM

UWIC Ethics Reference Number:

Participant name or Study ID Number:

Title of Project: **'A Physiological Profile of Female Rugby Union'**

Name of Researcher: Jade Newman

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason ☐

3. I agree to take part in the above study ☐

4. I agree to my vital statistics (height, weight, and maximum heart rate) being recorded ☐

5. I agree to matches being video recorded ☐

6. I agree to the use of anonymised data being used in publications ☐

____________________________________ ____________________

Signature of Participant Date

____________________________________ ____________________

Name of person taking consent Date

____________________________________ Signature of person taking consent