

Physiological demands of rugby union matches and practice sessions

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Abstract

Research studies indicate that, by determining the physiological load placed on athletes during competitions, it can aid in the development of strength and conditioning programmes, according to the specific demands placed on athletes. Physiological data, specifically on rugby union players, are limited, thus stressing the need for more information in this area. The aim of the study was to investigate the physiological demands of South African male U/21 club rugby players and to establish the relationship between physiological demands experienced during rugby games and practice sessions. Scientific methods to describe physiological demands in sport that are used are heart-rate and blood-lactate measurements. A group of U/21 rugby players (n=15) of the University of Pretoria (Tuks) rugby club participated in this study. Variables that were tested included blood-lactate concentrations and mean heart-rates during a rugby match and practice sessions. The Tuks U/21 team's data were analysed by means of descriptive statistics (means and standard deviations). Significant differences between rugby match and practice sessions were determined by a dependent t-test ($p < 0.05$). An independent t-test was used to determine significant differences between the forwards and backs group. The results showed statistically significant differences between mean heart-rate in the rugby match (154.40 ± 13.53) and practice sessions (138.33 ± 4.81). No significant differences were found between peak lactate measurements in the match (5.39 ± 2.44) and practice sessions (4.93 ± 1.83). Between the forwards and backs group no statistical significance could be found for average heart-rate and blood-lactate levels in practice sessions and during the match. The findings of the present study indicate that rugby union matches for club level U/21 players are an intermittent type of activity, which utilise both aerobic and anaerobic energy systems.

Keywords: Physiology, rugby union, amateur level, game, practice session, heart-rate, blood-lactate, strength and conditioning, coaching, specificity.

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Introduction

Rugby is a competitive and specialised sport in many countries. In South Africa, club rugby plays an important role, as provincial teams recruit their players from clubs. Development is therefore an important aspect of South African rugby. According to Gabbett, Kelly and Pezet (2007), players' high physical fitness can positively contribute to the effectiveness of the playing ability of rugby players, and thus may increase the standard of players. Applying specific exercise conditioning programmes can aid in optimal preparation of players for match conditions (Gamble, 2004b). Effective training programmes can, furthermore, be developed by the

information obtained through the measurement and monitoring of training loads (Borresen & Lambert, 2008). According to Eniseler (2005), measuring heart rates and blood-lactate is effective in objectively determining the physiological load on individual players. In addition, it can provide important feedback on the training stimulus applied to the players, thus contributing to the effectiveness of a training programme (Brooks, Fuller, Kemp & Reddin, 2008). One of the main purposes of practice sessions is indeed to condition players to tolerate the metabolic conditions experienced during a rugby match (Gamble, 2004a). The purpose of the study therefore is to evaluate the physiological demands placed on club rugby players by measuring their heart-rate and blood-lactate concentrations during matches and practice sessions.

Methods and Material

Subjects

Fifteen male rugby union players of University of Pretoria's under 21 team were studied during some practice sessions and a rugby match in the 2010 rugby pre-season. All participating players were informed of the purpose and procedures of the study before giving written consent to participate. The study was approved by the Ethics Committee of the Faculty of Humanities, University of Pretoria, South Africa.

Practice Sessions

The rugby practice sessions during which measurements were taken were prior to the official rugby game in the late pre-season phase of training. The training sessions represented the typical practice activities and drills of the participating team. The first part of the three practice sessions was started with some fitness training, consisting of two sets of 5-metre repeated sprints of 6 repetitions, 30 seconds running and 30 seconds rest, with a 2-minute rest period between the two sets. The other fitness drill consisted of sprinting 50 m every 20 seconds for 8 repetitions, in 3 sets, with a rest period of 2 minutes between sets. The last session included 10-metre sprints every 5 seconds from a downward position. Ten repetitions were done in a set for a total of 10 sets. The next part of the training session consisted of technical and tactical drills, which included semi-contact game plan structures and strategies done at high intensities. Ball drills and running grids to improve players' overall rugby skills were also performed. Rest during these drills was kept at a minimum for testing purposes, to increase players' fitness and improve concentration levels for match situations. The duration of the practice sessions were between 60 and 90 minutes.

The match

The team played a pre-round match home game against another highly-competitive U/21 rugby club team from Police Rugby Club, which also participates in the Blue Bull Carlton league. The match lasted 70 minutes and it was arranged that the players who participated in the study stayed on the field for as long as possible. Substitution was only made for injuries. Half-time lasted 6 minutes and a total of 7 injury stoppages were necessary. The night game was completed during March 2010, in mild weather conditions. Fluid was also readily available during the game for adequate hydration levels of the players, as dehydration can increase physiological strain and lead to a decrease in performance (Sirotic, Coutts, Knowles & Catterick, 2009).

Physiological Measures

Heart-rate

Measurements of the heart-rates of the 15 subjects in the study were taken during the practice sessions and the club rugby match. The real-time telemetry heart-rate system (Hosand®, TM 200, Italy) was used to record heart-rates (in beats per minute (bpm)) every 5 seconds throughout the sessions and match to get the average and peak heart-rates of the subjects during the above situations. The telemetry system works through a transmitting device (TX 200, Italy), which is placed into a pocket of a specially designed vest, worn by the subjects under their rugby jerseys. The transmitting device intercepts heart-rate signals from a heart-rate monitor chest strap (Polar). The signal is received through an antenna connected to a computer (PC), where a graphical representation of the heart-rate of the subjects can be seen. Heart-rate monitors were also checked regularly during the practice sessions and match to ensure that the device works properly for recording the heart-rate data.

Blood-lactate

Blood-lactate concentration was measured according to the method used by Rampinini, Impellizzer, Castagna, Abt, Chamari, Sassi and Marcora (2007). The lactate concentrations are taken from the capillary blood vessel of the athlete's ear lobe to obtain a sample of 5 ml whole blood. A single-use disposable lance is used to make the incision in the ear lobe to draw the blood sample. The blood drop is placed on the tip of the test strip (Lactate Pro™ test strip) and lactate concentrations are immediately analysed through the chemical reaction that takes place inside the portable lactate analyser (Lactate Pro Test Meter, Arkray, Japan), which expresses it in millimol per litre (mmol/l). The portable blood-lactate analysers used in the study are reliable and valid for athletic testing, as reported by McLean, Norris and Smith (2004). The blood samples were drawn before, during and after the practice sessions.

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In the rugby match samples were drawn before warm-up, during half-time and at the end of the match. The same order of measuring the subjects was followed in all circumstances when lactate measurements were taken. Before warm-up in the practice sessions and match, all 15 subjects' blood-lactate concentrations were measured. In the middle of the practice sessions and during half-time in the match, seven subjects' lactate concentrations were measured. These subjects included forwards nos 1, 4, 7 and 8 and back-line players nos 9, 11 and 13. After the match and after the practice session, the other eight subjects were measured, forwards nos 2, 3, 5 and 6 and backs nos 10, 12, 14 and 15. These measurements were taken in this particular way to collect peak blood-lactate data that represented the overall physiological stress placed on rugby players after the most recent activity performed during practice and match situations.

Statistical Analysis

The data of the Tuks rugby players was captured on Excel and analysed by the SAS-computer program (Version 9.2). Statistical data analysis procedures that were used in the study included descriptive statistics (means and standard deviations) to describe the data and inferential statistics to determine significant differences. Significant differences in the study were determined between the two different circumstances (practice and match) for the entire team as well as forwards and back-line players in terms of average heart-rate and peak blood-lactate concentrations. Significant differences were reported at a p-value of < 0.05 (Thomas & Nelson, 2005).

Results and Discussion

Table 1 and Figures 1 and 2 present the descriptive statistics of the whole team's physiological data during the practice sessions and rugby match.

Table 1: Descriptive statistics for Tuks under-21 rugby players in terms of heart-rate and blood lactate concentrations during different activities

Variable	Mean	Std Dev	Minimum	Maximum
Average heart-rate in practice session (bpm)	138,33	4,81	131	147
Average heart-rate in rugby match (bpm)	154,40	8,53	140	170
Peak blood-lactate levels in practice (mmol/l)	4,93	1,83	1,70	7,60
Peak blood-lactate levels in match (mmol/l)	5,39	2,44	2,0	13,30

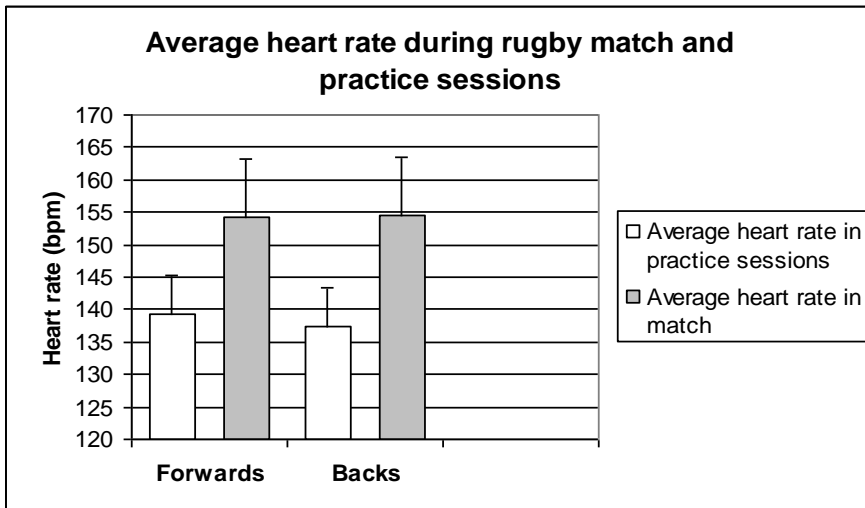


Figure 1: Heart-rates during rugby match and practice sessions (Error bars represent standard deviations).

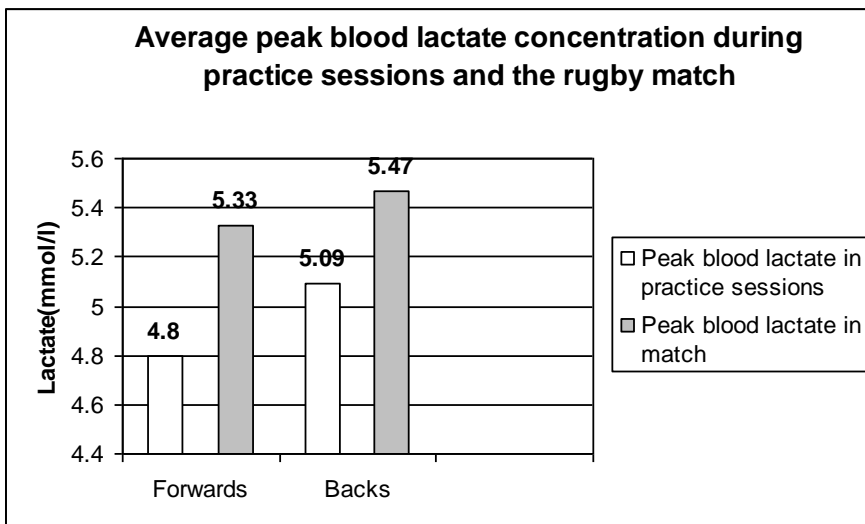


Figure 2: Peak blood-lactate levels during practice sessions and the rugby match

In Table 2 the significant and non-significant differences between different parameters, playing situations and players were given. Significant statistical differences were found between mean heart-rate in the rugby match and practice sessions (Table 2). The highest mean heart-rate was observed in the match (154.40 ± 13.53 bpm) and is much higher than the highest heart-rate observed in the practice sessions (138.33 ± 4.81 bpm). There are large differences between minimum and maximum values for the mean heart-rate achieved in practice and match situations, which means that there was a fluctuation between players' data, with standard

deviation of 4.81 for the practice sessions and 8.53 for the match. These differences can be due to individuality and individual effort made during the two different types of activities. The differences can further be ascribed to factors that influence performance in a match, such as game tactics that are applied and motivation to win the match (Bouhle *et al.*, 2006). It is also an indication that heart-rate values for U/21 club players vary during practice sessions, as well as in a rugby match situation. The heart-rates achieved during the team's practice sessions were low.

Table 2: Significant and non-significant differences between different parameters, playing situations and players

Paired-test (Signed rank test): Match versus Practice			
Variable	Backs	Forwards	Total
Heart rate	0.013	0.1484	0.0078
Resting Lactate	1.00	0.5938	0.6250
Peak Lactate	0.9844	0.4844	0.7093
t-test for independent groups: Forwards versus Backs			
	Practice	Match	
Heart rate	0.4502	0.9654	
Peak lactate	0.7755	0.9203	

A study by Lambert, Mbambo and St Clair Gibson (1998) on long distance runners indicated that the heart-rates of athletes responded differently during competition than in training. These heart-rate differences could not be explained by the terrain they ran on or added psychological stress. Another explanation for the low heart-rate values in the practice sessions is the fact that more closed-skill than open-skill drills were performed, which have been proven to elicit significantly higher heart-rates in athletes (Farrow, Pyne & Gabbett, 2008). No significant differences were found between peak lactate measurements in the match (5.39 ± 2.44 mmol/l) and practice sessions (4.93 ± 1.83 mmol/l) (Table 2). The study by Ekblom (1986) reported lactate levels for soccer players during a match as high as 7-8 mmol/l, as soccer is also an intermittent type of sport. Although the values were higher in the soccer match, it can be due to the different running patterns in a soccer game. McLean (1992) found blood-lactate levels of international players during a match to be between 5.8 and 9.8 mmol/l. Duthie *et al.* (2003) also indicate that blood-lactate levels of rugby union players during matches are 2.8 and 9.8 mmol/l. These differences in lactate results in the above studies could be due to the timing of taking the blood samples, which influences the value as well as the standard of players (ranging from 1st division to elite level). Coutts, Reaburn and Abt (2003) found a slightly higher mean blood-lactate of 7.2 mmol/l in rugby league players in a match. The difference in lactate levels could be due to different playing levels of the players. The review study of Gabbett (2005) also indicates similar heart-rate and blood-lactate data, as the study was carried out on amateur rugby league players (similar to club level as in the current study). The players achieved a mean heart-rate of 152 bpm and peak lactate level of 5.2 mmol/l in a match, which are similar to the finding of this study.

Mean heart-rates in elite junior Australian rule football matches were 173 bpm in the first half and 163 bpm during the second half of the matches. Blood-lactate concentrations of the Australian players ranged from 8.2-9.2 mmol/l (Veale & Pearce, 2009). In comparison with the current study, the differences in heart-rate and blood-lactate concentration could be due to the disparity in the level of participation, as well as the difference between the rules prescribed by the rugby union and those applied in Australian football. In Australian football the average amount of distance run during a match (10-16km) is more than that covered in a rugby union match, where an average distance of 5-8 km is covered by players (Deutch, Maw, Jenkins & Reaburn, 1998).

The study of Tessitore, Tiberi, Cortis, Rapisarda, Meeusen and Capranica (2006) found a mean lactate concentration of 3.7 mmol/l for older basketball players, aged between 55 and 64 years, during a basketball match. The lower lactate values achieved are most likely due to the age of the players. In the study of D'Artibale, Tessitore and Capranica (2008), which focused on motor cyclists' heart-rate and blood-lactate levels in official races and qualifying sessions, no significant difference was also found between the two situations in terms of session's peak blood-lactate levels. In the qualifying session an average peak lactate level of 5.2 mmol/l and 6.0 mmol/l in the race was found. These similar blood-lactate concentrations achieved could be due to the high physiological stress placed on the cyclists. The study of Rampinini *et al.* (2007) indicated a variety of blood-lactate levels for soccer players playing different small-sided soccer games (five-a-side) for aerobic interval training, which ranged between 3.4-6.5 mmol/l. Again the similar lactate values are due to the fact that small-sided soccer games are also classified as an intermediate type of sport with similar high-intensity activities in a game, followed by lower intensity activities, creating similar physiological responses.

Roberts, Stokes, Weston and Trewartha (2010) found that a rugby-specific exercise protocol performed on university standard rugby union players, with an average age of 21 years, elicited a mean heart-rate of 158-160 bpm during the exercises and mean blood-lactate concentrations of 4.6 mmol/l. The above study was done on a population group of players similar to those in the present study, which could explain the corroborating findings between the two studies. The general observation that heart-rates are higher in a competition situation corresponds with the results of other studies in different sports. The reason for the consistent results amongst the studies could be that competition circumstances do indeed impose a higher physiological load on athletes. There are a few studies which illustrate this fact. For instance, Eniseler (2005) indicated that in soccer, match situations elicit significantly higher mean heart-rates than in various training activities. In friendly matches the average heart-rate of the players was 157 bpm, during the modified soccer game (five-a-side), 135 bpm was recorded and during the technical session the mean heart-rate was 126 bpm. Greig, Naughton and Lovell (2006) examined physiological and mechanical

responses of semi-professional soccer players to soccer-specific intermittent exercises. They also indicated lower physiological responses during soccer exercises than reported in a soccer match, as mean heart-rate responses between 125-135 bpm were reached in the activities done by the participants in the study.

The study of Jones and Drust (2007) on small-sided soccer games indicated mean heart-rates of 175 bpm for the four vs four player games and 168 bpm for the eight vs eight player soccer match. Barbero-Alvarez, Soto, Barbero-Alvarez and Granda-Vera (2008) indicated a mean heart-rate of 174 bpm during small-sided five-a-side soccer matches and at no time during the game were the players' heart-rates below 150 bpm. The higher heart-rates achieved in the two above studies, during the small-sided soccer game studies, may be due to the higher pace and intensities at which the game is played, as well as few rest periods for the players because of the number of players involved in a match (Barbero-Alvarez *et al.*, 2008). Bouhlef, Jouini, Gmada, Nefzib, Abdallah and Tabka (2006) also found that Taekwondo athletes had a more significant rise in heart-rate during competitions than in normal training. A mean heart-rate value of the athletes was 197 bpm at the end of the competition and blood-lactate concentrations of 10,2 mmol/l were detected. Although Taekwondo is an intermittent type of sport, the same as rugby union, the results differ, because the duration of Taekwondo competitions is three rounds of three-minute bouts, with one-minute recovery between rounds.

A study by Baillie, Wyon and Head (2007) on the heart-rates of competition Highland dancers, found a significant difference between competition heart-rates and training, as a mean heart-rate of 195 bpm was achieved during competition and only 151 bpm during training. The high mean heart-rates achieved in the aforementioned study, compared with the present study, is that competition dance routines are only between two to three minutes long, therefore higher heart-rates can be sustained for a shorter period than in a rugby match, which lasts 40 minutes each half. Montgomery, Pyne and Minahan (2010) found that mean heart-rates of U/19 basketball players were 162 bpm during a game, while during different practice drills, which included defence drills, offence drills and a five-on-five game, mean heart rates ranged between 147-152 bpm. The mean heart-rates during practice is slightly higher than the mean heart-rates of 131-147 bpm during a practice session of the current study. The difference could be ascribed to differences in practice sessions between the two sports.

Figure 1 indicates the heart-rate data of forwards and back-line players respectively during practice sessions and the match. Forwards achieved a mean heart-rate of 139.25 ± 5.18 bpm and 154.25 ± 7.97 bpm for practice and match respectively. Backs completed the practice sessions and the match with an average heart-rate of 137.29 ± 4.50 bpm and 154.57 ± 9.54 bpm respectively. Differences of statistical significance were found for both the forwards and back-line players between these

average heart-rates during the practice sessions and the match. Between the forwards and backs group no statistical significance was found for average heart-rate in practice sessions and the match. In the practice session the same total number of fitness drills and distances to be covered were allocated to both the forwards and backline groups. In the match, mean heart rate values were also similar. However, these results do not reflect the findings of previous studies. Doutreloux, Tepe, Demont, Passelergue and Artigot (2002) found that mean heart-rates of forwards are 180 bpm; Deutch *et al.* (1998) indicated that forwards had a higher mean level of effort in a rugby union match than back-line players; and Duthie, Pyne and Hooper (2003) state that forwards indeed tend to perform a greater total amount of work in a match. However, these studies were conducted on elite players, and Coutts *et al.* (2003) indicate that a higher standard of rugby can lead to increased intensity at which rugby is played, therefore the intensities differ at club level rugby. Another reason for the result of the non-significant difference in heart-rate between forwards and back-line players, which is inconsistent with the results of previous studies, is the fact that the roles of forwards and backs in a match are becoming more interrelated in modern day rugby. The match is played at a faster general speed, owing to the ball being in play for most part of the match (Jarvis, Sullivan, Davies, Wiltshire & Baker, 2009).

In Figure 2, blood-lactate concentration values can be seen for both the forwards and the back-line players. No statistically significant differences were found for both groups between the rugby match and practice sessions. There were also minimal differences in the lactate values between the forwards and back-line players in both the practice sessions, the forwards achieving 4.8 ± 1.89 mmol/l vs the backs' 5.09 ± 1.90 mmol/l in the practice sessions, and forwards achieving 5.33 ± 0.49 mmol/l vs the backs' 5.47 ± 3.69 mmol/l in the match. It is note worthy that no statistically significant differences were found between the forwards and backline groups for peak blood-lactate concentrations during either practice or match. Similar findings on differences between forwards and back-line players were indicated by other studies, illustrating the small differences of mean blood-lactate concentration values between forwards and back-line players in rugby, as the same energy system is used by players at all playing positions. The study of Deutch *et al.* (1998) could also not establish a significant difference between forwards and backs for mean blood-lactate levels during an elite U/19 rugby match, but a difference was found as forwards reached a mean blood-lactate reading of 6.6 mmol/l and the back-line players' 5.1 mmol/l. Coutts *et al.* (2003) found that mean lactate values differed by 2.0 mmol/l between rugby league forwards and back-line players, as forwards tend to have a higher concentration of 8.5 mmol/l, whereas backline players had 6.5 mmol/l.

In the current study, the mean blood-lactate level of 5.33 mmol/l that was achieved in the rugby match is an indication that anaerobic glycolysis was the predominant energy system used by the players, as high blood-lactate accumulation levels of 4

mmol/l and higher are associated with glycolytic anaerobic metabolism (Swart & Jennings, 2004; Chatterjee, Banerjee, Majumdar & Chatterjee, 2005). Performing repeated high-intensity activities is also associated with high muscle lactate concentrations. Bouhlef *et al.* (2006) also indicated that a high rise in heart-rate and blood-lactate in a match is linked with anaerobic metabolism. Coutts *et al.* (2003) further state that the higher the blood-lactate level of the individual, the more the energy supply is sourced from the anaerobic energy system. As blood-lactate concentrations are associated with the most recent activity performed by an individual, which is a reason for the high blood-lactate levels that were achieved, together with the intermittent nature of rugby, the aerobic energy system cannot be excluded as a contributing energy source. Guevèl, Maisetti, Prou, Dubois and Marini (1999) suggest that mean blood-lactate concentrations in the range of 5-6 mmol/l can be an indication of both anaerobic and aerobic metabolism. Spencer, Bishop, Dawson and Goodman (2005) further indicate that, performing successive repeated high-intensity activities which happens in a rugby match, can reduce the use of anaerobic metabolism as contribution of the aerobic system is being increased. The total duration of a whole rugby match can also be linked to the aerobic energy system, as the duration of an activity can also determine which energy system is used (Baechle & Earle, 2000).

A mean heart-rate of 154 bpm that was recorded for the players, is another confirmation that aerobic metabolism was present in club rugby players during the match, as Baillie *et al.* (2007) indicate that a heart-rate of 152 bpm is associated with the aerobic energy system. The findings of the present study are consistent with those of other researchers, particularly concerning the pre-dominant energy systems used by rugby players (Deutch *et al.*, 1998; O'Conner, 2004; Gabbett, 2005; Deutch, Kearney & Rehrer, 2007).

Conclusion

The findings of this study indicated that there was indeed a correlation between blood-lactate concentrations during matches and practice sessions. However, heart-rates significantly differed between the two situations. Conditioning coaches should therefore ensure that practice sessions elicit similar types of intensities and physiological loads from players. The heart-rate values measured during the match further highlights the intermittent type of activities performed during a rugby match, as indicated in previous studies on rugby players. Further studies are needed to be conducted on club level players, involving more rugby clubs for development and extension of the knowledge of coaches to ensure an improvement in the quality of the club rugby players' fitness for successful competitive performance.

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