Position Specific Differences in Activity in Club Level Sevens Rugby Players

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ABSTRACT

The increase in popularity of seven-a-side rugby through the World Sevens Series has increased the need for training programmes to be developed specifically for the seven-a-side game. The aim of this thesis was to use time motion analysis to gather and compare data on match play variables in club sevens rugby, and interpret the results to construct effective guidelines for game-specific sevens rugby training. The first step in programme development was to identify the specific demands of sevens rugby, and then determine the best way for these demands to be replicated through training. Time motion analysis was used to identify the specific physiological demands of club-level game play. These demands included distances travelled, average speeds, the percentage of game time spent in different gaits and exercise intensities, and the number of activities and events performed per game half. The data were used to make comparisons between positional groups (forwards, backs, halfback), between game halves, and between pool and final games.

There were no significant differences found between positional groups, game halves or game type, which implies that all players in sevens should train in the same way. The average distance covered per half was 0.77km, with 9% of the game spent in passive rest, 81% spent in active recovery and 10% spent in high-intensity running, equating to an average work to rest ratio of 1:9. Each player performed an average of 12 activities per half. Only half of the passes received resulted in a continuation of passing, the other half of balls received were either taken into a tackle or fumbled.

The execution of activities at training should focus on maintaining possession of the ball at set plays and breakdowns, and using movement of the ball and players to create space to break through the defensive line and score a try. This can be achieved by working on game-specific skills, and may include executing these skills in a fatigued state to simulate the requirements of game play.

Game-based fitness training should focus on the development of both aerobic power and anaerobic capacity, with special emphasis on the development of the lactate energy system

through repeated-speed training. Work to rest ratios of 1:9 reflect club level game play, and are suggested as the standard for training at club level. To create overload and increase training response, smaller work to rest ratios (eg 1:3) may be used.

Training which specifically focuses on the development of acceleration, top-end speed, agility, and strength should also be implemented as these attributes have been identified as critical components for successful sevens players.

These results suggest that sevens rugby players require game-specific, rather than position-specific, training to promote maximal transfer to game performance.

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1.0 INTRODUCTION

Sevens rugby is a shortened version of the 15-a-side game. The major differences are in the number of players on the field, and the length of the games. Sevens teams consist of seven players on the field with three reserve players allowed for substitutions. In sevens, forward positions consist of two props and a hooker, back positions consist of a halfback, first five-eighth, centre and winger. Positional play in sevens rugby appears to be similar to that of 15-a-side rugby, with the forwards performing set plays (scrums and lineouts) and carrying the ball into contact situations such as tackles, rucks and mauls. The main job of forwards is to gain and maintain possession of the ball, and they may be described as the 'ball winners'. The main job of backs is to exploit possession of the ball, where they perform more sidestepping movements and look for more open space play, and they may be described as 'ball carriers' (Duthie, Pyne, & Hooper, 2003a). Halfbacks follow the movement of the ball, and act essentially as a link player, passing the ball from set plays (scrums and lineouts), and from breakdowns in play (rucks and mauls) out to the backs.

Even though there are fewer players on the field, sevens rugby matches are played on a full-size rugby field. To ensure the quality of play, matches are shorter in length, comprising two 7-minute halves in pool games, and two 10-minute halves in finals. Games are held in tournament format, with pool and final matches being played either over a single day or over several days. This means that the players are required to compete repeatedly on the same day in a typical sevens tournament. Playing in two or more games per day and playing with fewer players on a full-size rugby field is likely to increase the physiological demands of match-play (Rienzi, Reilly, & Malkin, 1999). In many instances, the tournaments are part of a series, with teams competing for a championship over a season extending from weeks to months, depending on the level of play. Club level championships run over a few weeks, while the International Rugby Board (IRB) World Sevens Series Championship is held over several months. The IRB World Sevens Series for the 2004-2005 season was from December to June, and consisted of seven tournaments in seven different host countries.

Sevens rugby is a game which involves short duration, high intensity exercise. Players usually progress from club level competitions to provincial and international level as their ability and fitness improves. A major barrier to selection from club level sevens rugby to provincial level may be the fitness level of the individual players. Players who lack fitness are not able to perform to a consistently high level for the duration of each game throughout a tournament and so may be a disadvantage to their team.

Identifying the specific demands of sevens rugby is a major step in the development of training programmes to increase the game specific fitness of all sevens players.

Although there are increasing numbers of research articles being published on the physiology of rugby union players, comparatively few research articles were published on seven's rugby before 1999. There has been a notable increase in the number of research articles published since that date, which may be a result of the increase in interest in sevens rugby through introduction of sevens rugby into the Commonwealth Games and the commencement of the International Rugby Board World Sevens Series.

1.1 World Sevens History

The first sevens tournament was played in April 1883 in the Scottish town of Melrose to make money for the Melrose Football club. The tournament was the brainchild of a Scotsman named Ned Haig, who stated after the tournament:

> Want of money made us rack our brains as to what was to be done to keep the club from going to the wall, and the idea struck me that a football tournament might be attractive. But as it was hopeless to think of having several games in one afternoon with fifteen players on each side, the teams were reduced to seven men (Lagos, 2005).

The festive nature of sevens was reported by the Border Advertiser (May 2, 1883) "By the time this event...commenced an enormous crowd of spectators had assembled...about 1600 tickets being taken at Melrose during the day." Sevens rugby remained confined to Scotland until the early 1920s when sevens tournaments started being played in England, Ireland, Fiji and Argentina. Since this time, sevens rugby has spread to be played in many countries throughout the world.

Significant events in sevens rugby history which have helped to develop sevens into a global game include the following:

1973: The first sevens tournament to feature national teams was held in Scotland.

1976: Sevens rugby was elevated onto the international stage with the inaugural Hong Kong Sevens.

1993: The World Cup of Sevens began in Scotland. The world cup is held every four years.

1998: Sevens Rugby was included in the Commonwealth Games for the first time.

1999: The International Rugby Board (IRB) World Sevens Series began; 9 tournaments involving 16 nations.

The history and development of sevens rugby in New Zealand includes the following events:

1940s: Club sevens was introduced around this time, although the exact date is not certain.

1951: The first annual club championship, the Middlesex Cup, was played.

1975: The first Inter-Provincial Seven-a-Side Rugby Tournament was held.

1977 – 1981: The Provincial champions, rather than a national team, represented New Zealand at the Hong Kong Sevens.

1978: The Inter-Provincial tournament date was moved from October to March so that the winning team was at its peak to compete at the Hong Kong tournament.

1983: The first year that New Zealand competed as a national team in Hong Kong.

The provincial championship has served as a 'trial' for selection of players for the national squad to play in the World Sevens Series. It has also provided the opportunity for many future All Blacks to display their skills to selectors and the public.

The New Zealand sevens team has been the IRB World Sevens Series champion every year since it was created (1999 – 2005), and has also taken gold at both Commonwealth Games that have included sevens rugby (1998 & 2002). This clearly demonstrates the strength of sevens rugby in New Zealand. Despite this success in major world tournaments, New Zealand has only won the Sevens Rugby World Cup once during that time (in 2001), with England and Fiji taking the title in the other years. Consequently it is clear that there are still improvements to be made in sevens rugby in New Zealand, and these improvements may need to start at the club level.

Because sevens rugby is a by-product of fifteen-a-side rugby union, and is continuing to become more specialized, it is important to research both sevens rugby and fifteen-a-side rugby to identify similarities and differences between the two games and investigate the crossover effect between them.

The main focus of most of the studies on fifteen-a-side rugby has been on the physiological game requirements, with many researchers investigating different variables such as distances travelled and playing intensities as they relate to different positions. The research ultimately guides the development of rugby-specific training programmes. This focus allows trainers, coaches and players to transfer what is happening in game play into training, and to use training to improve player physiological adaptation to the requirements of game play.

Docherty et al (1988) used time motion analysis and blood lactate data to relate the time spent in different match play activities to the physiological demands of the game of fifteen-a-side rugby. Comparisons of match play activities were made by position (centres and props) and by the level of competition (club and representative). The decision to only compare two playing positions, and the positions chosen to compare (centres and props) was not clearly justified. Each position in rugby has both unique and common roles, so only focussing on one position from each positional group (backs and forwards) may be viewed as a limitation of this study as it does not give a general overview for all positional groups. Therefore the results and outcomes of the research may only be relevant to the prop and centre playing positions. Each of 27 players (13 props and 14 centres), were taped for alternating 5 minute time periods for a total of 40 minutes per game. This alternate taping can be viewed as a limitation to this study as activities and intensities in a game are intermittent and unpredictable. Periods of play which are taped may or may not contain a representative number of activities, which may change the overall outcome for each player. A true representation of game play would require players to be tracked continuously for a half (40 minutes) or whole game (80 minutes). Players spent 85% of total time in low-intensity activity (standing, walking & jogging), and the 15% high-intensity work was split into 6% in running-related intense activity (running & sprinting) and 9% in non-running intense activity (tackling and competing for the ball). Variations by position were evident where props experienced greater involvement in general high-intensity activity during a game than centres (20% and 10.8% respectively). This variation was also displayed in non-running intense activity, where props spent 16% of time in contact situations competing for the ball compared to 3.3% for centres. Profiles were similar in both club and representative level. The data presented in this study suggested that the development of specific training programmes relative to position and demands of the sport were required for optimal performance of each individual player.

Deutsch et al (1998) collected physiological and kinematic data on 24 elite under-19 rugby union players during six competition games. The aim of this study was to provide a greater understanding of the physical demands and positional differences of rugby union. Time motion analysis was used to classify player movements, but was limited by recording and analyzing only 35 minutes of game time for each player. To represent a full game, the data for each player were multiplied by an appropriate factor, although this process may not have been accurate as a whole-game representation because of the unpredictable and intermittent nature of rugby. Heart rate data were gathered for the whole match to assess intensity. Blood samples were analysed to assess the accumulation of lactic acid, which is a factor that is linked to fatigue during high intensity activity, and can indicate the contribution of the anaerobic glycolytic energy system. The results showed that forwards spent significantly more time in high exertion (57.3%) than backs (37.2%). This was attributed to more constant motion and a greater involvement in static high-intensity activities. Backs spent significantly more time in moderate exertion (37.5%), and covered significantly greater distances walking (1760m), in utility movements (446m), and sprinting (274m) than forwards (21.2%; 996m; 130m; 83m) , with outside backs showing a significantly greater distance sprinting than inside backs (340m and 206m respectively). Outside backs also spent significantly more time in low exertion (20.1%) and covered a significantly greater total distance (5750m) than forwards (5.7%; 4240m). Mean blood lactate concentration showed no significant differences between positions, yet the high concentrations observed (4.67-7.22 mmol.l-1) indicated the need for "lactate tolerance" training to improve hydrogen ion buffering and facilitate lactate metabolism following high-intensity efforts. The author concluded that the intermittent nature of match play and the large distances covered indicated a need for sound aerobic conditioning in all groups, but in particular backs, to minimize fatigue and facilitate recovery between high-intensity efforts.

Deutsch (2001) again used time motion analysis to study the different activities, intensities, and work to rest ratios of professional and club level players. Heart rate data and blood lactate concentrations were measured in club level players only. Four positional groups were used to group players (front-row and back row forwards, inside and outside backs). The author did not include halfbacks as it was determined that their position and activity on the field did not fit comfortably within any of the positional groups. It is possible that the author could have included halfbacks as a separate group, therefore giving a full representation of all playing positions. Professional level players demonstrated differences between front row and back row forwards, with front row forwards spending approximately 25% more time rucking and mauling than back row forwards, which was a reflection of their specific roles within the structure of the game. Forwards spent 12% of total match time performing high intensity work, and subsequently performed more high intensity work than backs at both representative and club levels. Non-running high intensity activity accounted for 80-90% of high intensity work for forwards, while the bulk of high-intensity work for backs was accumulated through cruising and sprinting (60-70%). Outside backs may be required to perform up to 20 sprints during one match. Therefore, sprint training should not only focus on speed development, but also on the ability to perform repeated bouts of maximal sprinting over the course of a match. Sprint training requires a greater focus on acceleration, balance, agility, and the ability to maintain speed despite interactions with the ball and other players. Mean work to rest ratios showed some differences between backs and forwards. Both forwards and backs tended to have average work periods of 5 seconds, but the rest periods varied between positions, with forwards taking 30-40 seconds rest, and backs taking 80-110 seconds rest. Forwards displayed longer maximum work periods (20-25 seconds) than backs (12-14 seconds), with most of the energy for these work periods being supplied by anaerobic glycolysis. The author concluded that an aerobic base for both forwards and backs would supply energy and facilitate recovery during a rugby game. The author recommended that when prescribing aerobic conditioning for rugby, intermittent, high-intensity training may carry more benefits for development of aerobic power and anaerobic capacity than training at a continuous moderate intensity, and that this training should include rugby-specific movements.

Quarrie et al (1995) studied anthropometric and physical performance characteristics of 356 players, comparing forwards to backs. Comparisons were also made between club level and representative levels of play. The research included observation and measurement of players of different ages, sexes and playing grade. Both anthropometric and physical performance variables showed significant differences between forwards and backs, and between genders. Forwards were found to be taller, heavier and more endomorphic than backs of the same grade. It was concluded that this greater body mass allowed forwards to achieve greater momentum while sprinting, which was reported as being important in the body contact phases of rugby. To maintain this higher body mass, forwards may have compromised, to some extent, their aerobic fitness and speed. Backs performed better on physical performance measures, being more aerobically fit, faster, more agile, and possessing a higher degree of muscular endurance. Differences in these variables were also apparent between various grades, with higher level players being generally larger and performing better on the physical performance tests. The anthropometric and physical performance characteristics of players appeared to reflect the demands placed on them by the sport.

Roberts et al (2005) used time motion analysis of four rugby matches to quantify player movement in elite rugby union. They focused on differences during match play between positional groups (front-row forwards, back row forwards, inside backs and outside backs). The use of time motion analysis enabled calculation of total distances covered and counting of player activities, including movements and static activities, in these positional groups. To determine the work-to-rest ratios of players, low intensity activities were classified as rest and high intensity activities were classified as work. No significant differences in total distance covered were found between positional groups (range 5000-9500m). A large percentage of time in high-intensity work for backs was attributed to cruising and sprinting (65-75%). The results showed that outside backs sprinted a significantly greater distance than forwards (outside backs 258m±212m; front row forwards 7m±17m; back row forwards 22m±54m). Forwards were involved more in rucks and mauls, which increased their time performing activities of static exertion (11.2% of total match time), and contributed to forwards demonstrating higher work-to-rest ratios (1:6.8) than backs (1:18.2).

> The results demonstrate that different playing positions in elite rugby union require different physical demands. Improved knowledge of player movement patterns during match play is important for further research into the physiological responses of players to match play and development of specific conditioning programmes. The results suggest that time motion analysis could provide such knowledge (Roberts, 2005).

Duthie et al (2005) used time motion analysis and statistical analysis to quantify movement of 47 professional Super 12 rugby players in competition, and investigate differences between playing positions. Time motion analysis was used to examine the low intensity activities of standing, walking and jogging (classified as rest) and the high intensity activities of striding, sprinting, static exertion, jumping, lifting or tackling (classified as work). Forwards spent significantly more time in static exertion (10±3% of total time) and 'work' activities (14±4% of total time) than backs (static exertion 1.5±0.8% of total time; 'work' activities 6%±1% of total time). These activities were frequent and of short duration (<4 seconds), with moderate duration rest (<20 seconds) between each work period. Backs spent significantly more time sprinting (1.5%±0.5% of total time) than forwards (0.5%±0.4% of total time). For backs, high intensity sprinting was followed by extended rest periods (>100 seconds). These variations support the claim that "elite rugby union is characterized by highly intense, intermittent movement patterns and marked differences in the competition demands of forwards and backs". High intensity efforts, including static exertions and high-speed running, occurred repeatedly throughout the game. All players performed approximately 35% of these high-intensity efforts with less than 20 seconds rest between them. This occurred even though the mean rest duration was influenced by the extended rest periods during conversions and penalties, therefore actual work to rest ratios during actual playing time could have been considerably smaller than indicated by these figures. Optimal physical preparation for rugby would be facilitated through specific training and conditioning which reproduced the reported high-intensity demands and work-to-rest ratios of the game. High-intensity training should be position-specific, with speed training included as an important component for backs, and repeated static exertion and running efforts for forwards. Recommendations for training include using similar work-to-rest periods as reported in this study (work <4 seconds, rest ranging from < 20 seconds to >100 seconds) as the basis of conditioning training; using activities which involve frequent acceleration and deceleration which match these work and rest durations; and increasing aerobic power through aerobic conditioning, which enhances recovery from high-intensity bouts of anaerobic exercise through the metabolism of lactic acid.

In summary the reviewed research indicates that each position in rugby has a role that requires players to display specific physiological characteristics. Although each position is unique, playing positions with similar roles may be grouped together to form positional groups, or subunits. Typical positional groups are 'tight-five (or front row) forwards' (props, hookers and locks), 'back-row forwards' (flankers, number 8), 'inside backs' (halfback, first five-eighth), 'midfield backs' (second five-eighth and centre), and 'outside backs' (wingers and fullback). Commonly the hooker may be grouped with the flankers as their role on the field in open play is more similar to that of back-row forwards than the tight-five.

The reviewed research identified that all positions spent an average of 85% of game time performing low intensity activities and 15% of game time performing running and non-running high intensity activities.

There were some specific differences identified between the roles of forwards and backs during game play, these included the following;

Forwards were found to have:

- Performed more activities at a high intensity, yet most of those were static, non-running activities (scrums, rucks, mauls).
- A lower level of aerobic fitness compared to backs (running fitness), but forwards maintained a higher level of exertion than backs due to static high-intensity activities and more constant motion during a game.
- Typical work periods of <5 seconds followed by up to 40 seconds rest (ratio up to 1:8), with maximum work periods of up to 25 seconds.
- Greater body mass which was reported as being advantageous in body contact phases (rucks, mauls, tackles, scrums, lineouts), but which may have compromised aerobic fitness and speed.
- Differences between forward positional groups, where front row forwards performed more static, non-running activities than back-row forwards, who performed more high-intensity running activities.

Backs were found to have:

- Performed high intensity activities that were made up mostly of cruising and sprinting (60-75% of high intensity activity).
- Work periods of <5 seconds followed by 80-110 seconds rest (ratio 1:16 – 1:22), with maximum work periods of 12-14 seconds.
- Better aerobic fitness, speed, agility, and higher muscular endurance than forwards.
- Differences between positional groups, where outside backs sprinted more than inside backs.

When comparing and contrasting forward and back positions in fifteen-a-side rugby, it was found that all positions spent 85% of game time performing low-intensity activities and 15% of game time performing high intensity activities. The only direct similarity of on-field activity between forwards and backs in 15-a-side rugby was the average length of performing 'work' (high intensity activity), which was <5 seconds. There was a distinct difference in the type of high-intensity activity performed by forwards and backs, with forwards performing predominantly static, non-running high intensity activities (such as scrummaging, rucking and mauling) and backs performing predominantly running high-intensity activities. Work-to-rest ratios were smaller for forwards than backs. The differences in the type of high-intensity activity performed by forwards and backs highlight differences in positional demands in 15-a-side rugby. The identification of different positional demands helps clarify the positional differences in anthropometric characteristics.

The studies reviewed indicate that there should be position-specific training in 15-a-side rugby to cater to the physical demands of each position. This relates mainly to high-intensity 'work', where forwards perform more non-running high-intensity activities, and backs perform more running high-intensity activities. There were also differences in work to rest ratios, which should be taken into consideration for each position. General training for all positions should include aerobic conditioning to supply energy, minimize fatigue and facilitate recovery from high-intensity efforts. When prescribing aerobic conditioning work for rugby, intermittent, high-intensity work may be more beneficial for development of aerobic power and anaerobic capacity than training at a continuous moderate intensity. There is also a need for 'lactate tolerance training' to maintain high intensity efforts when players are required to perform repeatedly with little rest. Rugby-specific sprint training is required for speed development, repeated speed efforts, acceleration, agility, balance and developing the ability to maintain speed despite interactions with the ball and other players. Training should include rugby-specific movements to mimic and train the movements carried out in a game.

The research on fifteen-a-side rugby gives guidelines on game demands and training methods that can be applied to meet those demands. To identify whether there may be a crossover between training for fifteen-a-side rugby and sevens rugby, the literature on sevens rugby needs to be reviewed.

The main focus of the limited research on sevens rugby has been on physiological and anthropometric profiles of forwards and backs, and patterns of play of successful and unsuccessful teams.

Rienzi et al (1999) investigated 30 international sevens rugby players to describe anthropometric and match performance profiles between forwards and backs, and explored correlations between anthropometric characteristics and work-rates in matches. For all players, 93.7% of game time was spent in low-intensity activity, and 6.3% of time was spent in high-intensity running. Both aerobic and anaerobic energy systems were utilised during game play. Anthropometric comparisons found that forwards were taller and had a greater body mass than backs, although the differences were less than those typically observed for fifteen-a-side rugby. The reduced differences may represent a measure of selectivity in sevens rugby, where all forwards may need to be more mobile than in the fifteen-a-side game, possibly because of the more open style of play, which indicated that back-row forwards were more suited to sevens play than front-row forwards. The author stated that prop forwards in fifteen-a-side rugby lacked the running speed and fitness to compete in top class sevens tournaments and therefore were unlikely to be considered for selection, but presented no evidence for this claim. Forwards in sevens rugby jogged more frequently and paused more often than backs, and both positions saw a decrease in movements requiring acceleration and deceleration throughout the game. Acceleration and deceleration require more energy utilization than travelling at a constant speed, so in sevens rugby the ability to effectively space anaerobic and aerobic efforts throughout the game would appear to be an important aspect of performance. High intensity activity was negatively correlated with muscle mass and mesomorphy, meaning players with more muscle mass completed less high-intensity activity. The author reported that the extra muscle mass should not be seen as a disadvantage as extra muscle bulk was favourable in anaerobic activities such as scrums and rucks. The author speculated that players with more muscle mass were possibly selected as they had an increased ability to win the ball at breakdowns. It was concluded that anthropometric features were related to components of match play, but did not necessarily determine whether a game was won or lost, and therefore may not have been a good indicator for selection of individuals for a sevens team.

In 2003, Rienzi et al again published findings on the evaluation of anthropometric characteristics of rugby sevens players in two consecutive international events, measuring 246 players from 28 countries (138 backs and 108 forwards). Significant differences were found between forwards and backs when comparing all players studied. Forwards had significantly greater absolute muscle mass, absolute bone mass and percent body fat, and scored higher in the categories of endomorphy and corrected endomorphy, and mesomorphy. Backs had a significantly greater number of players who were ectomorphic. Differences were also found between successful teams (which finished in the top four in each tournament) and unsuccessful teams (which finished in the bottom four in each tournament). Players in successful teams were found to have significantly greater absolute muscle mass, relative muscle mass, absolute bone mass and scored higher in the mesomorphy category. Players in unsuccessful teams were found to have a greater percentage of body fat and were categorised as endomorphic. When the players in successful teams were divided into forwards and backs, the only significant difference found was in the relative bone mass of players, with forwards being the greater of the two, although these differences became less apparent when relative body composition was considered. There were distinct differences between players in successful and unsuccessful teams, and so future research may need to focus on these variables to determine why these differences occurred.

Hughes & Jones (2004) studied the patterns of play in men's seven-a-side rugby union to determine if there were any significant differences in patterns of play between successful and unsuccessful seven-a-side teams. Video recordings were taken of the 2001 IRB World Sevens Series, and data were gathered using a specifically designed hand notation system. Teams classified as successful won more than 70% of the games they played (their winning profile was greater than 70%), while unsuccessful teams had a winning profile below 70%. Significant differences in patterns of play between successful and unsuccessful teams were present. In attack, successful teams played a 'cat and mouse' style, meaning they attempted to avoid contact situations and outwit their opponents. This was demonstrated as they performed significantly fewer rucks, mauls and kicks, and performed significantly more dummy passes, sidesteps, swerves and clean breaks. Unsuccessful teams played a more direct style, committing themselves to more contact situations. Successful teams obtained significantly higher territory percentage (62% compared with 51%) and possession percentage (51% compared with 43%), and performed significantly more 'miss passes' and fewer normal passes, loop passes and passes per try than unsuccessful teams. This suggested that successful teams played using the width of the field to create space between the defenders, and were more structured in attack. In defence, successful teams had to make significantly fewer tackles and missed fewer tackles than unsuccessful teams. In conclusion, successful teams used structured 'cat-and-mouse' style play to maintain possession of the ball and dominate territory to win games.

The reviewed research identified that for all positions in sevens rugby, an average of 93.7% of game time was spent in low-intensity activity, and 6.3% of time spent in high-intensity running. Positional differences identified from these studies related to both anthropometric and activity differences. Compared to backs, forwards were found to have a larger absolute body mass and possess more body fat, and, while playing, jogged more frequently and paused more often. These positional differences were not evident between players in successful elite teams.

Differences between successful and unsuccessful teams were evident in both anthropometry and activities on the field. Anthropometrically, players in successful teams had a greater muscle mass and less body fat percentage than players in non-successful teams. The reasons for this were not stated in the reviewed research but possible reasons could include superior fitness, the type of training undertaken by the players, and nutrition.

When observing on-field activities, successful teams showed characteristics that were different from those of unsuccessful teams, these included:

- performing fewer rucks, mauls, and kicks
- performing more dummy passes, sidesteps, swerves, clean breaks ('cat & mouse' style play)
- having more territory and possession
- using more width in the field and being more clinical in attack
- missing fewer tackles and making fewer tackles

Therefore, players in successful teams, and the team as a whole, were technically, tactically and physically superior to those in unsuccessful teams.

As stated earlier, sevens rugby is a by-product of fifteens rugby, and so many sevens players are originally fifteen-a-side players, who then choose to play sevens. To select the best players from a fifteen-a-side team who meet the physiological criteria for successful sevens players, the research suggests that:

- Backs may be more suited to sevens due to their superior aerobic fitness, speed, agility and muscular endurance.

- Back row forwards may be more suited to sevens than front row forwards due to their smaller body mass, and better speed, acceleration, endurance, mobility and power (Duthie et al., 2003a).
- All players require a high level of fitness as there is a high level of both anaerobic power and aerobic capacity required during game play.
- As there are fewer static high-intensity activities in sevens, forwards are not required specifically in that role as they may be in fifteens rugby, and therefore may not be selected if they do not meet the other criteria.

All the reviewed research indicated that there were differences in patterns of play between successful and unsuccessful teams. There were also anthropometric differences between players in successful and unsuccessful teams. Reasons for these differences were not explicitly stated but were probably related back to the type of training undertaken by these teams. This indicates that the physiological demands of sevens rugby and the training requirements of sevens players in relation to these demands should be a major focus of research in sevens rugby. Studying game demands and training requirements may help to determine the fitness characteristics that are required for players to be competitive and successful. The research also highlighted that both aerobic and anaerobic fitness were important components of sevens rugby to ensure peak performance on the field, and would also assist recovery after the games so that multiple games could be played in one day. The type of recovery required between games is an area in which further research would be beneficial. The physiological demands of sevens rugby may be assessed by conducting time motion analysis on games and interpreting the results to assist in the development of training programmes. The data collected through time motion analysis may be complimented by the collection of heart rate and blood lactate data, as has been used in fifteen-a-side rugby.

Time motion analysis is an effective tool for recording and quantifying data related to match play activities and energy requirements when focusing on a specific player or group of players in team sports (Docherty et al., 1988), (Mohr, Krustrup, & Bangsbo, 2003), (Duthie, Pyne, & Hooper, 2003b). It involves recording individual players during match play, then replaying the data while using specialised software to track player movements and record activities through the duration of a game. The output data give a summary of player movements around the field, movement speeds, and activities performed during game play. This allows playing demands to be determined and transferred into the design of training programmes for sevens players.

The validity of computer notation systems to conduct time motion analysis in rugby union was established by Hughes and White (1997) (cited in Hughes et al, 2004) where no significant differences in the collection and analysis of data were found between computer notation and hand notation systems. Duthie et al (2003b) reported that the simplification of movement patterns for categorization led to some questions about the validity of the time motion analysis data as actual play is more complex, which may explain why many different computer software programmes have been developed to conduct time motion analysis in many different sports.

The major limitation of time motion analysis for rugby is the reliability of the observer conducting the analysis. Duthie et al (2003b) reported that although prone to measurement error, time motion analysis was moderately reliable, (typical measurement error of 7.1-9.3%), as an evaluation tool for examining the movement patterns of players in competitive rugby.

To gather data that are useful for the development of sport-specific training programmes, Hughes & Franks (2004) reported that:

> While research into movement analysis and definition of fitness profiles is of value to rugby union coaches, players and others, it does have limitations. For any fitness or training norms to be taken from such studies then the following guidelines should be practiced:
>
> 1. A specific player/position is traced for the entire match and for a series of matches. This will then give a global figure which will also have accounted for environmental factors such as weather and pitch conditions, importance of the match, and personal attitude of the player.
> 2. The nature of the game is accounted for. The work-rates of players may vary from position to position according to whether the game is fast and fluid or whether they are on the winning or losing side.

Time motion analysis has been used to gather information on movement patterns and energy demands in a range of sports including soccer (P. Krustrup, & Bangsbo, J., 2001); (P. Krustrup, Mohr, & Bangsbo, 2002); (Mohr et al., 2003), indoor soccer (Barbero Alvarez, 2004), field hockey (Spencer, 2004), rugby union (Docherty et al., 1988); (Duthie et al., 2005); (Deutsch et al., 1998); Doutreloux et al (2002); (Roberts, 2005); (James, Mellalieu, & Jones, 2005); (Duthie et al., 2003a), and sevens rugby (Rienzi et al., 1999); (Rienzi, Perez, Stefani, Maiuri, & Rodriguez, 2003); (M. Hughes, & Jones, R., 2004).

Data gathered in these studies using time motion analysis included movement patterns, work to rest ratios, distances and velocities, and differences between levels of competition. In all these studies data were collected to help understand the demands of match play in these different sports, and ultimately assist in the development of sport-specific training programmes.

While recent research on fifteen-a-side rugby has focussed on identifying physiological game requirements and specific physical characteristics of different playing positions, the limited research on sevens rugby has focused mainly on anthropometric differences between players and physiological game requirements as they relate to team success, or winning. The research reviewed may be compared and contrasted to determine the physiological differences, and potential training crossovers, between fifteen-a-side rugby and sevens rugby.

The research on sevens rugby by Hughes & Jones (2004) gives a good indication of the 'cat and mouse', minimal contact, fast break, style of play that is required of successful sevens rugby players. Based on this style of play, the research on fifteen-a-side rugby indicates that the players more suited to crossover to sevens rugby are more likely to be backs as they are reported as being fitter, faster, more agile, having higher muscular endurance, and sprint more during a game than forwards (Deutsch, 1998; Deutsch, 2001; Quarrie, 1995; Roberts et al, 2005; Duthie et al, 2005). Of the back positions, outside backs may be preferred as they perform more sprinting in a game than other positions (Deutsch, 1998; Deutsch, 2001; Roberts et al, 2005). Forward positions in sevens rugby require players to be effective in contact situations, yet more mobile than in fifteen-a-side rugby. This indicates that, crossing over from fifteen-a-side rugby, back-row forwards are more likely to be suited to this position than front-row forwards. Front-row forwards may not be as suited as sevens rugby players because their primary role on the field is to perform non-running static activity in the form of competing for the ball in contact situations (Docherty, 1988; Deutsch, 1998; Deutsch, 2001; Roberts et al, 2005; Duthie et al, 2005). Although anthropometric differences are evident between forwards and backs in both fifteen-a-side and sevens rugby, greater differences are evident in fifteen-a-side rugby (Quarrie, 1995; Rienzi et al, 1999; Rienzi et al, 2003). The front-row forward positions (props and hookers) may account for the greater anthropometric differences in fifteen-a-side rugby. Being heavier is an advantage in contact situations, and the majority of high-intensity activity performed by front-row forwards is in contact situations. Positions requiring a greater body mass may be more suited to fifteen-a-side rugby because of the contact demands, and be less suited to sevens rugby which has a greater focus on aerobic fitness and speed, therefore props may not be suited as sevens rugby players (Quarrie, 1995; Rienzi et al, 1999).

Because many players are involved in both versions of the game, the identification of specific positional crossovers from fifteen-a-side rugby to sevens rugby, and vice versa, is an area which may warrant further research. The current research on both variations of the game indicates that further research on positional crossovers would probably focus on the inside back, outside back, and back-row forward positions as they possess the characteristics required of sevens players. It is unlikely that front-row forwards possess these characteristics and therefore may be omitted from future comparative studies.

Further to the identification of positional crossovers is the need to identify potential crossovers between training for sevens and fifteens rugby. The reviewed research on sevens rugby identifies that both aerobic and anaerobic energy systems are utilised during game play (Rienzi et al, 1999), but does not make any recommendations for specific training protocols.

The reviewed research on fifteen-a-side rugby suggests that training for all positions should focus on the development of aerobic power and anaerobic capacity to supply energy and facilitate recovery between high-intensity activities through lactate metabolism. The modes of training should be position-specific due to the different demands of each position (Docherty, 1988; Deutsch, 1998; Deutsch, 2001; Roberts et al, 2005; Duthie et al, 2005). Backs require a higher level of aerobic power and anaerobic capacity, conditioned in the form of intermittent, high-intensity speed training. Forward positions should develop aerobic power and anaerobic capacity through static exertion and running efforts.

Backs and back-row forwards have been identified as being the positions which are most likely to crossover to produce successful sevens players. These positions require specific positional training protocols for fifteen-a-side rugby, yet it is unknown if the same is required in sevens rugby. When the training requirements for sevens rugby are established we will be able to compare them to the training requirements for fifteen-a-side rugby and determine the areas of similarity and difference between the two.

Much of the research on both fifteen-a-side and sevens rugby used time motion analysis, along with measurement of other variables such as heart rate and blood lactate concentration, to gather physiological data for analysis of game demands. One of the major questions that has not, as yet, been directly addressed in any of the reviewed studies relates to the specific game demands of club level sevens rugby, and the type of training that should be undertaken to meet these demands. Data from time motion analysis of club sevens games to determine the physiological and physical characteristics of sevens rugby may be interpreted to develop training programmes specific to the demands of sevens rugby.