Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA:

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Comments	**Section**
	Title and Abstract 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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A Comparison of Somatotype Characteristics among Player Positions in Collegiate Rugby Union Players.

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Notes:

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ABSTRACT

The objective of this study was to compare somatotypes of rugby players at a collegiate level and examine the anthropometrical differences found between playing positions. “While a variety of different sciences apply the principles of anthropometry, from nutritionists concerned with obesity to ergonomists concerned with low back pain, anthropometry has long been applied in a sporting setting due to the influence body morphology and somatotype has on sporting performance” (Norton and Olds, 2004).

Ten Anthropometrical measurements were carried out on Thirty-Five male collegiate rugby players, in order to gain somatotypes for comparison between playing positions. Players were split into six positional groups; Front row(1), second row(2), back row(3), half backs(4), midfield backs(5), and outside backs(6). Groups were compared with each other in order to find significant difference ($p<0.05$) between the individual components; endomorphy, mesomorphy, and ectomorphy.(1,2,3, forwards/ 4,5,6, backs)

Significant difference ($p<0.05$) was found between positional categories within both the forwards and backs. The front row were found to me mesomorph-endomorphs, while the second row, outside backs and midfield backs were classified as balanced mesomorphs, the two final groups the back row and the half backs, were endomorphic mesomorphs.

CHAPTER ONE

INTRODUCTION

1. Introduction

1.1 Somatotypes

"Morphology is the science of structure and form without regard to function, but it is a basic biological dictum that form follows function, and so there is a relationship between the two." Carter (1995). Morphology, physique or body composition has been investigated for centuries, various systems for classifying physique have been developed, Sheldon (1940) was the first to propose somatotyping. Since then there have been various modifications (Parnell, 1958; Heath and Carter., 1967) to his theoretical model which suggested that a "somatotype was a fixed or genetic entity" (Norton and Olds, 2004). However Carter and Heath (1990) presents views which relay that "somatotype is phonotypical and thus amendable to change under the influence of growth, aging, exercise and nutrition". Somatotyping is defined by Norton and Olds (2004) as "the quantification of the present shape and composition of the human body." It is also important to acknowledge that somatotypes are general descriptors of physique as a whole and do not represent specific body dimensions.

1.2 Anthropometric Literature

Various studies have addressed anthropometry and somatotyping within a wide range of sports such as Volleyball (Gualdi-russo, et al. 2001), Football (Can, et al., 2004; Reilly, 2000), Tennis (Barbaros-Tudor, et al., 2011), Basketball (Carter, et al., 2005), and rugby league (Gabbett, 2006). With regards to rugby union there are very few studies that have been undertaken over the past decade. Duthie, Pyne, Hopkins et al's (2006) study on anthropometric profiles of elite rugby players: quantifying changes in lean mass, is the most recent study with regards to anthropometry and rugby union. It gave a brief insight into the anthropometrical profiles of rugby players however the main focus of this study was to develop research on seasonal changes of body composition and more specifically changes in lean mass. Also due to time restraints the anthropometric assessment of the athletes consisted of only height, mass and skinfold thickness and therefore the data collected was insufficient for calculating the Heath-Carter anthropometric somatotype. Quarrie et al, (1996) is the most recent literature to carry out anthropometrical measurements on rugby union players in order to highlight the differences between the playing positions. They also used physical performance assessments in order to gain a clearer view on the physiological demands of each position. However due to the age of the study the reliability of the results can drop due to the major shifts in physique of rugby union players over the last thirty five years (Olds, 2001).

1.3 Research Purpose/ Hypothesis

The purpose of this study is to examine and compare the varying somatotype characteristics found among different playing positions in collegiate rugby union players. Ten anthropometrical measurements will be taken from 35 regularly training/playing collegiate rugby players in order to gain body composition. The data collected will be entered into equations derived from the rating form method of Heath and Carter (1967), to calculate the somatotype. The data collected will be displayed on somatocharts in order to give a visual representation of where each somatotype is relative to one another. It is hypothesised that due to the varying physiological demands of rugby union on specific playing positions, forwards will have a higher endomorphic rating, and backs will have a higher mesomorphic rating. From this particular study the findings will give participants a greater knowledge about themselves in relation to rugby, giving insight into what and how then can make changes to their training to best excel in their individual position. It will aid coaches in developing training programmes specific for individuals in different playing positions consequently, giving them the opportunity to focus on strengths and develop weaknesses where needed. Finally, the study will enhance and develop the small amount of existing research on anthropometry within rugby union. Thus, developing the knowledgebase related to anthropometry specific to playing positions, while also giving further understanding into the differences in body composition and physiology between performance levels with rugby union.

CHAPTER TWO

LITERATURE REVIEW

2. Literature Review

2.1 Morphology

Carter (1985) states that “morphology is the science of structure and form without regard to function, but it is a basic biological dictum that form follows function, and so there is a relationship between the two.” The physical characteristics of an athlete’s often imitate physiological, biomechanical, and functional strains of their specific sport and the alterations which come about through training (Malina, 1995; Shephard,1998; Maestu, Jurimae, & Jurimae, 2000). Various studies such as Battista’s (2007) comparison of physical characteristics and performances among female collegiate rowers corresponded with the suggestion that the demand of a sport can dictate the morphology of an athlete. Therefore we can assume that there is a conclusive relationship between a specific sport and the morphology of the performer.

Sport mirrors itself to a Darwinian system; successful characteristics are selected while unsuccessful ones are dropped. Sports where the physiques of the performers have an impact on the outcome of the game will innately select players who imitate the idealistic morphology. Olds (2001) denotes that the there is a significant correlation between body size and success due to the positive gradients across competitive standards and also the final rankings of different sized teams in the recent rugby union world cups. There are many studies which propose that certain anthropometrical physiques are best suited for a particular sport. Landers et al, (2000) states that various authors (Tittle and Wutscherk 1988, Sleivert and Rowlands, 1996) stated that in swimming having long limbs allows for a greater economy of effort because an increase in stride or stroke length is more efficient than an increase in frequency. Atwater (1990) put forward that body fat correlates negatively with running success because it is essentially a dead weight that must be carried throughout the event.

2.1.1 Importance of Morphology to Sport

Duthie et al., (2006) study of anthropometry profiles of elite rugby players found that there is a significant relationship between the physical prowess of a rugby player, and competitive success. Earlier research carried out by Duthie et al., (2003) suggested that particular physiques will orientate a player towards a specific position. Therefore, further research needs to be undertaken in order to find the relationship between positions and morphology; the data would be able to identify which position would best suit each individual performer. Hene, Bassett and Andrews (2011) suggest that within rugby sevens, back line players whose job it is to attack and cover defend, have a lean physique, whereas forward players are heavier and taller, with a greater proportion of body fat and muscle density and size in order to dominate in scrums, tackles, rucks and mauls (Rienzi, Reilly & Malkin, 1999).

Olds (2001) denotes that the physique of players is not the only factor which determines success in sport. In an earlier study Norton and Olds (1996) relay that in sports such as football no particular height, or body mass apart from goalkeepers, would suggest an advantage over other physiques. Olds (2001) goes on to suggest that in order to determine how much body size and shape influences success, one has to observe the sporting sample compared to the source population, if there are greatly differing values of mean, and variances, then it is probable that physique is an important factor for success. Also if physique gradients exist throughout competitive standards showing clear trends from recreational to regional to international standards (Olds, 2001) then physique-based selection would be assumed and furthermore a suggestion of a positive relationship between physique and success.

2.2 Rugby Union

In 1995 men's rugby union became professional; since then the sport has quickly developed in order to meet requirements for the increased demand in knowledge of the game and the physical fitness characteristics of players

(Nicholas,1997). The International Rugby Board (IRB) are involved in over 92 different countries and In the UK and Ireland alone there are approximately 2,441,668 rugby union players (International Rugby Board, 2012).

On average during an 80 minute match, Mclean (1992) found that the ball is usually in play for 30 minutes. Morton (1978) suggests that the remaining time is made up when the ball is out of play or during conversions, penalty shots, setting up line outs, scrums and injury time. Teams consist of 15 players on the field at any time with the exception of players being sent off for misconduct (Duthie, Pyne and Hooper 2003). Players are assigned individual positions outlined by the International Rugby Board (2012). These positions are divided into two major groups; players numbered one to eight are classified as 'forwards', and players numbered nine to fifteen are described as 'backs'. Duthie, Pyne and Hooper (2003) split these two groups again into subgroups, one to five being referred to as 'tight 5' and six to eight, being referred to as the 'loose forwards'. Within the backs, nine and ten are 'half backs' and the 'midfield backs' are twelve and thirteen, and finally eleven, fourteen and fifteen are referred to as 'outside backs'. Quarrie et al.,(1996) describes the broad physical requirements of the players, the front three have to be strong and powerful as they are close to contact throughout game play. The second row, numbers four and five are commonly the tallest players while having a similar overall body mass to the rest of the forwards as they provide stability in the scrums and are again close to contact throughout. The loose forwards generally strong and powerful while also having additional traits such as agility, speed and endurance as they are commonly ball carriers and involved in open field play while also being largely involved in contact situations during the game. Half backs control possession of the ball gained by the forwards it is necessary for them to have good endurance along with speed in order to follow play of the ball, and avoid contact if possible. Twelve and thirteen have a high amount of contact with opposition and it is important for them to have strength, power, and speed. Finally the outside backs require substantial speed and agility in order to out manoeuvre the opposition, while also having a great deal of endurance as the carry out a large amount of defensive covering along with support for ball runners and chasing down kicks. Roberts et al., (2008) and Deutsh et al., (1998) found that on average over a game, backs travel a greater distance than forwards (6217m to 5581m respectively) and that back travelled a greater distance at a higher intensity than forwards. However, forwards were found to perform high intensity activities for longer periods over all during a game.

2.2.1 Evolution of Physique

Changes in height and body mass through consecutive generations of humans populations living in similar environments are described by the term ‘secular tend’ (Ulijaszek et al., 1998). Over the last century Tanner (1976) found that there has been an upward trend in height and body mass in the majority of the world population. It can be seen in numerous sports such as basketball, high jumping, and ‘Australian rules’ football, that the athletes have shown an increase in height which has outstretched that of the secular trends. This can also be found when comparing at body mass in rugby league and American football (Norton et al., 1996; Norton and Olds, 2000). Olds (2001) found that over the last thirty five years there have been major shifts in the physique of rugby union players with Body Mass Index (BMI), body mass and mesomorphy of players increasing at a rate, twice the rate of the average for the whole population over the twentieth century, and a growth rate five times that to the secular trend of the source population. This suggests that literature older than a decade can have a limited application to current day rugby (Duthie et al., 2003)

2.2.2 Morphological changes over a season

Duthie et al (2006) states that “During a competitive season, a variety of factors, including the amount of playing time, training, dietary practices, illness, injury, and travelling, may lead to changes in body composition.” The study found that during a competitive season there is approximate 5% decrease in skinfolds. Holmyard and Hazeldine’s (1993) research on seasonal variations of anthropometrical and physiological characteristics also found similar results to support Duthie et al (2006). Individual changes were reported to be typically much larger than the respective technical error percentage. Due to significant changes and adaptations of body composition during a competitive season, somatotype data collection must be carried out within a restricted time constraint in order to gain a fair representation of each individual.

2.3 Anthropometry

The somatotype is defined as the quantification of the present shape and composition of the human body (Norton and Olds, 2006). The way in which a somatotype reading is presented is in a three number rating representing endomorphy, mesomorphy and ectomorphy components respectively, and always in this particular order. Endomorphy is the relative fatness, an example of a sport which requires a high endomorphic rating would be sumo wrestling and individuals are required to have a low centre of gravity and large body mass. Mesomorphy is the relative musculo-skeletal robustness, weight lifters required a large and ectomorphy is the relative linearity or slenderness of a physique (Carter, 2002). In this study the method which will be used is the anthropometric method, where anthropometry is used to estimate the criterion somatotype (Carter and Heath 1990). Anthropometry is a branch of anthropology and is the study of the measurement, of the human body in terms of the dimensions of bone, muscle and adipose tissue (NHANES, 2004). While a variety of different sciences apply the principles of anthropometry, from nutritionists concerned with obesity to ergonomists concerned with low back pain, anthropometry has long been applied in a sporting setting due to the influence body morphology and somatotype has on sporting performance (Norton and Olds, 2004)

2.4 Similar Research

Numerous studies have attempted to report somatotypes with various different sports such as Volleyball (Gualdi-russo, et al. 2001), Football (Ayan, et al., 2011., Can, et al., 2004., Reilly, 2000), Tennis (Barbaros-Tudor, et al., 2011), Basketball (Carter, et al., 2005), and rugby league (Gabbett, 2006). Very few studies related to morphology and performance, are based on

Rugby Union. It seems that the majority research similar to this study is outdated by over a decade such as Nicholas (1997).

While comparisons of anthropometric characteristics of specific rugby union playing positions are uncommon, similar studies (Gabbett, Jenkins, Abernethy 2011; Gabbett 2006; Landers et al., 1999; Battista, 2007; Quarrie et al,. 1995, 1996; Carter et al., 2005; Can, Yilmaz, Erden, 2004; Reilly, Bangsbo, Franks 2000) have also used anthropometric methods where anthropometry is used to determine the criterion somatotype of subjects. Norton and Olds (2006) suggest three ways of obtaining a somatotype. The anthropometric method; where anthropometry is used to estimate the criterion somatotype. The photoscopic method; where the ratings are gathered from a standardised photograph, and finally a combination of the two, which is considered the 'Criterion' method. Most people do not get the opportunity to become criterion raters using photographs, and therefore the anthropometric method has proven to be most useful. It requires little equipment, calculation or time and measurements can be made with relative ease on subjects dressed in minimal clothing (Norton and Olds, 1996). In past studies the anthropometric method has been used and has been successful in determining somatotypes for subjects (Gabbett, Jenkins, Abernethy 2011; Gabbett 2006) and therefore strengthens and favours this particular protocol.

2.4.1 Research Critique

Few studies have attempted to analyse differences between positional groups within the backs and forwards, Quarrie et al. (1996) carried out a review of previous research done by Rigg and Reilly (1988) which brought together fitness profiles and anthropometric analysis of two different levels of competition within rugby union. Comparative analysis was undertaken between positional groups along with between levels of performance. Differences in positional categories were found however, these differences were only noticeable in terms of height and weight, and in fact, when observing somatotypes there was no significant difference between the positions. This was found due to such a small sample size, which when split into positional categories reduced significantly to cause the number of subjects in each category to be ranged from three to seven. Other studies such as Boennec, Prevost and Ginet (1980) identified forwards to be more endo-mesomorphic than backs, nevertheless, they also used a small sample size of approximately thirty rugby players and did not consider differences within specific playing positions. Owing to the age of the study the reliability of the results drop considerably due to the major shifts in physique of rugby union players over the last thirty five years (Olds, 2001). Casagrande and Viviani (1993) collected anthropometrical data to gain the somatotypes of twenty eight “A” league Italian rugby union players and compared them with twenty five sedentary young Italians, along with a previous study carried out by Bailey, Carter and Mirwald (1982). Again in this study we can identify the limitations to be the small sample size, and the comparisons that they made are redundant, due to the age of the research (1982). Quarrie et al, (1996) assessed 94 senior ‘A’ club rugby players using anthropometrical measurements to gain somatotypes while also using physical performance assessments such as aerobic shuttle runs, vertical jumps and a push up tests in order to observe the true demands imposed on players by their position. They found that typically forwards differed significantly between positions, all though in terms of physical performance, few differences were reported. Quarrie et al’s (1996) study used a larger number of participants compared to previous studies, which helped to enable some differences between positional categories to be more clearly identified. By using a combination of anthropometric characteristics and performance indicators, players were able to give a better representation of the demands imposed on them by their position.

2.5 Significance of the study

Former studies for anthropometrical characteristics for elite team sports have suggested substantial variances among playing positions for height, body mass, and skinfold thickness (Gabbett 2006; O’Connor, 1996; Meir et al., 2001; Nicholas, 1997). Nonetheless even though these studies have conveyed differences between playing position in elite team sports, none have considered whether these differences exist among playing positions in collegiate rugby union players. Subsequently data for collegiate rugby union players does not exist and therefore making the development of realistic position-specific performance standards difficult (Gabbett, 2006). As a result furthering the available data on somatotype characteristics among player positions in collegiate rugby union players would enable coaches to identify player deficiencies. While also enabling them to develop specific training programmes for players according to their position, or a change to the athlete's role can be made in order to make that weakness a potential strength.

Taking that into consideration, the purpose of this particular study is to identify and compare somatotype differences in player positions within rugby union. As a result, a further understanding of these characteristics will enable researchers and coaches alike to use this information for talent identification schemes along with giving comparisons for elite and non-elite rugby players. These findings will give coaches an insight into the need for fitness attainment targets when preparing individual players for competitive matches (Nicholas,1997). It will allow coaches to ensure an athlete's strengths are optimised while also being able to take into consideration an athlete's weaknesses. Within rugby union there is a lack of comprehensive research into the anthropometric and physiological characteristics of its players (Nicholas, 1997). Previous research has focused on skill related aspects of the game, rather than the physical and physiological requirements, past studies have focused on elite rugby union performers (Nicholas, 1997) which has therefore minimised the amount of normative data for collegiate rugby union players, consequently providing coaches within the sport less information to inhibit the identification of players morphological deficiencies, and thus develop specific training programmes according to player position. It is, therefore, evident that further research is needed in order to increase the existing knowledge base. It is hypothesised that forwards morphological characteristics will have a higher endomorphic rating, and backs morphological characteristics will have a higher mesomorphic rating.

CHAPTER THREE

METHODOLOGY

3. Method

3.1 Participants

Thirty-five male participants aged 18-30 were split into two groups of 15 based on their position within rugby. Measurements and testing of the participants were taken during the competitive season due to variations in morphology when in full time training. It was found that over a competitive season there is an approximate 5% decrease in skinfolds, body fat percentage is reduced also improvements' in VO_{2max} and 30m sprint time are made. (Duthie et al., 2006; Holmyard and Hazeldine. 1993). The number of participants used in this study has been based on previous research (Can, Yilmaz, Erden, 2004; Hene, Bassett, Andrews 2011). Participants gave consent and ethical approval was confirmed by Cardiff Metropolitan University ethics approval committee (2012).

3.2 Testing Procedure

All participants will undergo ten anthropometric measurements in order to calculate their somatotype. These will include stretch stature, body mass, four skinfolds (triceps, subscapular, supraspinale, medial calf). Two bone breadths (biepicondylar humerus and femur), and two limb girths (arm flexed and tensed, calf) (Carter, 2002).

These measurements were taken in accordance to Carter and Heath (1990) and were collected three times in order to gain a technical error of measurements (TEM). Stature or height is to be taken standing straight with back against the stadiometer, touching the wall with heels together, and shoes removed. Body mass is measured with the subject wearing minimal clothing, then standing in the middle of the scale, weight is recorded to the nearest tenth of a kilogram. Skinfolds are taken using Harpenden calipers by raising a fold of skin and subcutaneous tissue firmly between thumb and finger and away from underlying muscle at the marked site. Apply the calipers 1cm below the fingers of the left hand and allow them to exert their full pressure before reading at two seconds the thickness of the fold. The exact positioning of each skinfold measurement was in accordance with procedures described by Norton et al., (2000) and all skinfolds are to be taken on the right side of the body (Carter, 2002). For the biepicondylar breadth of the humerus, with the elbow at a right angle apply the caliper at the angle approximately bisecting the angle of the elbow. Press firmly on crossbars to compress the subcutaneous tissue. The biepicondylar breadth of the femur is taken with the subject seated and knee at a right angle. Measure the greatest distance between the lateral and medial epicondyles of the femur pressing firmly on the crossbars to compress the subcutaneous tissue (Carter, 2002). When measuring the upper arm girth flexed a anthropometric tape measure should be wrapped around the middle of the upper arm when flexed and tensed. This can also be done for the calf girth. Stature and girths are to be measured to the closest mm, while the biepicondylar diameters are to the nearest 0.5mm and the skinfolds to the nearest 0.1mm (Carter and Heath, 1990).

With reference to reliability the advantages of anthropometry is lost unless the measurements are accurate and precise (Carter, 2002). The validity of the rating depends on the reliability of the measurements. The TEM is often used for evaluating the consistency, or precision, of the measurer on a given variable (Carter, 2002). In order for the TEM system to be used two independent measures for each measurement must be taken. The TEM is then the square root of the sum of the differences between measures one and two squared, divided by twice the number of subjects (Cameron, 1984; Norton and Olds, 1996)

3.3 Statistical Analysis

Firstly the data gathered were entered into equations derived from the rating form method of Carter and Heath (1990) in order to calculate the somatotypes of each individual. The somatotypes were then arranged into their relevant groups where they were entered into Somatotype (©2001 - Sweat Technologies) software which allowed the data to be presented as somatoplots on somatocharts. Somatocharts were used to display individual somatoplots within groups, while also presenting average somatotypes of each independent group. This is a key when interpreting results as the shape of the distribution of somatoplots imparts considerable useful information (Carter, 2002) while also acting as a visual aid for understanding the body compositions of athletes. A one-way analysis of variance (ANOVA) is used to determine whether there are any significant differences ($p<0.05$) between the means of independent components. In this case the ANOVA test was used to determine if there are differences between the groups within the individual somatotype components. It is important to note that the ANOVA test does not show which specific groups are significantly different from each other, it only relays whether or not there is significant difference between two or more of the groups. As there were six groups being compared a post-hoc test was carried out to find specific differences between groups. The least significant difference (LSD) pairwise comparison technique was used for the post- hoc test. Williams and Abdi (2010) state that the LSD is used to “compute the smallest significant difference between two means as if these means had been the only means to be compared and to declare significant any difference larger than the LSD.”

CHAPTER FOUR

RESULTS

4. Results

This section will display the results gathered from the data collection, and the statistical analysis undertaken in order to find a statistical significant difference where $p<0.05$. The results should give a further insight into the relationship between playing positions within rugby union.

4.1 Stature and Weight

Table 1 brings together the mean stature and weight for each group, while also showing the height-weight ratio (HWR). From the data collected, second row players were on average 11.4cm taller than any other player, also front row players are the heaviest being on average more than 8kg heavier than any other player. Overall it can be seen that forwards are heavier than backs with an average of 100.43kg, (against the backs average weight of 82.5kg) and taller with an average height of 184.43cm against a back line of on average 179.66cm.

Figure 1,2, and 3 display the three individual components of a somatotype, Endomorph, Mesomorph, and Ectomorph respectively, showing the mean and standard deviation of each specific group.

4.2 Somatocharts

Figure 4-9 each display the somatotypes of the six different groups on somatocharts. From the somatochart we can begin to see the differences in somatotypes for each different group or playing position. A number of trends within groups can be found on each of the somatocharts this can be seen in Figure 6 where five out of seven subjects are grouped in an area which spread over two units 5-8-1/3-6-1. However anomalies in the data can also be identified, for example, in Figure 4 we can see the somatotypes of the front row and a grouping of a number of profiles around 7-8-1 however there is also a lone profile near to 6-4-2. Anomalies such as this occur in each of the somatocharts, and will be looked into further during the discussion.

Figure 10 shows the mean somatotypes of each group, this gives a clearer understanding of the differences between the somatotypes with relation to playing position. The significant difference found in the post hoc is also supporting by what can be seen in figure 10. It is clearly showing significant differences between group 1 and the rest of the group, while groups 3 and 4 also show differences to groups 2, 5 and 6.

4.3 Somatotype Classification

Based on the 13 categories defined by Carter and Heath (1990) we are able to use figure 10 to classify the mean somatotypes of each group. The Front row, were found to be Mesomorph-endomorph; which is where the endomorphic and mesomorphic component is equal or within half a unit of one another, and ectomorphy is smaller. The second rows along with the outside backs and mid backs were catagorised as balanced mesomorphs; mesomorphy is dominant and endomorphy and ectomorphy are equal (or do not differ by more than one-half unit) (Carter and Heath, 1990). The remaining two groups (Back Row, Half Backs) are both Endomorphic mesomorph: when the mesomorphy is dominant and endomorphy is greater than the ectomorphic component.

4.4 Statistical Significant Difference

The ANOVA test showed that there is a statistical significant difference ($P<0.05$) between groups within each dependant variable. The between groups ANOVA test with regards to Endomorphy, Mesomorphy, and Ectomorphy, gave a significant difference of .000, .040, and .000 respectively. In order to identify where this significance occurs a ‘least significant difference’ (LSD) post-hoc test was carried out. When observing the post hoc test specifically the endomorphic component we can see that group 1 (Front

Row) has a statistical significant difference with all subgroups. It can also be noted that there is a difference (P=.008) between groups 3 (Back Row) and 6 (Outside backs) along with groups 4 (Half Backs) and 6 where P=.018. The mesomorphic component reveals statistical significant difference between group 1 and 2 (second row) where P=.027. Additionally when group 1 and 5 (Mid Backs) and groups 1 and 6 are compared P=.020, .006 respectively. Group 3 compared to group 6 gives a P value of .028, also showing statistical significant difference. A high significant difference can similarly be seen between groups when analysing the ectomorphic component; P = .000 between groups 1 and 2, 1 and 5 and finally 1 and 6. Groups 1 and 4 also have a significant difference where P=0.045. Between groups 2 and 3, and also groups 2 and 4 there is evidence of significant difference where P=0.004 and 0.012 respectively. Significant difference can also be found between groups 3 and 5 where P=0.004 along with differences between 3 and 6 (P=0.001). When compared, Group 4 is also significantly different to group 5 and group 6, where P=0.015 and 0.003 respectively.

The ANOVA test was carried out on the variables, stature, body mass and height weight ratio (HWR), in order to find statistical differences ($p<0.05$) between groups. When looking at the ANOVA results we can notice that there is significant difference between groups for each dependant variable. To find specifically where these differences occur, a LSD post-hoc was carried out. Interesting when analysing the data it was found that between the second row and all the other groups there was considerable significant difference ($p<0.05$) with regards to stature. Statistical difference could also be noted between group 3 with 2 and group 3 with 5 p=0.036, 0.026 respectively. With regards to body mass there is a substantial amount of significant difference ($p<0.05$) occurring between many of the groups. Overall the forwards are significantly heavier than the backs; specifically when observing the post-hoc data for the forwards the only significant difference between the groups is when comparing the front row with the back row, when comparing the groups within the backs we find no significant difference. Height-weight ratio (stature/mass^3) as used in somatotyping (Carter and Heath, 1990) was also found to show significant difference ($p<0.05$) between groups. The front row were shown to be significantly different to all other groups, the second row were found to differ from the back row, and the half backs, while the back row showed statistical difference between all but the half backs. Within the backs the half backs HWR was significantly different to that of the midfield backs and the outside backs yet group 5 and 6 showed no significant difference between themselves.

4.5 Tables and Figures

Table 1 - Displays the mean height, and weight, along with the mean height and Weight Ratio (HWR) in relation to the different subgroups.

	Front Row	Second Row	Back Row	Half Backs	Mid Backs	Outside backs
Height (cm)	177.9	193.7	181.7	176.5	182.3	180.2
Weight (kg)	107.9	99.4	94	83.9	84.1	79.5
HWR	37.5	41.8	40.0	40.3	41.6	41.9

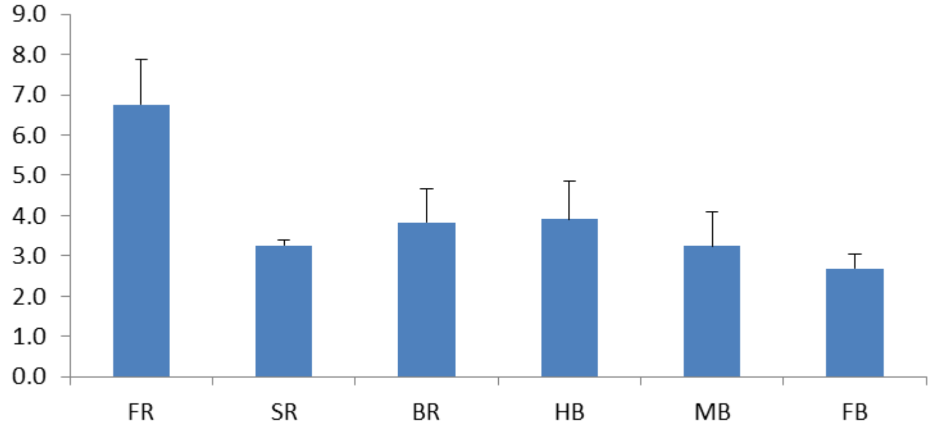

Figure 1. Mean and Standard Deviation of the Endomorphic rating.

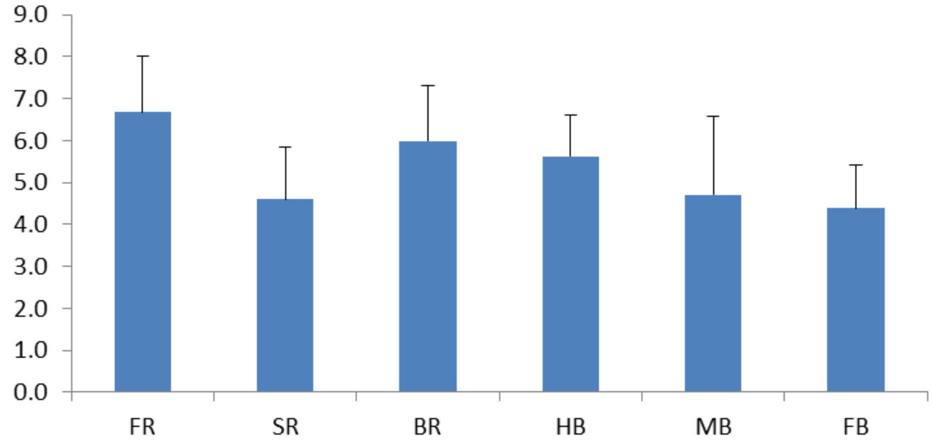

Figure 2. Mean and Standard Deviation of the Mesomorphic rating.

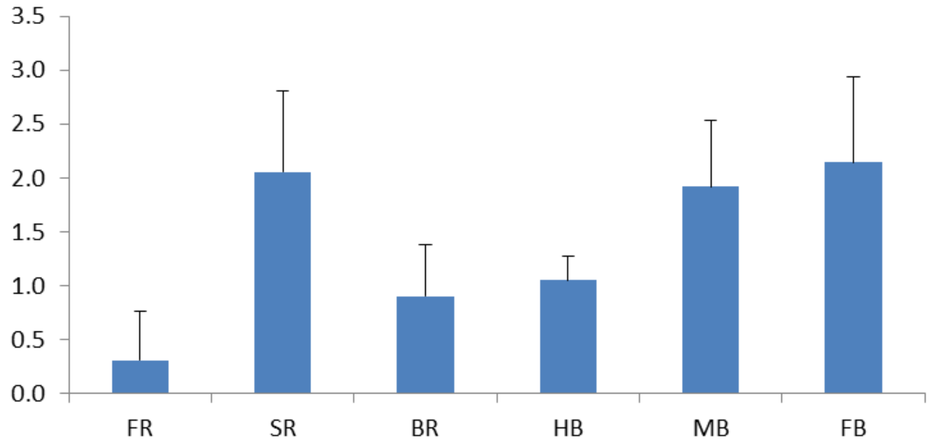

Figure 3. Mean and Standard deviation of the Ectomorphic rating.

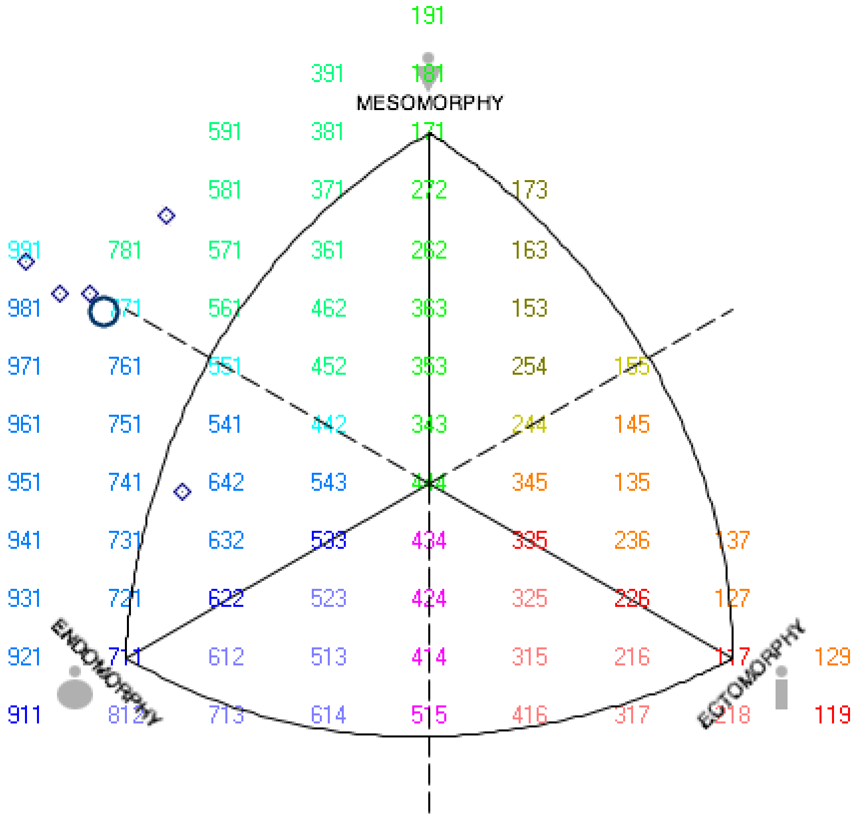

Figure 4. Group 1 (Front Row) - Somatochart

1

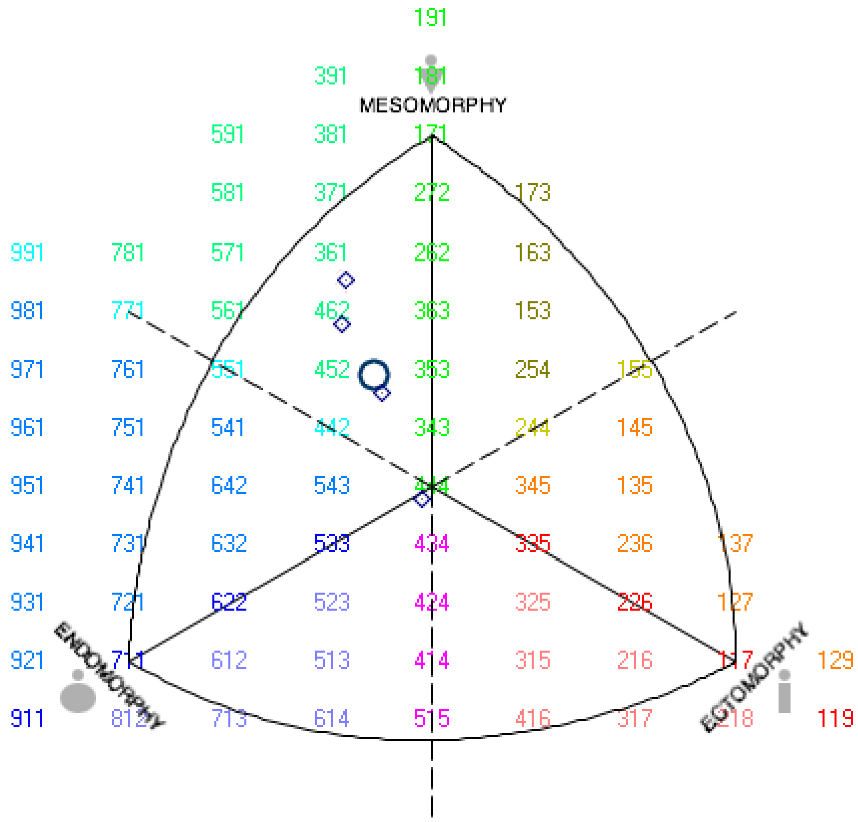

Figure 5. Group 2 (Second Row) - Somatochart

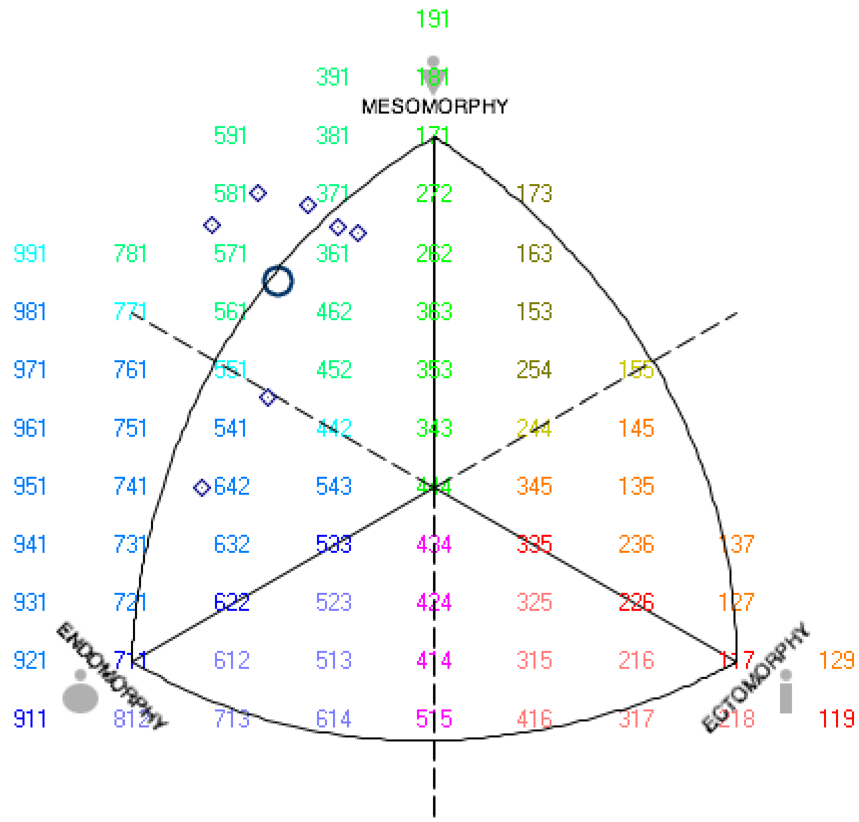

Figure 6. Group 3 (Back Row) – Somatochart

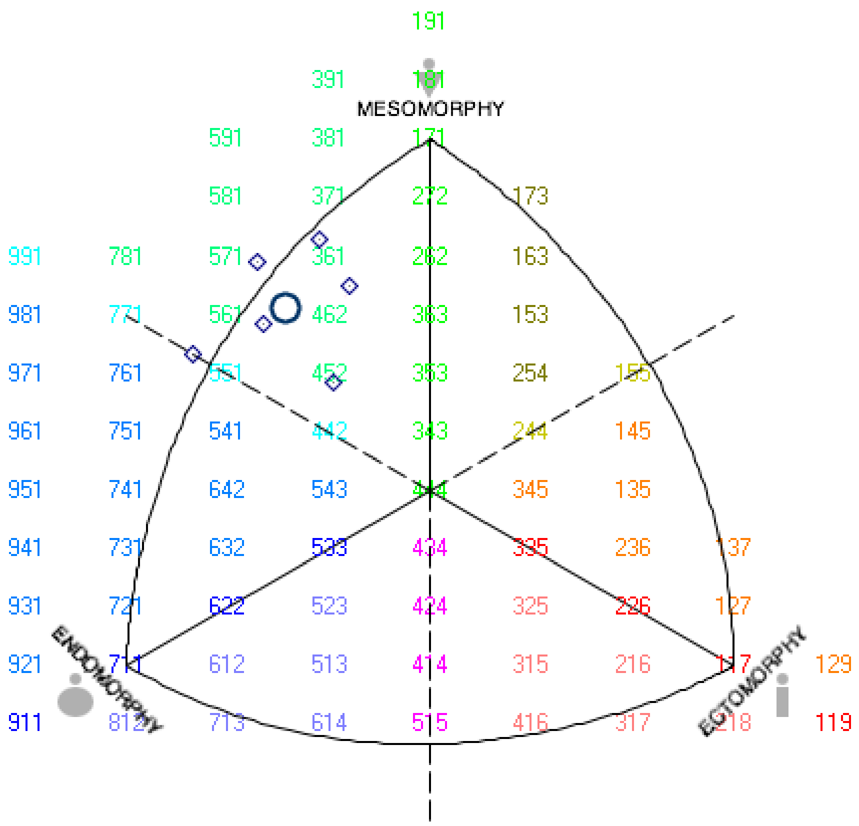

Figure 7. Group 4 (Half Backs) – Somatochart

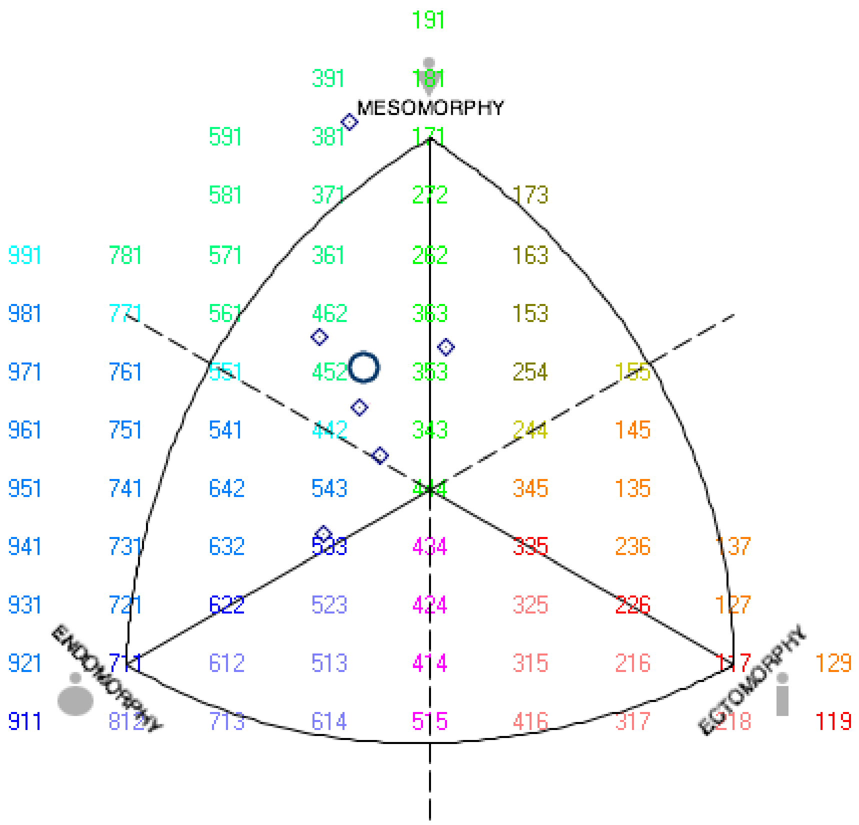

Figure 8. Group 5 (Mid Backs) – Somatochart

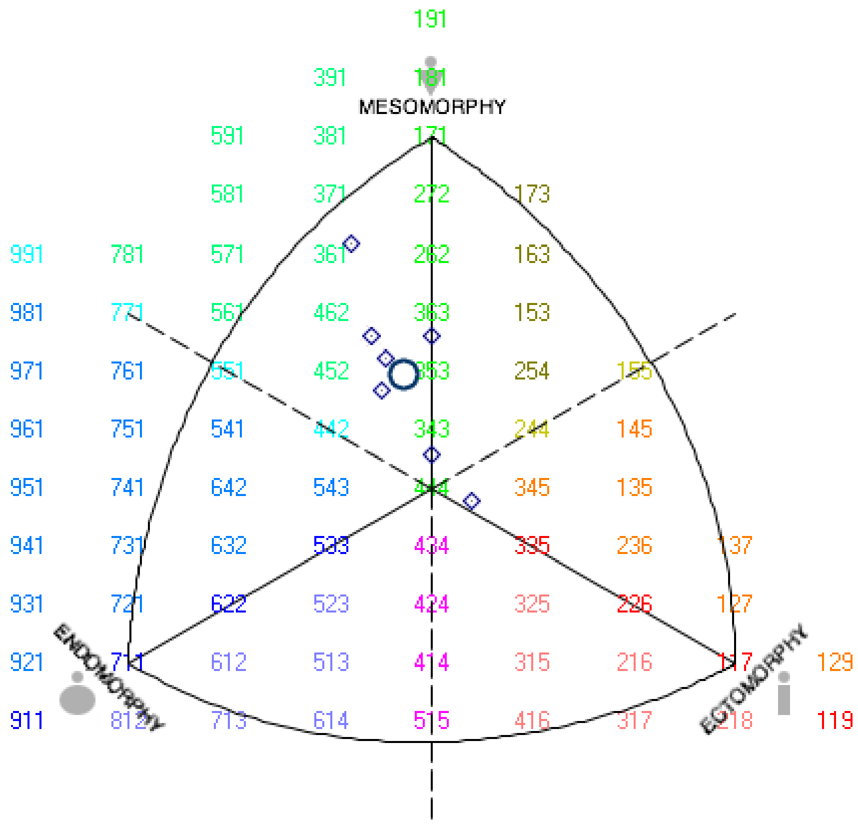

Figure 9. Group 6 (Full Backs) – Somatochart

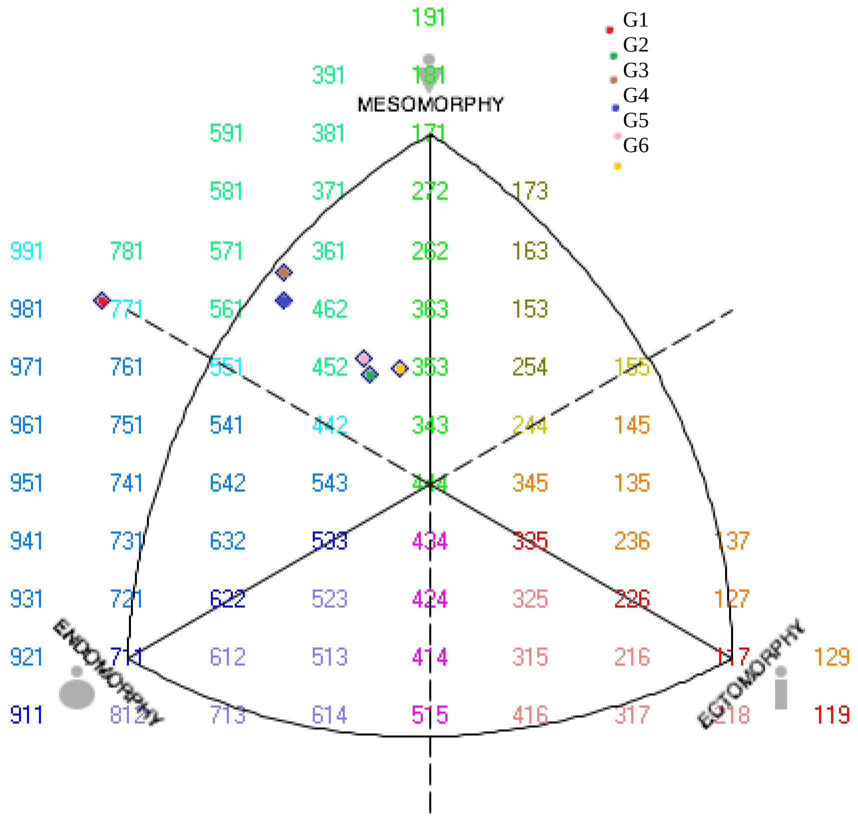

Figure 10. Mean Somatotypes of each individual Group.

CHAPTER FIVE

DISCUSSION

5. Discussion

5.1 Primary Findings

The aim of this study was to compare somatotypes of collegiate rugby players and determine the differences in anthropometric characteristics dependant on the playing position. The data collected confirms that there are distinct differences between playing positions. The results showed that mesomorphic component is the most vital for rugby players with only 6 subjects falling under a mesomorphic rating of 4. From the result (table 1) it can be found that forwards are heavier and taller on average than backs. When compared to the backs it can be seen that the individual somatotype components for the forwards are configured rather differently.

5.2. Findings and Comparison to Studies

5.2.1 Front Row

The mean somatotypes of the groups (figure 10) show the overall differences of body composition dependant on playing position. To correctly determine differences related to each position first we must analyse the individual components within the groups to identify specific roles that they play. Figure 1 shows the mean endomorphic component of each group; the group with the highest rating is the front row with a 6.8 mean endomorphy. Figure 2 shows the mean mesomorphy rating for each group and here it can be seen that the group with the largest mesomorphic component is group 1 or the ‘front row’. Interestingly the front row on average has the smallest ectomorphic component as shown in figure 3. This would suggest that front row players are the shortest of the team while also being the heaviest and having the largest muscle mass. Nicholas (1997) relays that props are the cornerstone of set pieces such as scrummages and line outs, they also play a major role in gaining possession of the ball, and are involved heavily in rucks and mauls, however have limited opportunities to run with the ball. Their weight, size and low centre of gravity makes them ideal for these roles, in the scrums, rucks and mauls they provide stability, power and strength. Within the lineouts they are key lifters using their power and strength. Hookers generally weigh less than the props and this is supported in the results when looking at subject 23. This is due to a change in the role of the performer, whereas with the props size, strength and power are key, a hooker specialises in gaining possession of the ball in set scrums and has more opportunities to run with the ball, this causes the need for them to be slightly more agile and supple hence the slight decrease in size and weight. It is important to note that these findings are supported by Quarrie et al (1996) where they found that props where significantly heavier than other players and had higher endomorphic and mesomorphic ratings than any other playing position.

5.2.2 Second Row

Group 2 or the second row was significantly different to the front row ($p<0.05$), figure 1 shows that they were the slenderest of all subjects with an endomorphy rating of 2.1 and table 1 identifies an average height 12cm taller than another players. This coincides with a low endomorphic average value of 3.3 (figure 2) and medium average mesomorphic value of 4.6 (figure 3). During the data collection; subject 27 declared a recent injury; because of the negative effects that an injury has on the physique of the body, omitting this subject's data will create a more reliable representation of the second row. Once the insignificant data was removed, the initial somatotype of 3.3/4.6/2.1 altered to 3.2/5.1/1.7. This would suggest that second row players tend to have a tall muscular build. Height is a key aspect of being a second row player, Nicholas (1997) suggests that it is important for second row players to have a height advantage as it is their responsibility to contest possessions in lineouts, while also having a weight advantage providing stability and structure in the scrums, ruck and mauls. Quarrie et al (1996) also had similar findings to support the proposition of it being advantageous for second row players to exceed in height.

5.2.3 Back Row

The Back Row (group 3) was also found to be significantly different to the front row ($p<0.05$), significant difference was found for the ectomorphic component between group 3 and 2 ($p=0.004$) however, the endomorphic and mesomorphic components derived no significant difference. The mean somatotype for the back row is 3.8/6/0.9 similar to the results gathered by Quarrie et al, (1996). This indicates back row players are Endomorphic mesomorphs; when the mesomorphy is dominant and endomorphy is greater than the ectomorphic component. Nicholas (1997) found that back rows require a great deal of power and mobility in open play. Gaining and retaining possession are key for the back row in offensive play. Therefore it is important for them to have significant speed, acceleration and endurance as well as having strength and power to carry out tackles throughout the game while being involved in scrums and having a key role in rucking and mauling.

5.2.4 Half Backs

The half backs (group 4) displayed significant difference ($p<0.05$) in the endomorphic component against the front row, and in the ectomorphic component they were significantly different to group 1 and 2 along with group 5 and 6. Collectively they produced an average somatotype of 3.9/5.6/1.0 which is a Endomorphic mesomorph (Carter and Heath, 1990), which suggests a more muscular build where height isn't a necessity factor. Hazeldine and Mcnab, (1991) and Quarrie et al (1996) state that the role of a half back is to control and distribute possession of the ball gained by the forward. Speed, agility and endurance are vital for the role of a half back as they are required to be in position at every ruck, maul, scum and lineout, yet also playing an important role of covering in defence and supporting ball carriers. When comparing these results to previous studies (Quarrie et al., 1996) we notice that for the half back results, they obtained an average somatotype of 2.3/6.2/1.5 which puts them into a different somatotype category as defined by Carter and Heath (1990). Due to endomorphy and ectomorphy not differing by more than one unit, and the mesomorphic component being so dominant they are classed as balanced mesomorphs.

Rigg and Reilly (1988), and Nicholas (1997) denote that there are significant differences ($P<0.05$) between body composition of elite half backs and that of collegiate or club half backs. Quarrie et al (1996) study was carried out on Senior A class Male Rugby Players, which would explain the differences in the average somatotypes.

5.2.5 Midfield Backs

Midfield Backs or group 5 were found to have a significantly higher ectomorphic component then that of the back row and half backs ($p<0.05$). The average somatotype produced was 3.2/4.7/1.9 yet we can see, when analysing the individual somatotypes, that there are two anomalies in this data subject 18 and subject 24 who both declared that they had recently been recovering from injury. In this case this has shown to have had a detrimental effect on the muscularity of the body aswell as an increase in the fat stores of the body. When these anomalies are taken out of the overall somatotype slight changes can be seen; 3.0/5.6/1.8. Notice an increase in the mesomorphic component by almost a unit, and a decrease in endomophy by .2 units, while the ectomorphic component only fluctuates by .1 of a unit. This gives a better representation of the somatotype of a midfield back and is supported by the findings of Quarrie et al (1996) who found that elite midfield backs had an average somatotype of 3.1/6.7/1.3. Note the difference between the two mesomorphic components from Quarrie et al (1996) and from this study, Riggs and Reilly (1988) found that first class backs were significantly higher in mesomorphy than the second class backs ($p<0.05$) which would consequently leave the explanation of the difference down to the variance in performance levels between the subjects for each study.

Nicholas (1997) describes midfield backs as having crucial defensive and offensive roles. With such a large area of the pitch in which to run, it is vital for them to have good speed, agility and endurance, while also having enough power and strength to take on a defensive line, or defend an offensive attack. Midfield backs in most cases have the most physical contact with the opposition. Having a high mesomorphic component is essential in this position as it important for the subject to have a good distribution of abilities such as strength, power, speed, agility and endurance.

5.2.6 Outside Backs

When reviewing the final group and taking into consideration the results from previous studies, we notice that the average somatotype (2.7/4.4/2.1) brought about by the outside backs falls distinctly beneath that of the rating (2.4/6.0/1.6) found by Quarrie et al (1996). The raw data shows that three of the participants had recently recovered from an injury causing a reduction in training, which as previously mentioned, has detrimental effects on body composition, specifically muscle mass. In order to give a better representation of the non-injured subjects an average somatotype rating can be formed (2.6/5.0/1.6) by taking out the anomalies. A decrease in endomorphy and ectomorphy are produced along with a rise in mesomorphy, this gives us a much better representation of a somatotype for outside backs. Again we must note the difference of the mesomorphic component between the supporting study and this one, and associate that with Rigg and Reilly's (1988) findings that first class backs were significantly higher in mesomorphy than the second class backs ($p<0.05$). The somatotype produced (2.6/5.0/1.6) suggests that of a balanced mesomorph as defined by Carter and Heath (1990). This somatotype would produce a muscular build along with little excess fat. Nicholas (1997) conveys that outside backs are required to have speed, acceleration, agility, strength and endurance; they are needed in order to beat opposition, while also providing cover in defence, creating supporting lines and chasing kicks. Atwater (1990) put forward that body fat correlates negatively with running success because it is essentially a dead weight that must be carried throughout the event. Outside backs are normally the fastest within the team and the relationship between Atwater (1990) and the Endomorphic results from the fullbacks also suggests this.

5.3 Comparisons Between Playing Positions

When observing the results gathered, it is interesting to look at the comparisons and differences that can be made between each of the positional groups. With regards to 'forwards' and 'backs' even at a collegiate performing level there is a clear distinction between the two. Table 1 and the ANOVA tests confirm that forwards are significantly heavier than backs, more specifically we notice that within the forwards the mesomorphic component is high and in most cases higher than that of any back line player. Front row players are seen to be significantly ($p<0.05$) heavier than any other players apart from second row players, who are found to be significantly taller than other players. These finding are supported by research carried out by Quarrie et al (1996), Riggs and Reilly (1988), Nicholas (1997). With regards to height we notice that the back row players are not significantly taller than the front row players however even though not significant, the differences in ectomorphy range from 0.3 to 1.4 units suggesting more of a slender physique in the back row positions. If we compare body mass of the forwards we notice that the second row has no significant difference with either the front row or the back row, yet between the front and back row we find significant difference in body mass. This indicates that back row players are the lightest of the forwards with second row and front row players being similar in weight, this is shown in table 1. Quarrie et al, (1996) study suggested no significant difference between the weights of the forwards, however this could be due to the differences in performance levels, as found in Riggs and Reilly's (1988) study where significant differences in weight were found between 1st and 2nd class rugby players. We do find significant difference between all of the forwards with regards to HWR. Differences in HWR suggest a clear difference in the somatotypes of each individual playing position.

Concentrating on the backs we see for table 1 that the half backs, on average, are shorter than other backs, the post-hoc confirms a significant difference ($p=0.026$) occurs between the half backs and the midfield backs. We can identify no significant differences between the midfield backs and the outside backs. If we compare body mass between we see no differences ($p>0.05$), indicating similar morphology between the back line players. The midfield backs and the outside backs have no significant differences ($p>0.05$) between any of the dependant variables. This would therefore suggest extreme similarities in the demands put on players within these positions. In order to explain the similarities between the morphology of the backs in more depth we need to assess the demands put on each of the positions. Quarrie et al (1996) used performance tests to show the physical demands put on players dependant on playing positions. Eight different physical performance tests were carried out, they denoted that significant difference ($p<0.05$) was found between the inside backs, midfield backs and the outside backs with regards to fatigue index, and momentum ($kg \cdot m \cdot s^{-1}$). Half backs had the lowest fatigue rate giving them the highest endurance of all the backs. This coincides with Nicholas (1997) who reported that 'Endurance is an important factor in order to be in the correct position, to distribute possession of the ball and to support ball carriers, while also covering in defence'. Overall we see that a more in depth analysis is needed in order to find the significant differences between the positional demands within the backs.

5.4. Amendments to Study

The present study focused on comparing anthropometric characteristics between playing positions within rugby union, In order to improve the study a greater amount of participant would be used in order to increase the reliability. This study was able to gain data which showed significant differences between playing positions, however using a greater number of participants, would increase the group sizes and consequently provide a much more accurate representation of each playing position.

In order to further the study participants could also have carried out various physical performance tests such, as vertical jump test to find leg power, bench press and leg press maximum for strength, sit and reach flexibility test, and further muscular endurance test along with finding aerobic and anaerobic performance. Similar studies to this such as Quarrie et al. (1996) were able to gain more of an insight into the physiological demands of the game while also seeing more specifically the changes in demands with regards to playing position.

To summarise, the findings of the study reveal that significant difference ($p<0.05$) is found between many of the positional categories. The results showed that mesomorphic component is the most vital for rugby players. While changes in endomorphic and ectomorphic components were observed between positional categories, mesomorphy remained dominant throughout the positional changes.

CHAPTER SIX

CONCLUSION

6. Conclusion

6.1 Observations of the Study

The present study confirms the findings of Quarrie et al (1996). A players body composition or anthropometrical profile will differ, dependant on which position they play. Although there are differences in the results between Quarrie et all (1996) and the current study, significant differences ($p<0.05$) between performance levels have been found and the results from this study provide a stepping stone for coaches and players at a collegiate level who aspire to be elite performers. Riggs and Reilly (1987) denoted that the most evident differences in anthropometrical data between the forward and the backs were the height and weight and did not find much difference in the somatotypes between playing positions. This study observed similar differences between height and weight to that of Riggs and Reilly (1987), however it also displayed significant differences in somatotypes between both forwards and backs, while also between the individual groups within the forwards and backs.

6.2 Limitations and Future Research

Although the research has reached its aim I am still aware of its limitations. Firstly, due to time constraints and the length of time it took to collect the anthropometrical measurements, data was only collected from thirty-five athletes which is a small sample size; this meant that when the samples where split in order to compare positional groups, the small numbers within each classification limited the validity of the statistical analysis. The results and sample size where suitable for this study and enabled us to find correlations and differences between groups, all though, if future research was to be carried out then at least 150 participants should be used in order to gain more reliable and in turn valid results. Furthermore due to the time consuming nature when collecting the anthropometrical data more trained data collectors would be required. Secondly, to gain a better understanding of the differences in the individual playing position further physiological performance tests could have been carried out to find more specific physiological differences and to give a better representation of the demands imposed on players by their position. This would have similarly benefited the participants as it would have allowed them to see what physiological factors they would need to improve in order to gain the correct somatotype dependant on their position. Lastly to gain a better representation of average somatotypes, players that are injured or have recently returned from an injury that prevented them from training will be excluded from the results, as it causes the standard deviation of the average results to rise which in turn causes the validity of the results to fall.

6.3 Summary

Evidently, from the data collected it is found that there are distinct anthropometrical differences between playing positions within rugby union. Based on the 13 different somatotype categories as denoted by Heath an Carter (1990) we see that from this study playing positions can be classified into three distinct somatotype groups. The front row were found to me mesomorph-endomorphs, while the second row, outside backs and midfield backs were classified as balanced mesomorphs, the two final groups the back row and the half backs, were endomorphic mesomorphs.

CHAPTER SEVEN

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APPENDIX

CHAPTER EIGHT

8.1 Participant Consent Form

CARDIFF METROPLOLITAN
INFORMED CONSENT FORM

CSS Reference No:
Title of Project: **A comparison of somatotype characteristics among player positions in collegiate rugby union players.**
Name of Researcher: Mitchell Bennett

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated ………. for this evaluation 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 it is possible to stop taking part at any time, without giving a reason. ☐

3. I also understand that if this happens, our relationships with the Cardiff Metropolitan University, or our legal rights will not be affected ☐

4. I understand that information from the study may be used for reporting purposes, but I will not be identified. ☐

5. I agree to take part in this study on a comparison of somatotype characteristics among player positions in collegiate rugby union players. ☐

____
Name of Participant

____
Signature of Participant

Date ________________

____
Name of person taking consent

Date ________________

____
Signature of person taking consent

* When completed, one copy for participant and one copy for researcher's files.

8.2 Raw Data

The Tables below are the raw data collected during the data collection process and statistical analysis process.

Table 2. ANOVA test for Endomorphy, Mesomorphy, and Ectomorphy

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ENDO	Between Groups	54.966	5	10.993	14.416	.000
	Within Groups	22.114	29	.763		
	Total	77.080	34			
MESO	Between Groups	23.363	5	4.673	2.702	.040
	Within Groups	50.146	29	1.729		
	Total	73.510	34			
ECTO	Between Groups	15.681	5	3.136	8.935	.000
	Within Groups	10.179	29	.351		
	Total	25.860	34			

Table 3. ANOVA test for Height, Weight and HWR

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Height	Between Groups	833.012	5	166.602	9.088	.000
	Within Groups	531.635	29	18.332		
	Total	1364.647	34			
Mass	Between Groups	3269.898	5	653.980	9.779	.000
	Within Groups	1939.469	29	66.878		
	Total	5209.367	34			
HWR	Between Groups	74.828	5	14.966	11.774	.000
	Within Groups	36.860	29	1.271		
	Total	111.688	34			

Table 4. LSD Post-Hoc for Endomorphy

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
ENDO	1	2	3.4900*	.5858	.000
		3	2.7257*	.5113	.000
		4	2.8400*	.5288	.000
		5	3.4900*	.5288	.000
		6	4.0543*	.5113	.000
	2	1	-3.4900*	.5858	.000
		3	-.7643	.5473	.173
		4	-.6500	.5637	.258
		5	.0000	.5637	1.000
		6	.5643	.5473	.311
	3	1	-2.7257*	.5113	.000
		2	.7643	.5473	.173
		4	.1143	.4858	.816
		5	.7643	.4858	.127
		6	1.3286*	.4668	.008
	4	1	-2.8400*	.5288	.000
		2	.6500	.5637	.258
		3	-.1143	.4858	.816
		5	.6500	.5042	.207
		6	1.2143*	.4858	.018
	5	1	-3.4900*	.5288	.000
		2	.0000	.5637	1.000
		3	-.7643	.4858	.127
		4	-.6500	.5042	.207
		6	.5643	.4858	.255
	6	1	-4.0543*	.5113	.000
		2	-.5643	.5473	.311
		3	-1.3286*	.4668	.008
		4	-1.2143*	.4858	.018
		5	-.5643	.4858	.255

Table 5. LSD Post-Hoc for Mesomorphy

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
MESO	1	2	2.0600*	.8821	.027
		3	.6600	.7700	.398
		4	1.0600	.7963	.193
		5	1.9600*	.7963	.020
		6	2.2886*	.7700	.006
	2	1	-2.0600*	.8821	.027
		3	-1.4000	.8242	.100
		4	-1.0000	.8488	.248
		5	-.1000	.8488	.907
		6	.2286	.8242	.784
	3	1	-.6600	.7700	.398
		2	1.4000	.8242	.100
		4	.4000	.7316	.589
		5	1.3000	.7316	.086
		6	1.6286*	.7029	.028
	4	1	-1.0600	.7963	.193
		2	1.0000	.8488	.248
		3	-.4000	.7316	.589
		5	.9000	.7592	.245
		6	1.2286	.7316	.104
	5	1	-1.9600*	.7963	.020
		2	.1000	.8488	.907
		3	-1.3000	.7316	.086
		4	-.9000	.7592	.245
		6	.3286	.7316	.657
	6	1	-2.2886*	.7700	.006
		2	-.2286	.8242	.784
		3	-1.6286*	.7029	.028
		4	-1.2286	.7316	.104
		5	-.3286	.7316	.657

Table 6. LSD Post-Hoc for Ectomorphy

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
ECTO	1	2	-1.7750*	.3974	.000
		3	-.6143	.3469	.087
		4	-.7500*	.3587	.045
		5	-1.6333*	.3587	.000
		6	-1.8286*	.3469	.000
	2	1	1.7750*	.3974	.000
		3	1.1607*	.3713	.004
		4	1.0250*	.3824	.012
		5	.1417	.3824	.714
		6	-.0536	.3713	.886
	3	1	.6143	.3469	.087
		2	-1.1607*	.3713	.004
		4	-.1357	.3296	.684
		5	-1.0190*	.3296	.004
		6	-1.2143*	.3167	.001
	4	1	.7500*	.3587	.045
		2	-1.0250*	.3824	.012
		3	.1357	.3296	.684
		5	-.8833*	.3420	.015
		6	-1.0786*	.3296	.003
	5	1	1.6333*	.3587	.000
		2	-.1417	.3824	.714
		3	1.0190*	.3296	.004
		4	.8833*	.3420	.015
		6	-.1952	.3296	.558
	6	1	1.8286*	.3469	.000
		2	.0536	.3713	.886
		3	1.2143*	.3167	.001
		4	1.0786*	.3296	.003
		5	.1952	.3296	.558

Table 7. LSD Post-Hoc for Height

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Height	1	2	-15.86500*	2.87220	.000
		3	-3.82571	2.50706	.138
		4	1.41000	2.59265	.591
		5	-4.39000	2.59265	.101
		6	-2.29714	2.50706	.367
	2	1	15.86500*	2.87220	.000
		3	12.03929*	2.68365	.000
		4	17.27500*	2.76377	.000
		5	11.47500*	2.76377	.000
		6	13.56786*	2.68365	.000
	3	1	3.82571	2.50706	.138
		2	-12.03929*	2.68365	.000
		4	5.23571*	2.38207	.036
		5	-.56429	2.38207	.814
		6	1.52857	2.28862	.509
	4	1	-1.41000	2.59265	.591
		2	-17.27500*	2.76377	.000
		3	-5.23571*	2.38207	.036
		5	-5.80000*	2.47199	.026
		6	-3.70714	2.38207	.130
	5	1	4.39000	2.59265	.101
		2	-11.47500*	2.76377	.000
		3	.56429	2.38207	.814
		4	5.80000*	2.47199	.026
		6	2.09286	2.38207	.387
	6	1	2.29714	2.50706	.367
		2	-13.56786*	2.68365	.000
		3	-1.52857	2.28862	.509
		4	3.70714	2.38207	.130
		5	-2.09286	2.38207	.387

Table 8. LSD Post-hoc for Body Mass

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Mass	1	2	8.49500	5.48591	.132
		3	13.94857*	4.78849	.007
		4	24.03667*	4.95197	.000
		5	23.85333*	4.95197	.000
		6	28.37714*	4.78849	.000
	2	1	-8.49500	5.48591	.132
		3	5.45357	5.12578	.296
		4	15.54167*	5.27882	.006
		5	15.35833*	5.27882	.007
		6	19.88214*	5.12578	.001
	3	1	-13.94857*	4.78849	.007
		2	-5.45357	5.12578	.296
		4	10.08810*	4.54977	.035
		5	9.90476*	4.54977	.038
		6	14.42857*	4.37128	.003
	4	1	-24.03667*	4.95197	.000
		2	-15.54167*	5.27882	.006
		3	-10.08810*	4.54977	.035
		5	-.18333	4.72152	.969
		6	4.34048	4.54977	.348
	5	1	-23.85333*	4.95197	.000
		2	-15.35833*	5.27882	.007
		3	-9.90476*	4.54977	.038
		4	.18333	4.72152	.969
		6	4.52381	4.54977	.328
	6	1	-28.37714*	4.78849	.000
		2	-19.88214*	5.12578	.001
		3	-14.42857*	4.37128	.003
		4	-4.34048	4.54977	.348
		5	-4.52381	4.54977	.328

Table 9. LSD Post-Hoc for HWR

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
HWR	1	2	-4.3030*	.7563	.000
		3	-2.4437*	.6601	.001
		4	-2.7913*	.6827	.000
		5	-4.0697*	.6827	.000
		6	-4.4037*	.6601	.000
	2	1	4.3030*	.7563	.000
		3	1.8593*	.7066	.013
		4	1.5117*	.7277	.047
		5	.2333	.7277	.751
		6	-.1007	.7066	.888
	3	1	2.4437*	.6601	.001
		2	-1.8593*	.7066	.013
		4	-.3476	.6272	.584
		5	-1.6260*	.6272	.015
		6	-1.9600*	.6026	.003
	4	1	2.7913*	.6827	.000
		2	-1.5117*	.7277	.047
		3	.3476	.6272	.584
		5	-1.2783	.6509	.059
		6	-1.6124*	.6272	.016
	5	1	4.0697*	.6827	.000
		2	-.2333	.7277	.751
		3	1.6260*	.6272	.015
		4	1.2783	.6509	.059
		6	-.3340	.6272	.598
	6	1	4.4037*	.6601	.000
		2	.1007	.7066	.888
		3	1.9600*	.6026	.003
		4	1.6124*	.6272	.016
		5	.3340	.6272	.598

Table 10. Data collected from all Participants.

	Group	HWR	Endo	Meso	Ecto	Height	Weight
Front Row	1	36	8.1	7.9	0.1	176.4	118.1
Front Row	1	38.3	5.3	7.3	0.1	181.7	106.5
Front Row	1	40.5	6.1	4.4	1.1	173.5	78.6
Front Row	1	36.3	7.4	7	0.1	179.3	120.2
Front Row	1	36.6	6.8	6.7	0.1	178.4	116.2
Secnd Rw	2	41.2	3.4	5.3	1.6	194.5	105.3
Secnd Rw	2	43.2	3.3	3	3.1	195.5	92.5
Secnd Rw	2	40.9	3.1	5.8	1.4	190.7	101.2
Secnd Rw	2	42	3.2	4.3	2.2	194.2	98.7
Back Row	3	40.4	3	6.5	1.1	186	97.9
Back Row	3	39.8	3.3	6.9	0.8	178.2	90.1
Back Row	3	38.3	4.5	6.8	0.1	176.9	98.3
Back Row	3	41	6.1	3.8	1.5	187.2	95
Back Row	3	39	3.9	7.2	0.4	177.4	94
Back Row	3	40.8	4.6	4.5	1.3	178.7	84.1
Back Row	3	40.6	2.7	6.3	1.2	187.4	98.4
Half Back	4	40.8	3.2	4.1	1.3	184.7	92.9
Half Back	4	40.3	4.3	5.5	1	175.4	82.7
Half Back	4	40.6	2.7	5.4	1.1	170.7	74.6
Half Back	4	40.4	4.5	6.7	1.1	178.6	86.7
Half Back	4	39.5	5.3	5.3	0.6	169	78.6
Half Back	4	40.6	3.4	6.6	1.2	180.3	87.8
Mid Back	5	39.8	2.4	7.9	0.8	171.7	80.4
Mid Back	5	41.3	3.8	5.3	1.6	183.3	87.5
Mid Back	5	42	4.3	2.5	2.2	185	85.5
Mid Back	5	42.2	3.7	4.4	2.3	183.5	82.5
Mid Back	5	42.1	3.2	3.4	2.3	186.9	87.4
Mid Back	5	42.3	2.1	4.7	2.4	183.1	81.1
Full Back	6	42.7	2.7	3.3	2.7	177.9	72.2
Full Back	6	40.3	2.6	6	1	179.5	88.6
Full Back	6	41.8	2	4.6	2	179.1	78.6
Full Back	6	41.2	2.8	4.8	1.6	180.1	83.5
Full Back	6	42	3.2	4.4	2.2	182.7	82.1
Full Back	6	43.8	2.7	2.9	3.5	181.6	71.1
Full Back	6	41.7	2.8	4.6	1.9	180.2	80.7