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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 $258\text{m}\pm 212\text{m}$; front row forwards $7\text{m}\pm 17\text{m}$; back row forwards $22\text{m}\pm 54\text{m}$). 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 ($10\pm 3\%$ of total time) and 'work' activities ($14\pm 4\%$ of total time) than backs (static exertion $1.5\pm 0.8\%$ of total time; 'work' activities $6\pm 1\%$ 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 ($1.5\pm 0.5\%$ of total time) than forwards ($0.5\pm 0.4\%$ 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, Krstrup, & 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. Krustup, & Bangsbo, J., 2001); (P. Krustup, 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.

2.0 METHODOLOGY

2.1 Subjects

Video data were collected from 58 Wellington club rugby sevens players during the fourth tournament of the 2003 Wellington Local Point Sevens Series. The tournament was held over one day, with teams split into four pools of five teams. Teams in each pool played against each other in a round robin. The top two teams from each pool went on to play the quarter finals, with the winners progressing on to the semi-finals and then the final. Pool games, quarter finals and semi finals were all played with two 7 minute halves and one minute half-time. The final game was 10 minutes each half with two minutes half-time.

Eight players were tracked during each game, four in each half, with players being classified into three positional groups:

- Forwards [n = 24]
- Backs [n = 24]
- Halfbacks [n = 10]

Players from all three positional groups were video-taped in each pool game. When a player was substituted, the replacement player was video taped. Because of a communication error between video operators, only forwards and backs were tracked in the final game. Although different players were tracked, each position was tracked through a whole game in accordance with the guidelines for successful movement analysis for training norms by Hughes and Franks (2004).

2.2 Set Play Positions

In sevens rugby, set plays (scrums and lineouts) are a miniature version of the fifteens rugby set plays. The number of players engaged in the scrums and lineouts is reduced from 8 forwards in the fifteens game to only 3 forwards in the sevens game. In both versions of rugby, the halfback participates in the set plays as a ball distributor (Figures 1 and 2).

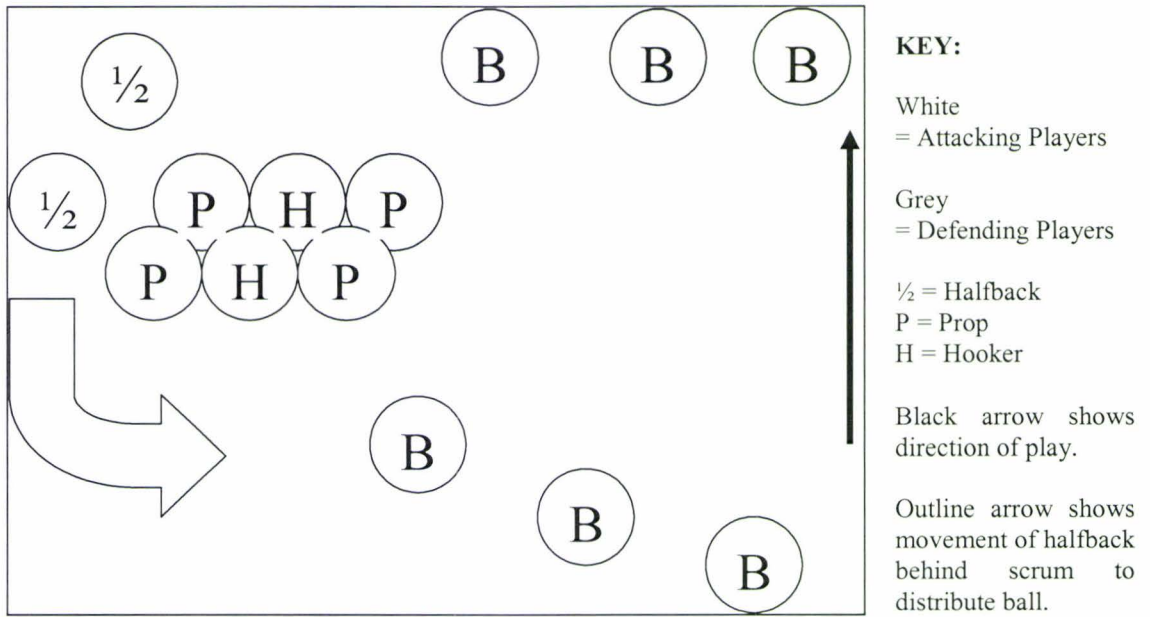


Figure 1: Example of player positions at the start of a scrum

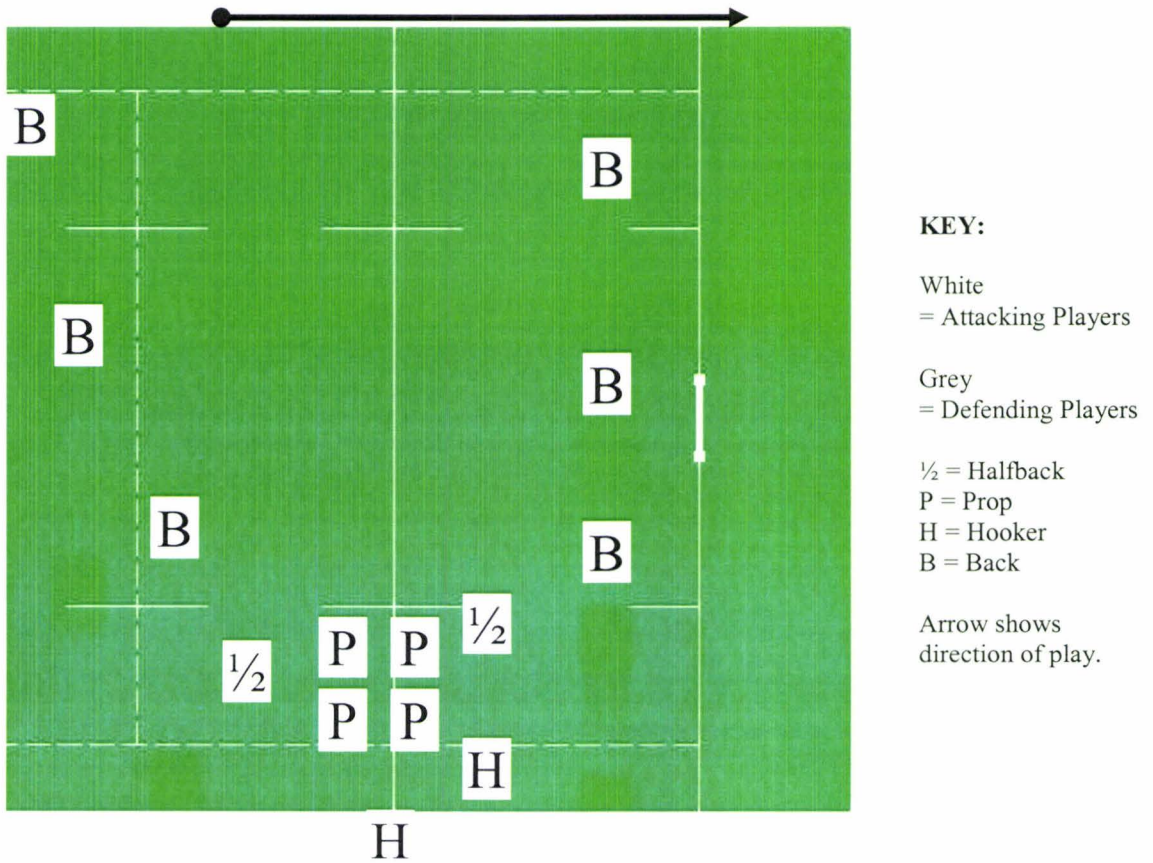


Figure 2: Example of player positions in lineout formation; note the depth of the attacking team backline

While forwards primarily perform the physical aspect of scrums and lineouts, halfbacks also participate in these set plays in a unique role. The function of the halfback is to feed the ball into scrums and distribute the ball from scrums and lineouts. Consequently, halfbacks were deemed to have taken part in these set plays. This participation is expressed in the halfback activity data.

2.3 Equipment and Procedures

Seven pool games and one final game were used to collect the data. The New Zealand Rugby Union gave approval to record video footage at this tournament. Ethical approval was granted by the Massey University Human Ethics Committee, protocol number 03/123, and all participants gave written informed consent.

Four Sony handycams on tripods were positioned at the top of the Porirua Park grandstand, between the 10m lines on either side of the half-way point of the playing field (Figure 3). Four camera operators recorded players, with each operator assigned a single player to follow during the first half, and a different player to follow during the second half. The operator was required to keep the player approximately in the centre of the camera view, with a 5-10m visible radius around the player. The large radius enabled field markings to be seen, which allowed the player's field position to be established accurately.

Time Motion Analysis was performed on the video data using Trak Performance software (version 2.1.1), supplied by Sportstec International. The software contained a default image of a rugby field, which was adjusted to conform to the size of the actual playing field used (Figure 3). The video footage was viewed on a TV screen placed beside the computer screen showing the Trak Performance software field image. While watching the video footage the cursor was moved simultaneously over the field image using the mouse to track individual player movements. The software estimated distances travelled from the cursor movement in relation to the field image size. Gait proportions were determined by the software and based on pre-set speed ranges.

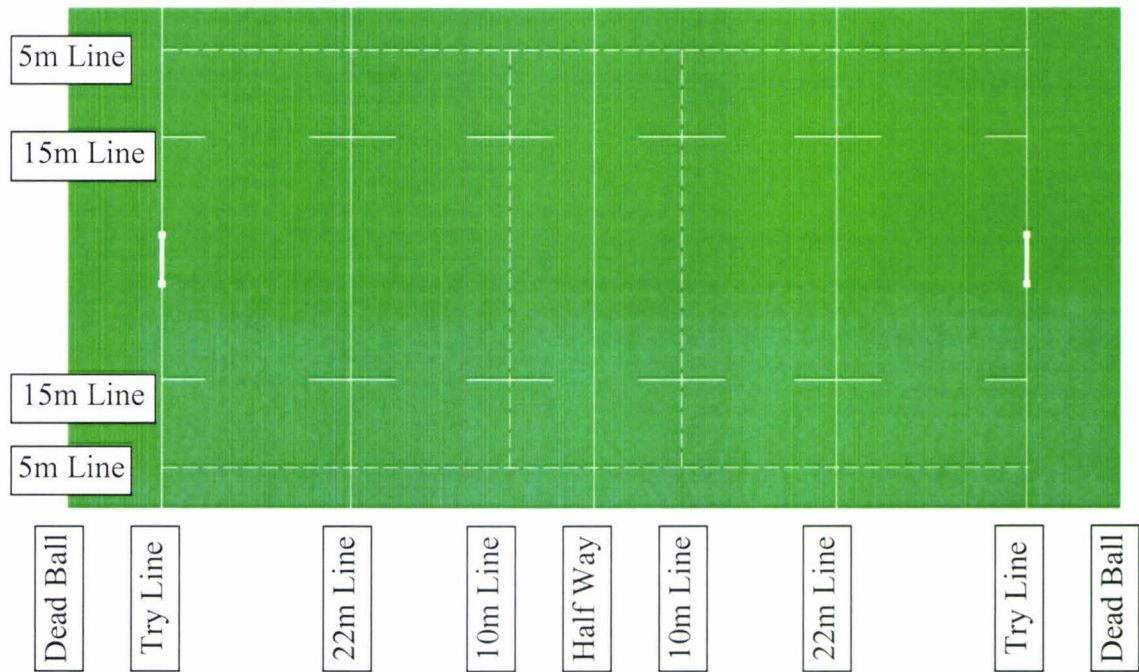


Figure 3: Trak Performance rugby field image with field markers added

Watching the player footage on one screen and tracking the player on a separate screen at the same time presented some difficulties. The main difficulty was maintaining the accuracy of the cursor movement over the field image. To overcome this, one game was used as a practice game to perfect cursor movement and simultaneous operation of activity buttons with activities on the field. The data from this practice game were not included in the analysed data.

Gait speeds were classified using a system modified from Docherty et al (1988). Each gait classification was defined by a speed range, which was entered into the software, which determined the speed of movement from the motion of the mouse over the image of a rugby field.

The gait classification used was:

- Standing: 0 km/h (0 m/sec)
- Walking: 0.1-7.2 km/h (0-2 m/sec)
- Jogging: 7.3-14.4 km/h (2-4 m/sec)
- Cruising: 14.5-21.6 km/h (4-6 m/sec)
- Running: 21.7-28.8 km/h (6-8 m/sec)

- Sprinting: ≥ 28.9 km/h (> 8 m/sec)
- Passive Rest: Standing. 0 km/h (0 m/sec)
- Low Intensity Locomotion: Walking & Jogging. 0.1-14.4 km/h (0-4 m/sec)
- High Intensity Locomotion: Cruising, Running & Sprinting. 14.5- ≥ 28.9 km/h (4-> 8 m/sec)

The software classified all static activity, including lying on the ground, as standing.

Field position of each player was recorded by dividing up the field into zones. The SportsTrak software then calculated the percentage of time that each player spent in each of the field zones. The zones were defined by splitting the field into attacking and defensive halves, then splitting those halves into sections dependent upon the field markings (Figure 4). The arrow in figure 4 shows the direction of play of the tracked player. The attacking half was defined as the area between the half-way line and the attacking team's try line, the defensive half was defined as the area between the half-way line and the opposition's try line.

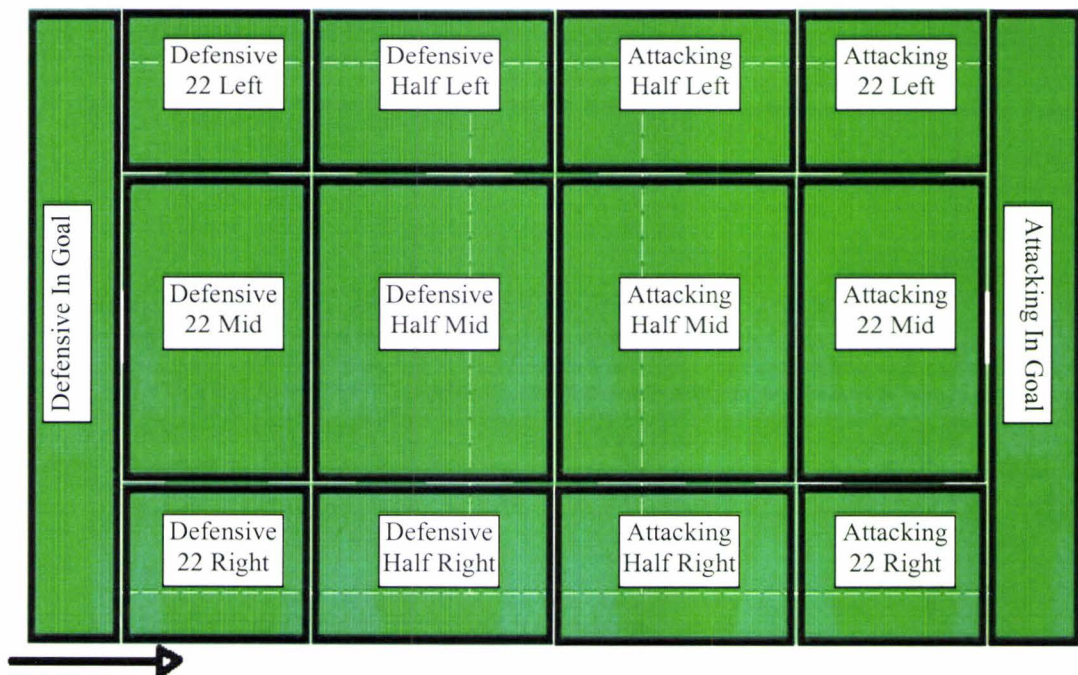


Figure 4: Playing field with field zones marked

The field zones were defined as follows:

- Attacking In Goal: The borders of this area were between the attacking try line and the left, right and back dead ball line.
- Attacking 22 Left: The borders of this area were the attacking try line, the attacking 22m line, the left-hand side line and the left-hand 15m line.
- Attacking 22 Mid: The borders of this area were the attacking try line, the attacking 22m line, the left-hand 15m line and the right-hand 15m line.
- Attacking 22 Right: The borders of this area were the attacking try line, the attacking 22m line, the right-hand 15m line and the right-hand side line.
- Attacking Half Left: The borders of this area were the attacking 22m line, the half way line, the left-hand side line and the left-hand 15m line.
- Attacking Half Mid: The borders of this area were the attacking 22m line, the half way line, left-hand 15m line and the right-hand 15m line.
- Attacking Half Right: The borders of this area were the attacking 22m line, the half way line, right-hand 15m line and the right-hand side line.
- Defensive Half Left: The borders of this area were the defensive 22m line, the half way line, the left-hand side line and the left-hand 15m line.
- Defensive Half Mid: The borders of this area were the defensive 22m line, the half way line, left-hand 15m line and the right-hand 15m line.
- Defensive Half Right: The borders of this area were the defensive 22m line, the half way line, right-hand 15m line and the right-hand side line.
- Defensive 22 Left: The borders of this area were the defensive try line, the attacking 22m line, the left-hand side line and the left-hand 15m line.
- Defensive 22 Mid: The borders of this area were the defensive try line, the attacking 22m line, the left-hand 15m line and the right-hand 15m line.
- Defensive 22 Right: The borders of this area were the defensive try line, the attacking 22m line, the right-hand 15m line and the right-hand side line.
- Defensive In Goal: The borders of this area were between the defensive try line and the left, right and back dead ball line.

Prior to analysis, all expected activities were assigned to hot-keys (Table 1). Player activities were recorded by pushing the appropriate key as the activity happened.

Table 1: Hot keys assigned to activities for coding on Trak Performance

Hot Key	Activity
Q	Pass Ball
R	Receive Ball
B	Kick in Play
F	Drop Kick
W	Lineout
G	Get Tackled
S	Scrum
T	Tackle Made
A	Ruck
E	Maul
Z	Try Scored

The activities were classified as follows:

- Receive Ball: the ball entered the hands, either by catching a pass, catching a kick, or picking the ball up from the ground.
- Pass Ball: the ball left the hands in a purposeful pass, did not include knocking the ball forward.
- Get Tackled: the player in possession of the ball was tackled by an opposition player and either was taken to the ground, or stayed on his feet, but no forward movement took place.
- Tackle Made: the attacking player was prevented from advancing up the field by a defending player's tackle.
- Ruck: defined by players from opposing teams (minimum 3) converging over a ball that was on the ground.
- Maul: defined by players from opposing teams (minimum 3) converging around a ball that was off the ground (held by a player). To prevent the maul becoming stationary and possession being given to the opposition team, the team in possession of the ball could release the ball from the maul, move the maul forward, or turn it into a ruck.
- Scrum: a set play called by the referee where three players from each team set in formation and pushed against each other. Primarily forwards participated in scrums as either a prop or hooker. Halfbacks were classified as participating because of their unique role at this set play.
- Lineout: a lineout was formed when the ball went over the sideline out of the field of play. Primarily forwards participated in lineouts as either a jumper or

lifter, with halfbacks classified as participants because of their unique role at this set play.

- Drop Kick: the ball was deliberately bounced on the ground before it was kicked; this included drop kicks for restarts and conversions.
- Kick in Play: the ball was kicked in the air or along the ground during general play or from a penalty.
- Try: the ball was placed on the ground over the opposition try line.

At the end of each half, and for the whole game, the software displayed the distances, gait speeds and activities of the player in detailed and summary form. These could be viewed as a summary upon the field image (Figure 5), or as a tabular summary (Figures 6 and 7).

18 Oct T1 #1 Norths #19 #21 1/2B-B - Tue, 27 Jan 2004 - 0:00:00 1st Half to 0:08:40 1st Half

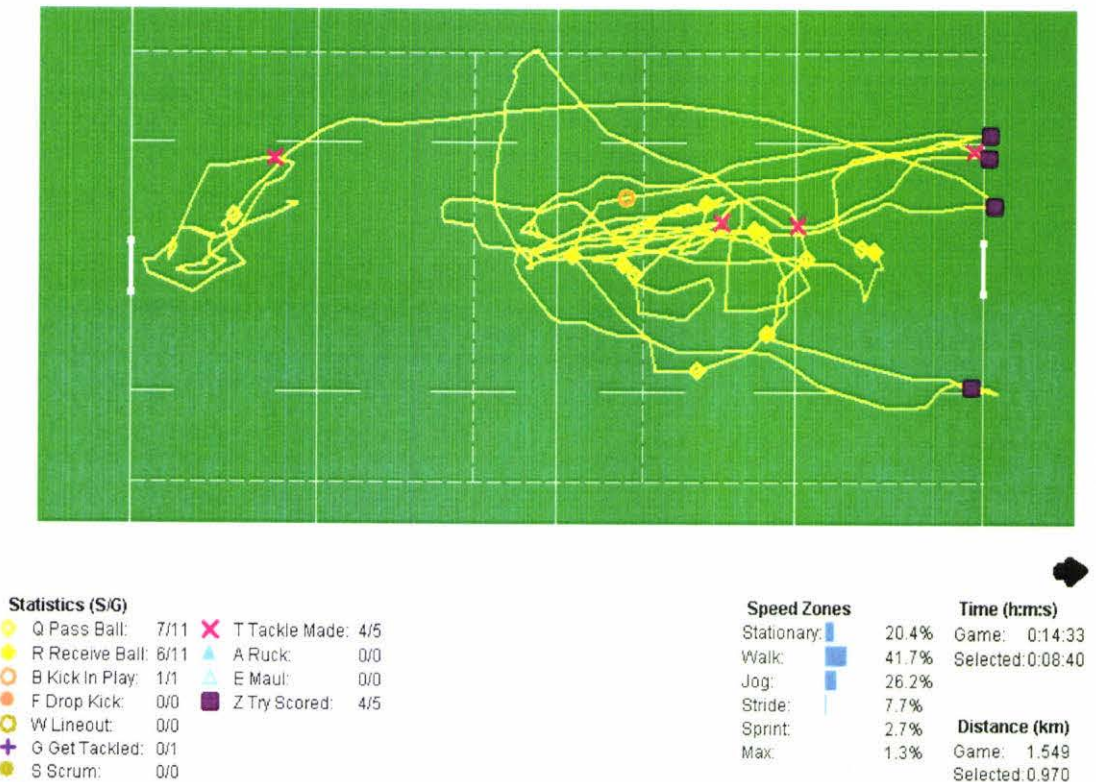


Figure 5: Sample halfback plot track with activities shown

The summary included:

- The total distance travelled.
- The distance travelled in each field zone.
- Percentage of time spent in each gait in relation to the game half.
- Percentage of time spent in each gait in relation to the field zone where the gait was observed (Figure 6).
- The time during the game half that each activity occurred.
- A summary of activities that occurred during the game half.
- The activities related to occurrences in field zones (Figure 7).

Game Analysis Report - 18 Oct T1 #1 Norths #19 #21 1/2B-B - Tue, 27 Jan 2004			
0:00:00 1st Half to 0:08:40 1st Half			
Speed	Range (km/h)	Percent of Time	Distance (km)
Stationary	0 - 1	20.4%	0
Walk	1 - 6.9	41.7%	0.25
Jog	6.9 - 14	26.2%	0.37
Cruise	14 - 21	7.7%	0.19
Run	21 - 28	2.7%	0.09
Sprint	28 - 35	1.3%	0.06
Zone		Percent of Time	Distance (km)
DHalf LSide		4.2%	0.04
DHalf Mid		24.4%	0.08
D22 Mid		14.8%	0.11
A InGoal		3.7%	0.01
A22 RSide		1%	0.01
AHalf LSide		1.9%	0.05
AHalf Mid		34.6%	0.44
A22 LSide		2.3%	0.03
A22 Mid		14.6%	0.2
Totals			
Time: 0:08:40 Distance: 0.97 km Average Speed: 6.71 km/h			

Figure 6: Sample first half game analysis report - speed and distances for a halfback

Data analyses were carried out using SPSS software (SPSS Inc., 1989-2003, version 12.0.1). Descriptive statistics (mean, standard deviation, maximum and minimum) were calculated for each continuous variable. One way ANOVA was carried out for time, distance and activity data with position, game half and game type as grouping variables.

Descriptive statistics were obtained for the sample as a whole, and split by positional group, game type and game half grouping variables. Analysis of variance (ANOVA) was used to examine differences in the dependent variables of speed, distance, speed zones and activity, using position, game type and game half as grouping variables. The p value was set at .05 to determine the significance, and where significance was found, post-hoc comparisons were conducted to compare positional differences in relation to each dependent variable.

Player Event Report - 18 Oct T1 #1 Norths #19 #21 1/2B-B - Tue, 27 Jan 2004			
0:00:00 of 1st Half to 0:08:40 of 1st Half			
Event Name	Time	Period	Zone
Tackle Made	0:00:41	1st Half	D22 Mid
Pass Ball	0:01:14	1st Half	D22 Mid
Try Scored	0:01:36	1st Half	A InGoal
Receive Ball	0:02:44	1st Half	A22 Mid
Pass Ball	0:02:46	1st Half	A22 Mid
Try Scored	0:02:59	1st Half	A22 LSide
Tackle Made	0:04:08	1st Half	AHalf Mid
Pass Ball	0:04:10	1st Half	A22 Mid
Try Scored	0:04:19	1st Half	A22 Mid
Receive Ball	0:05:38	1st Half	AHalf Mid
Pass Ball	0:05:39	1st Half	AHalf Mid
Receive Ball	0:05:42	1st Half	AHalf Mid
Pass Ball	0:05:43	1st Half	AHalf Mid
Receive Ball	0:05:48	1st Half	AHalf Mid
Kick In Play	0:05:51	1st Half	AHalf Mid
Tackle Made	0:05:58	1st Half	A22 Mid
Try Scored	0:06:01	1st Half	A InGoal
Tackle Made	0:07:05	1st Half	AHalf Mid
Receive Ball	0:07:16	1st Half	AHalf Mid
Pass Ball	0:07:17	1st Half	AHalf Mid
Receive Ball	0:07:32	1st Half	AHalf Mid
Pass Ball	0:07:33	1st Half	AHalf Mid
Totals			
<u>Event Name</u>	<u>Number of Events</u>		
Kick In Play	1		
Pass Ball	7		
Receive Ball	6		
Tackle Made	4		
Try Scored	4		
<u>Zone Name</u>	<u>Number of Events</u>		
A InGoal	2		
A22 LSide	1		
A22 Mid	5		
AHalf Mid	12		
D22 Mid	2		
Total Number of Events: 22			

Figure 7: Sample player event report for a halfback

3.0 RESULTS

The data in tables 2, 3 and 4 are calculated means, standard deviations, maximums, minimums and p values for game half and game type.

- The average distance for each position is presented in km travelled per half.
- The average speed for each position is presented in km/h during the half.
- Locomotion (Stationary, Walking, Jogging, Cruising, Running, Sprinting), and intensities (Passive Rest, Low Intensity, High Intensity) are presented in percentage (%) of time spent in the activity during a game half.
- Work to Rest Ratios (Low Intensity : Rest, High Intensity : Rest, High Intensity : Low Intensity) are included.
- Field Zones (Attacking Half, Defending Half) are presented in percentage (%) of time spent in the field zone during a game half.
- Activities for each position are presented as the mean number of events per game half.

Because an individual player was tracked for only one half of the game, results are presented as totals for a single half only. The effect of game half (first half vs second half) and game type (pool game vs final game) on positional differences was estimated by carrying out a oneway ANOVA on the pooled data, with 'game half' and 'game type' as factors. A priori p-value was set at .05 to determine significance.

From these analyses there were very few significant differences between halves when looking at distance travelled, average speed, percentage of time in different gaits, percentage of time in different field zones, and number of events performed (Table 2).

Significance was found between the first and second half in the distance travelled by walking ($p=0.013$). Players covered a greater distance walking in the first half ($0.254\text{km}\pm 0.048\text{km}$) than in the second half ($0.224\text{km}\pm 0.040\text{km}$). When comparing the differences in distance walked to the total distances covered in the first and second half, the total distance covered by walking was 32% of total distance during first half play and 30% of total distance during second half play.

Table 2: Distance (km) and time (% of playing time) data showing first half and second half comparisons

DISTANCE	First Half			Second Half			p value
	Mean	Max	Min	Mean	Max	Min	
Total Distance	0.796±0.202	1.17	0.41	0.743±0.146	1.03	0.47	0.236
Walking	0.254±0.048	0.37	0.12	0.224±0.040	0.36	0.17	0.013
Jogging	0.289±0.085	0.47	0.16	0.272±0.070	0.45	0.17	0.396
Cruising	0.157±0.080	0.36	0.04	0.148±0.037	0.21	0.07	0.605
Running	0.062±0.034	0.13	0.01	0.071±0.037	0.16	0.01	0.352
Sprinting	0.035±0.029	0.11	0.00	0.029±0.027	0.11	0.00	0.387
Att In-Goal	0.008±0.017	0.08	0.00	0.009±0.014	0.05	0.00	0.824
Att 22 Left	0.017±0.017	0.07	0.00	0.009±0.019	0.07	0.00	0.107
Att 22 Mid	0.074±0.052	0.20	0.00	0.041±0.043	0.15	0.00	0.011
Att 22 Right	0.007±0.016	0.06	0.00	0.011±0.020	0.07	0.00	0.387
Att Half Left	0.028±0.034	0.15	0.00	0.044±0.050	0.20	0.00	0.138
Att Half Mid	0.240±0.123	0.44	0.00	0.148±0.092	0.37	0.01	0.002
Att Half Right	0.026±0.036	0.16	0.00	0.016±0.022	0.08	0.00	0.215
Def In Goal	0.004±0.009	0.03	0.00	0.006±0.011	0.04	0.00	0.416
Def 22 Left	0.013±0.024	0.11	0.00	0.028±0.033	0.12	0.00	0.044
Def 22 Mid	0.099±0.087	0.28	0.00	0.116±0.083	0.30	0.00	0.450
Def 22 Right	0.016±0.024	0.08	0.00	0.024±0.034	0.15	0.00	0.314
Def Half Left	0.040±0.044	0.17	0.00	0.037±0.035	0.10	0.00	0.737
Def Half Mid	0.204±0.077	0.38	0.06	0.224±0.092	0.36	0.03	0.372
Def Half Right	0.026±0.034	0.14	0.00	0.038±0.043	0.19	0.00	0.248
TIME	First Half			Second Half			p value
	Mean	Max	Min	Mean	Max	Min	
Average Speed	6.21±0.97	8.03	4.37	6.35±0.95	7.97	4.54	0.571
Standing	9+5	24	2	9+4	16	2	0.807
Walking	59+8	72	36	57+5	68	47	0.335
Jogging	22+5	30	15	23+4	31	17	0.706
Cruising	7+3	13	2	7+2	11	4	0.400
Running	2+1	4	0	3+1	6	0	0.060
Sprinting	1+1	3	0	1+1	3	0	0.660
Att In-Goal	1+2	7	0	1+1	4	0	0.732
Att 22 Left	2+2	7	0	1+2	8	0	0.370
Att 22 Mid	8+6	24	0	5+5	16	0	0.024
Att 22 Right	1+3	14	0	1+3	13	0	0.640
Att Half Left	2+3	11	0	4+5	18	0	0.073
Att Half Mid	24+11	43	0	14+8	34	0	0.000
Att Half Right	3+4	16	0	2+2	9	0	0.166
Def In Goal	1+1	3	0	1+4	19	0	0.190
Def 22 Left	1+2	7	0	5+6	23	0	0.002
Def 22 Mid	14+14	65	0	20+16	57	0	0.107
Def 22 Right	3+6	21	0	4+8	40	0	0.679
Def Half Left	5+7	25	0	6+6	20	0	0.684
Def Half Mid	34+12	62	7	31+14	52	6	0.464
Def Half Right	3+5	18	0	7+9	43	0	0.105

Significance was also found between the distance travelled in first and second halves within field zones. Players travelled significantly further ($p < 0.05$) in the first half than

the second half in the ‘attacking 22 middle’ (0.074km±0.052km first half; 0.041km±0.043km second half), and also in the ‘attacking half middle’ (0.240km±0.123 first half; 0.148±0.092km second half). Players also travelled significantly further (p=0.044) in the second half compared to the first half in the ‘defensive 22 left’ (0.028km±0.033km second half; 0.013km±0.024km first half) (Table 2).

The significant differences in distance data field zones were complemented by the significant differences in time data, where time data showed first and second half significant differences (p<0.05) in field zones only. Players spent longer in the ‘attacking 22 middle’ in the first half compared to the second half (8%±6% & 5%±5% respectively) and the ‘attacking half middle’ (24%±11% and 14%±8% respectively). A significantly greater length of time in the second half was spent in the ‘defensive 22 left’ (5%±6% to 1%±2%).

Table 3: Activity data showing first and second half comparisons

EVENTS	First Half			Second Half			p value
	Mean	Max	Min	Mean	Max	Min	
Total Events	13±5	22	2	11±5	24	3	0.286
Pass	3±2	7	0	2±2	6	0	0.631
Receive	4±2	9	0	3±2	9	0	0.648
Drop Kick	1±2	7	0	0±1	3	0	0.201
Kick In Play	0±1	2	0	0±0	1	0	0.080
Get Tackled	1±1	3	0	1±1	4	0	0.700
Lineout	0±0	1	0	0±0	1	0	0.424
Tackle Made	2±2	6	0	2±2	8	0	0.983
Ruck	1±1	2	0	1±1	3	0	0.631
Try	0±1	4	0	0±0	1	0	0.693
Maul	1±1	5	0	0±0	1	0	0.126
Scrum	1±2	5	0	1±2	6	0	0.540
Att In Goal	1±1	3	0	0±0	1	0	0.279
Att 22 Left	0±1	3	0	0±1	2	0	0.333
Att 22 Mid	1±2	6	0	1±1	4	0	0.153
Att 22 Right	0±1	4	0	0±1	5	0	0.442
Att Half Left	1±1	5	0	1±1	5	0	0.430
Att Half Mid	3±3	12	0	2±2	7	0	0.013
Att Half Right	0±1	3	0	0±1	3	0	0.186
Def In Goal	0±0	0	0	0±0	2	0	0.086
Def 22 Left	0±1	3	0	1±1	5	0	0.093
Def 22 Mid	2±2	10	0	1±2	8	0	0.542
Def 22 Right	1±1	4	0	0±1	6	0	0.501
Def Half Left	1±1	4	0	0±1	3	0	0.089
Def Half Mid	3±2	11	0	3±3	8	0	0.260
Def Half Right	0±1	3	0	1±1	5	0	0.125

Activities and events only showed one significant difference ($p=0.013$) between first and second half. More first half activities (3+3) were performed in the ‘attacking half middle’ than the second half (2+2) (Table 3).

Table 4: Raw distance (km) and time (% of playing time) data for pool and final game comparisons

DISTANCE	Pool Game			Final Game			p value
	Mean	Max	Min	Mean	Max	Min	
Total Distance	0.729+0.149	1.10	0.41	1.031+0.107	1.17	0.85	0.000
Walking	0.232+0.040	0.32	0.12	0.290+0.055	0.37	0.20	0.001
Jogging	0.263+0.065	0.43	0.16	0.394+0.051	0.47	0.32	0.000
Cruising	0.140+0.051	0.32	0.04	0.230+0.077	0.36	0.13	0.000
Running	0.065+0.035	0.16	0.01	0.073+0.037	0.13	0.01	0.591
Sprinting	0.029+0.028	0.11	0.00	0.048+0.023	0.08	0.02	0.090
Att In-Goal	0.009+0.017	0.08	0.00	0.005+0.008	0.02	0.00	0.507
Att 22 Left	0.013+0.018	0.07	0.00	0.011+0.018	0.05	0.00	0.782
Att 22 Mid	0.059+0.054	0.2	0.00	0.051+0.021	0.08	0.02	0.676
Att 22 Right	0.009+0.019	0.07	0.00	0.011+0.011	0.03	0.00	0.744
Att Half Left	0.031+0.042	0.2	0.00	0.056+0.049	0.15	0.00	0.132
Att Half Mid	0.192+0.123	0.44	0.00	0.220+0.082	0.34	0.12	0.537
Att Half Right	0.020+0.031	0.16	0.00	0.028+0.028	0.08	0.00	0.510
Def In Goal	0.005+0.010	0.04	0.00	0.003+0.007	0.02	0.00	0.432
Def 22 Left	0.015+0.025	0.12	0.00	0.053+0.038	0.11	0.00	0.001
Def 22 Mid	0.097+0.082	0.3	0.00	0.166+0.086	0.28	0.07	0.032
Def 22 Right	0.019+0.031	0.15	0.00	0.025+0.023	0.07	0.00	0.575
Def Half Left	0.032+0.035	0.12	0.00	0.083+0.042	0.17	0.04	0.000
Def Half Mid	0.204+0.083	0.38	0.03	0.278+0.067	0.35	0.15	0.020
Def Half Right	0.028+0.034	0.19	0.00	0.054+0.059	0.14	0.00	0.084
TIME	Pool Game			Final Game			p value
	Mean	Max	Min	Mean	Max	Min	
Average Speed	6.22+0.94	8.03	4.37	6.65+1.05	7.64	4.86	0.242
Standing	9+4	24	2	11+4	18	6	0.304
Walking	59+6	72	47	53+8	63	36	0.022
Jogging	22+4	31	15	25+4	29	19	0.152
Cruising	7+2	13	2	9+3	13	5	0.079
Running	2+1	6	0	2+1	4	0	0.523
Sprinting	1+1	3	0	1+1	2	0	0.420
Att In-Goal	1+2	7	0	0+1	2	0	0.288
Att 22 Left	1+2	8	0	1+1	4	0	0.411
Att 22 Mid	7+6	24	0	5+3	11	1	0.370
Att 22 Right	1+3	14	0	1+1	3	0	0.781
Att Half Left	3+4	18	0	4+4	11	0	0.492
Att Half Mid	20+12	43	0	18+5	26	12	0.771
Att Half Right	2+4	16	0	2+2	6	0	0.857
Def In Goal	1+3	19	0	1+1	3	0	0.860
Def 22 Left	1+4	23	0	7+7	18	0	0.004
Def 22 Mid	17+16	65	0	19+9	29	5	0.746
Def 22 Right	3+7	40	0	2+2	6	0	0.681
Def Half Left	5+6	25	0	7+7	22	1	0.311
Def Half Mid	33+13	62	6	28+9	40	12	0.314
Def Half Right	5+7	43	0	6+8	20	0	0.702

Of 67 possible differences between the first half and second half, only 8 were significant. Of the significant differences, 7 occurred in the ‘attacking 22 middle’, ‘attacking half middle’ and ‘defensive 22 left’ field zones. These differences may be due to game structure or environmental factors such as playing with or against the wind, but are not likely to be specific to an individual half. Therefore first and second half data were pooled for positional analysis during game play.

Table 5: Distance data (adjusted for variables that showed a significant difference in the raw data) shown as values for 1 minute of game play

DISTANCE	Pool Game			Final Game			p value
	Mean	Max	Min	Mean	Max	Min	
Total Distance	0.102±0.017	0.13	0.07	0.109±0.021	0.13	0.07	.355
Walking	0.033±0.005	0.04	0.02	0.030±0.004	0.03	0.02	.119
Jogging	0.037±0.008	0.02	0.05	0.042±0.009	0.03	0.05	.153
Cruising	0.020±0.007	0.01	0.04	0.024±0.009	0.01	0.04	.080
Running	0.009±0.005	0.00	0.02	0.008±0.004	0.00	0.01	.512
Sprinting	0.004±0.004	0.00	0.02	0.005±0.003	0.00	0.01	.421
Def 22 Left	0.002±0.004	0.00	0.02	0.006±0.004	0.00	0.01	.018
Def 22 Mid	0.014±0.013	0.00	0.05	0.018±0.010	0.01	0.03	.406
Def Half Left	0.005±0.005	0.00	0.02	0.009±0.005	0.00	0.02	.038
Def Half Mid	0.029±0.012	0.00	0.05	0.029±0.007	0.02	0.04	.951

Some significant differences were found for the ANOVA with ‘game type’ as a factor, especially with respect to distances travelled and activities performed during pool and final games (Table 4). Many of these differences were a consequence of the difference in length of pool and final games. The difference in length of pool and final game play (~14 minute pool games and ~20 minute final games) was taken into account by dividing the mean distance data for pool games and final games by the actual length of a game half in minutes. Exact player distances in km and times in minutes were used to calculate the distance travelled per minute. Activities and events were not included as the number of activities was too low to calculate whole numbers. The ANOVA was repeated on the time-adjusted variables (Table 5). From this ANOVA, only the distance travelled in the defensive 22 left and defensive half left remained significantly different ($p < 0.05$). These differences were in very small distances (2-9m) and so were not considered to be sufficiently important to require separate analysis of pool and final games because they may have been a reflection of the nature of the single final game analysed. When taking the pool and final game time differences into account, pool

games and final games were not considered to be different. Therefore data from pool and final games were pooled for positional analysis.

Table 6: Activity data showing pool game and final game comparisons

EVENTS	Pool Game			Final Game			p value
	Mean	Max	Min	Mean	Max	Min	
Total Events	11+5	22	2	15+6	24	5	0.076
Pass	2+2	7	0	4+3	7	1	0.022
Receive	3+2	9	0	6+3	9	1	0.004
Drop Kick	1+1	7	0	1+2	4	0	0.313
Kick In Play	0+0	2	0	0+1	1	0	0.148
Get Tackled	1+1	2	0	1+2	4	0	0.017
Lineout	0+0	1	0	0+0	1	0	0.540
Tackle Made	2+2	8	0	1+1	3	0	0.355
Ruck	1+1	3	0	1+1	2	0	0.601
Try	0+1	4	0	0+0	1	0	0.257
Maul	0+1	5	0	0+0	1	0	0.623
Scrum	1+2	6	0	0+0	0	0	0.031
Att In Goal	0+1	3	0	0+0	1	0	0.555
Att 22 Left	0+1	3	0	0+0	0	0	0.143
Att 22 Mid	1+1	6	0	1+1	3	0	0.910
Att 22 Right	0+1	5	0	0+0	1	0	0.728
Att Half Left	1+1	5	0	1+2	5	0	0.163
Att Half Mid	2+2	12	0	3+2	7	2	0.204
Att Half Right	0+1	3	0	0+0	1	0	0.459
Def In Goal	0+0	2	0	0+0	0	0	0.512
Def 22 Left	0+1	5	0	1+2	4	0	0.006
Def 22 Mid	1+2	10	0	2+3	6	0	0.363
Def 22 Right	0+1	6	0	1+1	3	0	0.516
Def Half Left	0+1	4	0	1+1	3	0	0.305
Def Half Mid	3+3	11	0	3+2	8	0	0.903
Def Half Right	1+1	5	0	1+1	3	0	0.661

3.1 Time Motion Analysis

Data are presented for time motion analysis in the form of ‘mean \pm standard deviation’. All values are shown for a half only (on average 7 minutes of playing time). The duration of a half was nominally 7 minutes, but was often longer as the half did not finish until there was a stoppage in play, for example, the ball was knocked forward by an attacking player or kicked out of bounds. The duration of a half could also be extended by the referee to allow for unexpected stoppages in play, for example, injury breaks. Actual times were used to calculate average speed and percentage of time spent in each speed zone.

3.2 Distances and Speeds

Values for distance are shown in kilometres (km), and values for speeds are shown in kilometres per hour (km/h). All values are for half a game, for a whole game value, multiply the mean by 2. For example, backs travelled 0.8km in half a game, so for a whole game, the average distance travelled by backs is 1.6km.

Backs travelled further than halfbacks, who travelled further than forwards (0.80km \pm 0.19km, 0.78km \pm 0.20km & 0.74km \pm 0.16km respectively). Halfbacks travelled at a faster average speed during game play than backs, who travelled at a faster average speed than forwards (6.59km/h \pm 1.09km/h, 6.34km/h \pm 0.81km/h & 6.09km/h \pm 1.02km/h respectively).

3.3 Locomotion

Values for locomotion are presented as a percentage of playing time. Although the variation in these values appears small, commonly 1% differences between positions, the differences become more apparent when converted to distances travelled (Table 7). For example, the amount of time that halfbacks spent cruising was one percent greater than that of backs and forwards. These differences appear small but when converted to distances show a variation of up to 12 metres (halfbacks, 64 metres; backs, 56 metres; and forwards, 52 metres).

Table 7: Distances travelled in metres, in different locomotions per game half

Locomotion	Backs			Halfbacks			Forwards			P value
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	
	Distance travelled per game half (metres)									
Stationary	0	0	0	0	0	0	0	0	0	0.244
Walking	472	576	288	445	530	374	429	496	348	0.756
Jogging	176	240	120	187	242	133	163	222	118	0.442
Cruising	56	104	16	64	101	31	52	81	22	0.791
Running	16	32	8	23	47	16	15	37	0	0.497
Sprinting	8	24	0	8	23	0	7	22	0	0.139
TOTAL	800			780			740			

Stationary

Forwards tended to spend a greater percentage of game time stationary ($10\% \pm 5\%$), than backs, who were stationary for a greater percentage of time ($9\% \pm 4\%$) than halfbacks ($8\% \pm 4\%$).

Walking

Backs spent a greater percentage of time walking than forwards, who spent a greater percentage of time walking than halfbacks ($59\% \pm 8\%$, $58\% \pm 5\%$ & $57\% \pm 6\%$ respectively).

Jogging

Halfbacks tend to spend the greatest percentage of game time jogging during game time ($24\% \pm 5\%$). Backs and forwards, spent equal amounts of time jogging ($22\% \pm 5\%$ & $22\% \pm 4\%$ respectively).

Cruising

Halfbacks spent a greater percentage of game time cruising than backs and forwards, who spent an equal percentage of time cruising ($8\% \pm 3\%$, $7\% \pm 3\%$ & $7\% \pm 2\%$ respectively).

Running

Halfbacks spent a small proportion of time running during game time ($3\% \pm 1\%$). Backs and forwards spent an equal percentage of time running ($2\% \pm 1\%$ & $2\% \pm 2\%$ respectively).

Sprinting

Backs, halfbacks and forwards all spent equal percentages of time sprinting throughout a game ($1\% \pm 1\%$, $1\% \pm 1\%$ & $1\% \pm 1\%$).

3.4 Intensity

The classes of locomotion were grouped into 'passive rest', 'low intensity locomotion' and 'high intensity locomotion'. Grouping allowed comparisons to be made between activities that would be classed as 'easy', 'moderate' and 'hard'. Intensities are related to locomotion only, and do not include physical exertion during plays such as scrums, rucks and mauls.

Values for intensity are presented as a percentage of playing time for a half.

Passive Rest

Passive rest was classified as all static activity (0 km/h), including standing and lying on the ground.

Forwards spent the greatest percentage of time during a game in passive rest (10%±5%). Backs spent a greater percentage of time in passive rest than halfbacks (9%±4% & 8%±4% respectively).

Low Intensity Locomotion

Low intensity locomotion was classified as the slower locomotion speeds of walking and jogging, or more specifically, travelling at speeds between 0.1-14.4 km/h (0-4 m/sec).

All positions spent approximately equal percentages of time during a game in low intensity locomotion (81%±3% halfbacks, 81%±6% backs, 80%±4% forwards).

High Intensity Locomotion

High Intensity Locomotion was classified as the faster locomotion speeds of cruising, running and sprinting, or more specifically, travelling at speeds between 14.5-≥ 28.9 km/h (4-> 8 m/sec).

All positions spent approximately equal percentages of time during a game in high intensity locomotion (11%±3%, halfbacks, 10%±4%, forwards & 10%±3%, backs).

Work to rest ratios were calculated from the values in the intensity (as above) and rounded to the nearest integer ratio. All positions showed similar work to rest ratios during a half (Table 8).

Table 8: Work to rest ratios by position

Work to Rest Ratios	Back	Halfback	Forward
Low Intensity : Rest	9:1	10:1	8:1
High Intensity : Rest	1:1	3:2	1:1
High Intensity : Low Intensity	1:8	1:7	1:8

3.5 Field Zones

The small number of significant differences between movements and activities in each of the field sub-zones allowed all attacking sub-zones to be grouped together and all defending sub-zones to be grouped together.

Values for field zones are presented as a percentage of playing time for a half.

Attacking Half of Field

Backs, halfbacks and forwards spent an equal percentage of time in the attacking half of the field (35%±17%, 35%±25% & 35%±21% respectively).

Defensive Half of Field

All positions spent an equal percentage of game time in the defensive half of the field (Backs: 67%±17%; Halfbacks: 66%±25%; Forwards: 67%±21%). Note: the percentage figures for the attacking and defensive halves do not add up to 100% because the Sportstrak software rounded all figures up to the nearest whole number.

All positions spend a greater amount of time during a game in the defensive half of the field than in the attacking half.

3.6 Activities and Events

The individual activities and events are defined and explained in full in the methodology. Activities have been grouped together with other activities of similar movement patterns or relevance to game play, for example scrums and lineouts are grouped together as they are set plays.

Where values for activities are presented they are in the format of mean, maximum and minimum number of events performed during playing time for a half (mean; max; min). Results are displayed with the mean number used as the value most relevant to the study.

Total Activities/Events

Halfbacks participated in the highest mean number of activities during a game half (14; 22; 8). Forwards participated in a higher mean number activities than backs (13; 24; 5 & 10; 20; 2 respectively).

Receive & Pass

Halfbacks, backs and forwards receive the ball an equal number of times during a half. All positions pass the ball an equal number of times during a half, although the number of times that the ball is passed is less than the number of times that the ball is received (see Table 9 for values). The difference between receiving the ball and passing the ball arises because players may for example get tackled with the ball before passing it.

Get Tackled & Tackle Made

On average, all positions were tackled and made tackles an equal number of times during a game half. However, the maximum for forwards being tackled was twice that

for halfbacks. The maximum number of tackles made by both halfbacks and forwards was twice that for backs (Table 9).

Ruck & Maul

When comparing positions, halfbacks, backs and forwards participated in an equal number of rucks and an equal number mauls. Overall, the maximum and mean number of rucks completed during a half was greater than the number of mauls (Table 9).

Scrum & Lineout

On average, halfbacks and forwards participated in an equal number of scrums during a game half, and both participated in more scrums than backs (2; 6; 0, 2; 5; 0 & 0; 2; 0 respectively). On average, there was no lineout participation by either backs, halfbacks or forwards. The maximum number of lineouts for all positions was 1 (Table 9).

Drop Kick & Kick In Play

All positions averaged an equal number of drop kicks and kicks in play. The maximum number of drop kicks taken by a back was twice that for a halfback or a forward (see Table 9).

Try

All positions average the same number of tries during a game half (Table 9). However, halfbacks scored a higher maximum number of tries than forwards or backs (4, 2, 1 respectively).

Table 9: Positional differences for all variables

	Variable	Back			Halfback			Forward			p value
		Mean+SD	Max	Min	Mean+SD	Max	Min	Mean+SD	Max	Min	
Distance (km)	Average per half	0.80+0.19	1.17	0.48	0.78+0.20	1.10	0.47	0.74+0.16	1.08	0.41	0.448
Speed (km/h)	Average	6.34+0.81	8.03	4.52	6.59+1.09	7.84	4.54	6.09+1.02	7.97	4.37	0.351
Gait (% of game time)	Stationary	9+4	18	2	8+4	16	2	10+5	24	3	0.244
	Walking	59+8	72	36	57+6	68	48	58+5	67	47	0.756
	Jogging	22+5	30	15	24+5	31	17	22+4	30	16	0.442
	Cruising	7+3	13	2	8+3	13	4	7+2	11	3	0.791
	Running	2+1	4	1	3+1	6	2	2+2	5	0	0.497
	Sprinting	1+1	3	0	1+1	3	0	1+1	3	0	0.139
Intensity (% of game time)	Passive Rest	9+4	18	2	8+4	16	2	10+5	24	3	0.244
	Low Intensity	81+6	91	65	81+3	86	78	80+4	87	70	0.626
	High Intensity	10+3	17	3	11+3	16	6	10+4	17	4	0.674
Work to Rest Ratios	Low Intensity : Rest	9:1			10:1			8:1			
	High Intensity : Rest	1:1			1.4:1			1:1			
	High Intensity : Low Intensity	1:8			1:7			1:8			
Field Zones (% of game time)	Attacking Half	35+17	72	7	35+25	73	1	35+21	72	0	0.998
	Defending Half	66+17	96	30	66+25	100	31	67+21	100	29	0.981
Activities (Mean number per half)	Total	10+5	20	2	14+4	22	8	13+5	24	5	0.054
	Receive Ball	4+2	9	0	4+2	7	0	3+2	9	0	0.978
	Pass Ball	2+2	7	0	3+2	7	1	2+2	7	0	0.494
	Tackle Made	1+1	3	0	3+2	8	0	2+2	6	0	0.016
	Get Tackled	1+1	3	0	0+1	2	0	1+1	4	0	0.503
	Ruck	1+1	2	0	1+1	2	0	1+1	3	0	0.744
	Maul	0+0	1	0	0+0	1	0	1+1	5	0	0.060
	Scrum	0+0	2	0	2+2	6	0	2+2	5	0	0.000
	Lineout	0+0	1	0	0+0	1	0	0+0	1	0	0.083
	Drop Kick	1+2	7	0	0+1	3	0	0+1	3	0	0.100
	Kick In Play	0+1	2	0	0+0	1	0	0+0	1	0	0.780
Try	0+0	1	0	1+1	4	0	0+1	2	0	0.051	

4.0 DISCUSSION

The information obtained from this first study of club level sevens rugby will give a clearer picture of the actual activity undertaken by club level sevens rugby players, and will be useful to assist coaches, players and fitness trainers to prepare effectively for competition.

The aim of this thesis was to use time motion analysis to gather and compare data on match play variables in club sevens rugby. These variables 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. Playing positions were used as grouping variables to compare the data and interpretation of the results will be used to construct effective guidelines for game-specific sevens rugby training.

Analysing game play helps to determine what kind of game-specific training the players should be undertaking. It allows us to determine the total distance players in each position travel during a game, the percentage of time the players spend in different speed zones, and the variety and frequency of different activities that each player typically performs in a game of sevens rugby. Comparing positions will determine whether forwards, backs and halfbacks in club level sevens rugby can undertake the same training regime, or whether each individual requires training which is position specific.

Each individual variable is considered to determine any variances between playing positions, and to determine specific training implications of each variable.

4.1 Set Plays – Scrums & Lineouts

Hughes and Jones (2004) studied the patterns of play of successful and unsuccessful sevens rugby teams and reported that successful teams obtained a higher percentage of ball possession than unsuccessful teams. Therefore, securing the ball from set plays is an important facet of the game and should be given consideration when training for sevens.

Only forwards and halfbacks participated in scrums because backs are, positionally, not part of the scrum formation (Figure 1). The results show that there are, on average, two scrums per half (Table 9). The frequency of the occurrence of scrums is lower than that in fifteen-a-side rugby, where, as reported by Deutsch (2001), teams averaged 30-40 scrums per game (3.75-5 scrums per 10 minutes). There is a large emphasis on the physical, technical and tactical aspects of scrums in fifteen-a-side rugby. The data indicate that these components should also be considered when training for sevens. Technical, tactical and physical scrum play is important so that possession of the ball can be secured and the probability of success for the team in possession increased.

There are generally two tactical variations of scrums, involving the forwards and halfback, that are used in sevens rugby. Technical, tactical and physical scrum play is required to execute these scrums effectively. The most common variant is similar to scrums in fifteen-a-side rugby, where opposing scrummaging players push against each other to retain or gain the ball after it has been put into the channel between the two opposing scrummaging teams. This type of scrum requires whole body strength from the players in the scrum. The alternative tactical scrum variation requires speed from the forwards and halfback. In the second variant, after the ball is put into the scrum, the defending forwards may move backwards quickly, taking the attacking forwards with them and exposing the ball for the halfback to gather. These differences in scrummaging style indicate a need for the implementation of strength training for the whole body with kinematic specificity where the players train in a horizontal pushing position. Strength training could be included during aerobic or anaerobic training, when the muscles are in a state of fatigue or energy depletion, to mimic the demands of the game. This may be performed either on the field where players push against each other to replicate the demands of scrums, rucks and tackles, or in the gym using complex training techniques to promote a greater transfer of power to physical play. Technique training should also be addressed to ensure a greater probability of gaining possession of the ball from set plays.

There were not enough lineouts during game play to generate any relevant data. This suggests that, unlike 15-a-side rugby, players do not intentionally kick the ball out of play to gain positional advantage. Although the data indicate that there are very few

lineouts during a game, they still need to be included in training to ensure players are able to secure possession of the ball and implement backline moves from this possession.

What are the implications for training and practice that arise from these data? Even though the data show that there are very few set plays during a game, they actually occur at only a slightly lower frequency than in fifteen-a-side rugby. Practicing set plays is important to maintain or possibly gain possession of the ball from the opposing team and create a platform from which structured attacking variations ('moves') may begin (Gardner, 2002). 'Moves' are characterised by players in the attacking backline running towards the defence in a pre-determined pattern. They are performed to force the defending players to break their defensive formation, creating a gap in the defence where an attacking player may be able to break through the line of the defending players. During the execution of a move, players may receive and pass the ball, be tackled, or ultimately break the defensive line and score a try. A solid platform at set plays and rucks is created through attacking players securing and moving forward over the ball to ensure the defending players are either static or moving backwards. This creates an advantage for the attacking players, allowing them to execute their moves more effectively and advance up the field towards the attacking try line. The data suggest that set plays are important to secure possession of the ball and create an advantage for the attacking team, allowing them to effectively perform moves which break the opposition defensive formation, which increases try-scoring opportunities. The main implication for training from these data is that the majority of moves practiced off set plays should start from scrums as these have a higher occurrence in game play.

Unfortunately in this study, gathering the ball from kick-offs and restarts was not documented. As the team is guaranteed to receive at least one kick-off per game, this should be considered as a set play. Possession of the ball needs to be secured by catching the ball from the kick-off, and moves should be practiced from receiving a kick off in the same way that they should be practiced off the other set plays.

4.2 Kicks in Play

The main aim of seven's rugby is to maintain possession of the ball and break the opposition's defensive line to place the ball over the try line (Rienzi et al., 1999). The very small number of kicks in play is an indicator that kicking during play delivers no advantage, and may in fact be a disadvantage to the attacking team. Through kicking the ball, the probability of opposing players gaining possession is significantly greater than if the player carried the ball into a tackle situation. Hughes and Jones (2004) reported that successful teams performed significantly fewer kicks than unsuccessful teams. Consequently, training should be focussed on skills and abilities to gain and maintain possession of the ball, rather than on creating situations where there is a higher probability of losing possession of the ball.

4.3 Drop Kicks

Backs performed drop kicks most frequently. Drop kicks were performed when starting play at the beginning of each half, restarting play after a try, converting a try and kicking a penalty goal. Although these different types of drop kick could have been considered separately, there were too few of each type of kick and so all drop kicks were pooled together. From a notational analysis perspective, data on the type of each drop kick, and whether each drop kick was successful would have been useful as it could outline the requirements for an accurate drop-kicker. An accurate drop kicker may create an advantage for their team by players gaining possession of the ball through accurately placed kick-offs and restarts, and gaining points through successful conversions and penalties. A successful kick-off or restart would be one in which the ball is caught and retained by the kicking team, a successful conversion or penalty goal would be one that was kicked between the posts to score points. In terms of selection of players, it would be advantageous to choose two or more players who had a high success rate of performing drop kicks; these players are most likely to be backs.

4.4 Receive & Pass Ball

The ball was received and passed an equal number of times in all positions (Table 9), indicating the requirement for all players to possess good catching and passing skills.

To reduce passing and catching errors (fumbles) and maintain possession, these skills should be executed both while stationary and moving. The execution of passing and catching while moving is more difficult than while standing as it combines the complexities of coordination, timing, technique, strength, accuracy and vision from both the passing player and the receiving player. Because of the smaller number of players on the field in sevens rugby, the ability to throw a long pass is an asset as often players need to pass the ball quickly across the width of the field. The width of the field can be used effectively to create more space for attacking players to attempt to out-manoeuvre defensive players.

Hughes and Jones (2004) found that in international level sevens rugby, successful teams averaged 29 passes per game, whereas unsuccessful teams averaged 24 passes per game. Similar numbers were reproduced in this study where teams completed an average of 15 passes per half. In contrast, players received the ball an average of 25 times per half, implying that only 60% of the balls received were actually passed. Tackles, tries and fumbles accounted for the other 40% of received balls. Assuming that these non-passing activities happened at the same rate, it would imply that 3-4 passes per half are fumbled, resulting in a turnover of possession to the opposition 3-4 times per half. The implications for training from the data indicate that players must do passing and catching drills to minimise the number of fumbled passes. Specifically, to increase competency, these drills should include both long and short passes, and be performed while players are running at game speed. These skills should also be practiced when players are under pressure from opposition players, and when players are fatigued, to increase the accuracy and the quality of passing in these situations. Passing technique may also be addressed to assist players with developing accurate and quality passing techniques. Additionally strength and flexibility training for the upper body and core should be included to assist with passing freely over large distances. Positionally, although not significantly different, halfbacks passed more often than other positions and therefore may require more training in this area.

4.5 Tackle & Be Tackled

Deutsch (2001) found that in 15-a-side rugby, back row forwards and inside backs were involved in more tackles than front row forwards or outside backs. These findings were

repeated in this study, as a significantly higher tackle rate was demonstrated by half-backs and forwards (Table 9). This relates directly to an increase in static high-intensity activity, indicating these positions may require higher levels of full-body muscular strength, power and endurance. Even though there are significant differences between backs and the other positions, it should be noted that all positions require good tackling technique and upper body strength to stop an opposing player, bring them to ground and contest for possession of the ball. Players will benefit defensively from one-on-one tackling drills to refine these tackling skills.

As previously stated, possession of the ball is extremely important. Therefore, when a player is tackled it is vital to retain possession of the ball in the tackle situation. This can be achieved by passing the ball off the ground, throwing the ball back to another player, placing the ball then quickly getting up and picking the ball up, or other team members coming in to create a ruck so the opposition cannot touch the ball. All of these actions must be done immediately in compliance with the laws of the game (IRB, 2005). The data showed that players in all positional groups were tackled an equal number of times, although the number of tackles was quite small. A limitation of this study was that possession of the ball at the tackle situation was not documented (whether the attacking player maintained or lost possession in the tackle), and so the extent of this occurrence and its impact on the game could not be assessed. Even with no data on ball retention, it should be acknowledged that gaining and maintaining possession in the tackle situation is an important technical skill in which all players should be competent.

Evidently, the tackle is a key situation where the ball may be 'turned over' to the opposition, and so it may be advantageous for an attacking player to avoid the tackle situation by sidestepping the tackling player or pulling out of the tackle situation before the tackle is effected. The effectiveness of avoiding the tackle situation can be assisted through training for agility by using tools such as speed ladders, speed hurdles and cones. These will help players to develop 'fast feet', and when used multidirectionally, to develop the balance, coordination and strength required for agility. The enhancement of transfer to speed and acceleration for rugby will be assisted by performing drills which incorporate both the use of these speed tools coupled with actual sprint, sidestepping and swerving drills. These drills may incorporate holding or catching the

rugby ball as well as the use of opposition to pressure the player into faster decision making and increase transfer to game play. The ability to step and beat an opposing player may be enhanced by increased strength and power of both the legs and the core. Complex training including weights, plyometrics, and sport specific exercises may be used to strengthen these areas in all planes of movement and assist in maximal transfer of strength and power to game play.

4.6 Breakdowns - Ruck & Maul

In 15-a-side rugby, rucks and mauls are mainly the domain of forwards (Duthie et al., 2003a). However, in sevens rugby there is no significant difference between positions in participation at rucks or mauls, so it can be stated that all positions participate equally in these breakdowns (Table 8). Although the data show that there are only a few rucks and even fewer mauls during a sevens game, it would still be an advantage to train for strength and technique at these breakdowns. Hughes and Jones (2004) reported that successful teams formed significantly fewer rucks and mauls than unsuccessful teams, yet had a ball retention rate of 91% at these breakdowns, compared to unsuccessful teams, who only had a ball retention rate of 84%. Therefore, it is important to have the ability to retain or obtain the ball in these situations. Because games can be decided (won or lost) through dominance of the breakdown (Gardner, 2002).

This implies that teams should train to be dominant at breakdowns and, therefore, need to address technique, strength and fitness to achieve this. Technique at breakdowns relates to the body position of players, a lower body position is advantageous as it promotes a lower centre of gravity, which makes it harder for opposing players to push the lower player out of the way. Strength should be developed in a way similar to that described for scrummaging, but should also include strength to grapple for the ball and pick it up off the ground. Fitness relates to supporting players being fit and fast enough to repeatedly get to the tackled player and assist in maintaining possession by creating a ruck situation. The need for repeated speed efforts, to repeatedly sprint to a breakdown situation and have the ability to recover quickly from this exertion, highlights the requirement for players to possess both sufficient aerobic power and a large anaerobic capacity. Since successful teams form fewer rucks and mauls, players should also train to avoid the breakdown situation by developing skills for open play such as passing,

sidestepping (agility), vision, communication and composure, therefore reducing the risk of losing possession of the ball (Gardner, 2002).

Vision is important to be able to 'read' the game. On attack this includes the ability to identify when the defence is out of position and make a break through a gap; enticing more than one defender in to a tackle to create an attacking overlap; and passing the ball to a team mate who has a mismatched defender, or who has space with no defender in front of them. On defence vision is important for preventing the attacking team from creating an overlap by correct defensive positioning. Verbal communication between players is extremely important for team cohesion, and for effective execution of attacking and defensive structures. Composure is required to remain calm and in control even when adversity or pressure is present which leads to the effective execution of activities and tactical play. These, in turn, lead to self belief and self confidence of all players (Gardner, 2002).

4.7 Speed

Periods of constant pace are not advisable for effective sevens play, so players need to have the ability to quickly change pace as the game requires (Gardner, 2002). The average speed over all players throughout a game ranged from 6.1km/h to 6.6km/h. This speed was classified as walking (Walking: 0.1-7.2 km/h (0-2 m/sec). Even though average speed of the game was walking, players most likely use this mode of locomotion for active recovery from periods of higher intensity exercise and for repositioning themselves on the field.

Although only 3% of game time is spent in high-intensity running, acceleration and top-end speed are important components of sevens rugby. Gardner (2002) reported that most of the high intensity play in sevens rugby is accelerating over short distances, and only infrequently will players sprint at top speed for an extended period of time. Studies on fifteen-a-side rugby also report that average distances travelled while sprinting are typically less than 50m (Deutsch, 2001), (Duthie et al., 2003a). These distances are likely to be repeated in sevens rugby, although the potential to sprint for longer distances is increased in sevens because fewer players are on the field, and therefore there is more space to run. These studies indicate that most speed work

should focus on the development of acceleration, although top-end speed is also extremely important and should not be overlooked. Changing pace (accelerating and decelerating) is important as it provides deception in attack and can help to manoeuvre the defence into susceptible positioning, (where the attacking team may be able to break through the defensive line). Once through the defensive line, attacking players must be possess a fast top-end speed to out-pace the chasing defending players. For maximum benefit to a game situation, training for speed and acceleration should be carried out both with and without the ball. Grant et al (2003) studied the effect of ball carrying method on sprint speed in rugby union and found that while carrying the ball, sprint speed was significantly slower than sprinting without the ball, and that sprinting while carrying the ball under one arm was significantly faster than carrying the ball using both hands. The reduction in sprint speed while holding the ball can be explained by the change of the body's biomechanics from the reduction in arm drive. Sayers (1998) studied running techniques for rugby and reported that arm drive is important biomechanically to increase stride rate and ground contact forces as well as to counter the body rotation initiated by the pelvis. Therefore, sprint training while holding the ball will help the body to adapt to these biomechanical changes, thus reducing these negative effects on sprint speed.

A players body position while sprint training must be considered as the ideal body position for rugby has been found to be different from the ideal body position for track sprinting (Sayers, 1998). A major difference between track sprinting and sprinting in rugby is that track sprinting requires linear speed while sprinting in rugby requires multidirectional speed (see figure 5 for player movement around the field). While track sprinters prefer a more upright stance, rugby players should adopt a stance in which the upper body is leaning slightly forward. This forward lean lowers the players centre of gravity, which in turn improves their balance and agility. Balance and agility are required to: accelerate and change direction quickly; to sidestep; to pass the ball more effectively while running; and give an advantage in contact situations. A player who exhibits better balance and strength may be able resist the contact situation (attempted tackle) for longer, which will allow supporting players more time to assist the tackled player maintain possession of the ball. Implications for sevens rugby training include players training specifically to maximise acceleration, top-end speed, balance, and agility, both with and without the ball. Techniques such as developing sport-specific

body positions (for example, a forward lean while running), and ensuring players are not over-striding while accelerating, may be addressed to assist players to run more effectively. Development of power for speed and acceleration specific to sevens rugby may be achieved by performing complex training session. Combining specific resistance exercises, plyometrics, and sport specific tasks in a single training session will assist transfer of sport-specific strength and power to game play (Graham, 2005). For running, tools such as acceleration ladders, speed ladders, hurdles and evasion belts can be used for movements in all directions to assist with refining stride length, stride frequency, footspeed and stride mechanics, which are particularly important when improving acceleration and agility. Resisted-speed and loaded sprinting equipment such as harnesses, parachutes, sleds, and over-speed bungees can be used to increase motor unit recruitment and develop power in leg muscles for movement in all planes (Tout, 2004). The effectiveness of the use of these tools will be enhanced when coupled with activities which promote specific transfer to game play, including changes of direction and training against opposition. Drills that promote speed, acceleration and agility should be practiced over varying distances to mimic the varying distances covered during game play.

4.8 Intensity

For all playing positions, 90% of time was spent in passive rest and low-intensity locomotion, while 10% was spent in high-intensity locomotion. This is similar to findings by Rienzi et al (1999), who reported international sevens players engage in game play which consists of 93.7% low-intensity activity and 6.3% high-intensity locomotion. Similarly, as cited in Duthie et al (2003a), fifteen-a-side rugby players have been found to spend 85-95% of time in low-intensity activities and 5-15% in high intensity activities. Therefore both fifteens and sevens players require contributions from both aerobic and anaerobic energy systems (Rienzi et al., 1999); (Jardine, Wiggins, Myburgh, & Noakes, 1988); (Docherty et al., 1988). As a comparatively similar game, rugby league has also been reported to be a game of physical contact that involves low-intensity, aerobic exercise, combined with periods of intermittent, intensive anaerobic activity, where the amount of time spent on low-intensity exercise exceeds the duration of high-intensity exercise (Brewer & Davis, 1995). Even with differences in game length, sevens rugby and the other rugby variations demonstrate

similar playing intensities, but comparisons cannot be made between different variations of the game without considering the work to rest ratios displayed in each game.

4.9 Work to Rest Ratios

The work to rest ratios reflect the percentage of time spent in passive rest compared with low intensity and high intensity locomotion. There were no significant differences between positions with all players performing the same percentages of passive rest, and high and low intensity exercise. This indicates that all players require the same fitness attributes regardless of playing position.

When compared to fifteen-a-side rugby, the work to rest ratios of sevens players (1:9) are more similar to those reported for forwards (1:6-1:8), while the work to rest ratios of backs in fifteen-a-side rugby are much greater than those reported for sevens players (1:16-1:22), (Deutsch, 2001); (Roberts, 2005); (Duthie et al., 2005). Although sevens players and forwards in fifteen-a-side rugby display similar work to rest ratios, they are qualitatively different. Sevens players perform high-intensity activity in the form of running, whereas forwards in fifteen-a-side rugby perform the majority of high-intensity activity as static activities (80-90% of high-intensity activity), therefore, although quantitatively similar, comparisons of work to rest ratios cannot be made due to their qualitative differences. Backs in fifteen-a-side rugby are more likely to possess the characteristics for playing sevens, as much of their on-field high intensity exercise is performed through running. Even though better suited, the large differences in work to rest ratios between sevens players and backs in fifteens rugby identifies the need for all players to undertake more intense, running specific training to meet the physiological demands of sevens rugby.

Although not a focus of this study, it should be noted that the ability to perform effectively in repeated games over the duration of a tournament is a requirement for sevens players. As reported by Rienzi et al (1999), playing in two or more games per day and playing with fewer players on a full-sized rugby field is likely to heighten the physiological demands of match-play, therefore training needs to meet this required increase in aerobic power so that player recovery times may decrease and ensuring that they can perform at a consistent level throughout all games in a tournament.

All positions spend the majority of time in a sevens game in low-intensity exercise (active recovery). The ability to minimise fatigue and enhance the rate of recovery from short bouts of high-intensity exercise would be an advantage as the player would be able to perform at a higher intensity more frequently. The ability to recover quickly from high-intensity intermittent exercise is enhanced by a high aerobic power, characterised by an increased aerobic response, increased post-exercise VO₂, improved lactate removal and enhanced phosphocreatine regeneration (Tomlin & Wenger, 2001). Training for sevens needs to match these specific game requirements to promote a definite transfer to performance on the field. Interval training with work to rest ratios of 1:9 or less would be ideal to train players to perform game-specific periods of high-intensity activity with game-specific rest periods.

Fatigue is one factor which may have a major effect on the ability to perform effectively in repeated games. Basically stated, the greater the fatigue, the greater the drop in performance. Fatigue is described as “an acute impairment of exercise performance, which leads to an eventual inability to produce maximal force output as a consequence of metabolite accumulation or substrate depletion” (St Clair Gibson, 2001). Therefore players should strive to minimise fatigue by building a base of aerobic power, anaerobic capacity and muscular strength endurance through overload training. These methods will help to enhance both performance during, and recovery after, a game. Typical methods to enhance recovery may include warming down after each game, stretching and massage. These methods are reported to have more of a psychological than physiological effect on recovery by enhancing relaxation (Suzuki et al., 2004); (Weerapong, Hume, & Kolt, 2005). More effective physiological methods of recovery include rehydration and carbohydrate supplementation which replenish body fluids and stores of liver and muscle glycogen, helping keep the body fuelled to perform repeatedly over the duration of the training sessions or a tournament (McArdle, 1996).

4.10 Distance

The average distance travelled in a half did not vary significantly between positions, (0.74km-0.8km), therefore it can be stated that there are no positional differences in the total distance travelled. Similarly, there were no significant differences between positions in regard to the distances travelled in different gaits, indicating that all

positions should do the same volume of training, regardless of position (Table 7). Comparatively, when calculating the average distances travelled by all positions in fifteen-a-side rugby, the distance travelled per 7 minutes ranged from 0.43km for under-19 players (Deutsch et al., 1998) to 0.63km for premiere club players (Roberts, 2005). Therefore, when adjusted for time, sevens rugby players travel greater distances than fifteen-a-side players, highlighting the fact that training for sevens needs to be more intense and specifically movement-based than that of fifteen-a-side rugby.

4.11 Field Zones

Proportions of time spent in the various field zones showed no difference between positions. Of interest to note was the much smaller percentage of time spent in the attacking half of the field (35%) compared to the defending half (66%). This may be because the players require ‘depth’ to execute an efficient attack. ‘Depth’ is achieved when players in the backline (usually the backs) stand in a staggered formation from a set play or breakdown (see figure 2). This allows the players to create time and space in which to break through the defensive line (Gardner, 2002), which in turn creates more try scoring opportunities.

4.12 Suggestions for Training

The study of actual game play allows specific guidelines for training to be created. Aerobic power and anaerobic capacity can be specifically trained using work to rest ratios that mimic those displayed in actual game play, and an appropriate number and variety of activities should be included in team trainings.

The data from this research show that there is no need for separate training for sevens players in different positions. Therefore, any training programme for sevens rugby should be based on the summarised data in table 10.

An example of a training session that focuses on fitness, skills and team cohesion is detailed below. Separate specific training sessions should be conducted to focus on the development of speed, acceleration and agility, which may involve the use of speed development tools such as speed ladders, speed hurdles, parachutes and evasion belts.

Resistance training sessions should be conducted to train whole body strength and power. To maximise transfer to game play, complex training consisting of non-specific resistance training coupled with semi-specific resistance training (often plyometrics) and a sport specific exercise should be used (Graham, 2005).

Table 10: All game variables expressed in values per 7 minutes and per 1 hour training

	VARIABLE	Mean per 7 mins	Max	Min	Values per 1 hour training
Distance (km)	Average per half	0.77	1.17	0.41	6.16
Gait (% of game time)	Stationary	9	24	2	5.4 min
	Walking	58	72	36	34.8 min
	Jogging	23	31	15	13.8 min
	Cruising	7	13	2	4.2 min
	Running	2	6	0	1.2 min
	Sprinting	1	3	0	0.6 min
Intensity (% of game time)	Passive Rest	9	18	2	5.4 min
	Low Intensity	81	91	65	48.6 min
	High Intensity	10	17	3	6 min
Work to Rest Ratios	Low Intensity : Rest	9:1			
	High Intensity : Rest	1:1			
	High Intensity : Low Intensity	1:8			
Activities (Mean number per half)	Total	12	24	2	96
	Receive Ball	4	9	0	32
	Pass Ball	2	7	0	16
	Tackle Made	2	8	0	16
	Get Tackled	1	4	0	8
	Ruck	1	3	0	8
	Maul	0	5	0	
	Scrum	1	6	0	8
	Lineout	0	1	0	
	Drop Kick	1	7	0	8
	Kick In Play	0	2	0	
	Try	0	4	0	

4.13 Sample Training Session (1½ - 2 hours):

Active Warm-Up (15 minutes)

10 minutes of moderate intensity exercise, including brief, task-specific bursts of activity for ergogenic benefit and neuromuscular activation, (these are most likely to be drills for improving running mechanics), plus 5 minutes of whole body dynamic stretching.

Ensure the intensity is moderate (60-70% VO₂max) to elevate the baseline VO₂ level and spare anaerobic capacity to be used later in the session. The rest period between the warm-up and the start of the next session component should not exceed 5 minutes (Bishop, 2003).

Anaerobic and Aerobic Conditioning (30-45 minutes)

The focus of this session is to increase anaerobic capacity and aerobic power. The session should be based around running (not static) activity to mimic game play. It should include running both with and without the ball, and may also include components of agility, balance, multidirectional speed and body contact phases to assist specific transfer to game play.

This session should consist of 2-3 sets of conditioning. To mimic the demands of game play as closely as possible, each set should last 15 minutes and be broken down into time periods of 7 minutes work, 1 minute static/active recovery, 7 minutes work. The rest between each set may vary between 1-5 minutes.

In an example to directly mimic club rugby game play, the work to rest ratios during each 7 minute work period should be set at 1:9 (high intensity : low intensity), and the total distance covered during this period should average 770 metres. An example of a seven minute period would be 9 x 47 second repetitions of 85 metres, with each repetition consisting of 5 seconds work and 42 seconds rest (Table 11).

Table 11: Example of a 15 minute anaerobic training period (1 set)

	Reps	Work		Rest		Rest after 7 minutes
		Time	Dist	Time	Dist	
Repeat twice for 1 set (15 minutes total)	9	5 seconds	30-50m	42 seconds	35-55m	1 min

As displayed in Table 12, each 7 minute period should consist of:

Work periods totalling 45 seconds. These can be broken down into:

30 seconds cruising (6 x 5 seconds), 10 seconds running (2 x 5 seconds), and 5 seconds sprinting (1 x 5 seconds).

Recovery periods totalling: 375 seconds. These can be broken down into:

4 minutes walking (6 x 42 seconds), 1 minute 40 seconds jogging, and 35 seconds standing (3 x 42 seconds).

Table 12: Breakdown of work and rest locomotions during a 7 minute training period

		Time / 7 mins	Reps	Time per Rep
Work		45 seconds total, broken down into:		
	Cruising	30	6	5 seconds
	Running	10	2	5 seconds
	Sprinting	5	1	5 seconds
Recovery		375 seconds total, broken down into:		
	Walking	4 minutes	6	42 seconds
	Jogging	1 min 40 seconds	3	42 seconds
	Standing	35 seconds	3	Incorporate into time for jogging.

The time periods of work and rest may be varied for each set to ensure players are working both their anaerobic and aerobic energy systems, and the overload principle should be considered to enhance training of both energy systems. To emphasise training anaerobic capacity, players should perform interval training with short-duration maximal work periods (<60 seconds). Emphasis may be placed on developing power by training the ATP-CP energy system with maximal work periods not exceeding 10 seconds. Minimal work to rest ratios of 1:3 can be used to create overload. The lactic acid energy system should be trained to increase anaerobic power-endurance for repeated-speed efforts, and may be developed by performing work periods up to 60 seconds, with work to rest ratios of 1:2 used to create overload. Work periods of longer than 60 seconds with work to rest ratios of between 1:1 and 1:1.5 can be used to train aerobic power, as can continuous training and fartlek training (McArdle, 1996). Interval training would be best to use as it transfers more directly to game requirements through repeated bouts of high-intensity activity.

Skills/Technical (30-45 minutes)

A skills and technical session is important for developing and refining skills and technique, and should focus on the following components:

Passing & Catching.

Over both short and long distances.

While standing and moving at match speeds.

While the player is fatigued.

Tackling & Being Tackled

Technique of tackling.

Technique of retaining possession.

Avoiding the tackle; tactics and agility.

Rucks

Number of players to be involved in rucks.

Body position at rucks.

Positioning of players not involved in the ruck.

Scrum

Physical strength.

Technical and tactical variations.

Lineouts

Technical and tactical variations.

Backline Moves

Sequence structure.

Lines and angles to run.

Choosing the right move for the right situation.

Team run (practice game) (15 minutes)

The team run should mimic actual game play as closely as possible. This may be achieved though the session being loosely structured and using activity numbers similar to those used in actual game play. The focus should be on gaining and retaining possession of the ball in various situations. The team run should be broken down into two halves of seven minutes with one minute halftime break, just like an actual game.

To mimic game play, each player should, in 15 minutes:

- Receive up to 8 passes.
- Pass at least 4 times.
- Be tackled at least twice.

- Make up to 4 tackles.
- Be involved in 2 rucks.
- Forwards should be involved in 2 scrums.
- One drop kick should be performed to start each half.

Although some structure should be present, the session should not be so structured that it restricts player initiative and flair.

Warm Down (15 minutes)

Active recovery of 5-10 minutes, followed by static stretching of the whole body.

The data and reviewed literature show differences between on-field play of fifteen-a-side rugby and sevens rugby, and indicate that training for, and playing, fifteen-a-side rugby does not directly crossover to training for and playing sevens. The degree of crossover may be determined by analysing the reviewed literature on fifteen-a-side rugby and comparing it to the results of this study. Attributes of an 'ideal' sevens player would include the following characteristics; a high level of both aerobic power and anaerobic capacity for the ability to perform repeated high-intensity activities and ensure maximal recovery over the shortest time between these activities. The player would need to be fast, agile and possess excellent ball skills, as well as possessing strength for contact situations. The literature suggests that backs and back-row forwards will potentially be most suited to sevens rugby, and identifies that intermittent high-intensity activity should be used as the base to develop aerobic power and anaerobic capacity fitness characteristics. When compared to this study, it is found that some similarities do arise within training for fifteen-a-side and sevens rugby, but the crossover between the two is not direct. The activities performed in a game of sevens rugby are executed at a different rate, and these activities are performed at a higher intensity and are more running-specific with less emphasis on high-intensity static activity. Therefore, training that is specific to sevens rugby should be undertaken to maximise the transfer of fitness and skills over into game play. This training needs to include a specific focus on repeated-speed efforts through appropriate work to rest ratios, and the accurate execution of activity numbers as demonstrated in game play.

Developing specific training guidelines for sevens players will increase the understanding of the different requirements between fifteen-a-side and sevens rugby, which in turn will lead to the enhanced performance of sevens rugby players.

5.0 CONCLUSION

This study used time motion analysis to conduct research on club level sevens rugby players. The research identified the physiological demands of game play, and investigated potential differences between playing positions. Through the findings, a sample training session was created to provide players, coaches and trainers with training guidelines which transfer specifically into game play.

The data showed that there were no significant positional differences between forwards, backs, and halfbacks in sevens rugby. Therefore, players do not need specific positional training as they do in fifteen-a-side rugby. All sevens players can undertake the same training programme and be confident that it will transfer to game play, regardless of position. The data also showed there were also no significant differences found between first and second half play, or between pool and final games.

Many players participate in fifteen-a-side rugby and the shortened version, sevens rugby. Although similar in the general concept of the game, players require game-specific attributes to be successful in both versions of the game. In fifteen-a-side rugby these attributes are defined quite clearly by playing position. As positional play in sevens rugby is found to be non-significant, the attributes required for sevens are game-specific, rather than position-specific.

Game-specific activities and work rates displayed in fifteen-a-side rugby do not directly transfer to sevens because of the different modes of intensities and different work to rest ratios, where sevens rugby involves more high-intensity running with shorter work to rest ratios than fifteens rugby. This highlights the need for fifteen-a-side players to undertake sevens-specific training to keep up with the intensity of the game.

Training for sevens rugby should be game specific, with minimum training intensities based on actual work to rest ratios displayed in game play. Shorter work to rest ratios should be used to increase the physiological response to training, as demonstrated through the training overload principle. Specifically, training should focus on using work to rest ratios of between 1:1 and 1:9 to train both anaerobic capacity and aerobic power for repeated short-duration high-intensity bouts of running, and to increase the

rate of recovery between these bouts. Consideration should be given to increasing aerobic power to maximise performance and recovery during each game and over the multiple games that are played over the duration of a sevens tournament (usually 1-2 days).

Areas that may be included in, or additional to, team trainings include conducting sessions which specifically focus on the development of acceleration, top-end speed, agility, and strength as these attributes are also critical components for a successful sevens player.

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 specifically on game-specific skills, and may include executing these skills in a fatigued state to mimic the requirements of game play.

Areas that may warrant further research in addition to, and to complement, those covered in this study, include: whether the players studied are on a winning or losing side, which would highlight the differences between successful and unsuccessful teams and assist with developing training programmes based on the game actions of successful players; the time that each team is in possession of the ball before it is turned over to the opposition, which may give an indication as to how long players should spend on training both attacking and defensive strategies; and finally the frequency of each mode of locomotion could be recorded to identify how many times a players perform each locomotion during a game, which can also be transferred into game-specific training.

The present study, plus the additional information that may be gathered from previous and future studies on sevens rugby, will assist in producing effective sevens-specific training programmes for club level sevens players. These data may also assist in the development of specific testing procedures that will assess the performance of sevens rugby players.

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