ASPECTS OF PHYSICAL CONDITIONING FOR RUGBY

Mike I. Lambert

1MRC/UCT Research Unit for Exercise Science and Sports Medicine,
Department of Human Biology, Faculty of Health Sciences, University of Cape Town
South Africa

Address for correspondence:
Associate Professor Mike Lambert
MRC/UCT Research Unit for Exercise Science and Sports Medicine,
PO Box 115, Newlands 7725, Cape Town, South Africa
Phone: +27 21 6854558, Fax: +27 21 659 5601, Email: Mike.Lambert@uct.ac.za

Providing coaches, referees, players, and administrators with the knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby.

INTRODUCTION

To prepare physically for rugby there are basic training principles that need to be understood and adhered to. Perhaps the most fundamental aspect of training for rugby is the "principle of specificity" which states that training adaptations arising from training are specific to the type of training stimulus. It follows that the type of training must be structured and planned in accordance with the requirements of the game and demands of the playing position. In some sports this is rather easy, as all the competitors in the team are faced with similar demands. In rugby, this is not so. Consider that the primary task of the forwards is to wrestle and compete physically for the ball, while the backline players are required to be able to run fast with the ball while avoiding being tackled. Forwards spend 12 to 13% of the total match time performing high-intensity work, in contrast to the 4.5% of the match time of the backline players [9]. The "game-within-a-game" in rugby requires that players have different physical characteristics so that they can do their job and fulfill the requirements of the team to the best of their ability. Therefore to apply the "principle of specificity" in rugby it is important that the physical demands of the game are understood, so that training can be prepared specifically to induce changes and adaptations in accordance with the requirements of the different playing positions. However, rugby is a game in which the laws are evaluated and changed regularly in an attempt to make the game safer, while also making it faster and more attractive for spectators. This confounds the understanding of the demands of the different playing positions and therefore the way that players need to prepare for matches, because the demands on the players change as the laws change. This was particularly noticeable coinciding with the onset of professionalism in rugby in 1995. It was also noticeable following the introduction of the Experimental Law Variations (ELV) in the Super 14 in 2008. The changing nature of the game will be discussed in more detail in the next section. This will be followed by a section on the physical demands on the players, illustrating how these demands have changed and how this may have an impact on performance and the risk of injury. This will be followed by a section discussing the aspects of fitness, particularly pertaining to rugby.

EVIDENCE FOR THE DEMANDS OF THE GAME CHANGING

The laws of rugby have changed more frequently than the laws of any other comparable sport [31]. Many of the law changes were designed to reduce the risk of injury, but others were designed to make the game more appealing to spectators. In accordance with this, the goal was to make the game faster, with more tries being scored. Following the onset of professionalism in 1995, the ball is in play for almost 10 minutes more at the elite level. This is shown clearly in Table 1 where the average ball-in-play times at the World Cup tournaments are shown (amateur era – 1991 and 1995, versus professional era 1999, 2003 and 2007) [23]. This has resulted in different physical demands for both forwards and backline players.

Table 1: Summary of average time of ball in play at the World Cup tournaments (1991-2007)

	Time (min:s)	*Era*
1991	24:48	Amateur
1995	26:43	Amateur
1999	30:43	professional
2003	33:35	Professional
2007	35:12	Professional

While the changing laws may, according to some observers, make the game a better spectacle, this always has to be weighed up against the risk of injury. For example, during the 1993-1994 season, there was an injury episode every 3.4 matches compared to an injury episode every 2.0 matches in 1997-1998 [20].

These changing demands require a refined development of the characteristics comprising the fitness profile of a player. For example, a summary of studies done over 10 years ago showed that the intensive efforts during a match lasted for five to 15 seconds with less than 40 seconds of recovery between each bout of match play [14;30]. These data however may not accurately reflect the demands of the game at present. A survey of the earlier studies, particularly from a comparative perspective, can be a little confusing because there is no consistency in the variables measured, and the definitions used to describe the various activities. Furthermore, the published data have not always included the degree of measurement error. These factors limit the use of the already published data for comparative purposes.

Perhaps the best source of comparative data to illustrate how the game has changed is the data collected from the World Cup tournaments. As the data are collected by one body (the International Rugby Board, or IRB), it may be assumed that there is some degree of consistency in the data collection. Accordingly, using the data of the World Cup played in 1995 (last tournament in the amateur era) versus the most current World Cup (2007), it is clear that the changes in the game have been profound. These are summarised in Table 2[23].

Table 2: Activities during the games at the 1995 (pre-professionalism) and 2007 World Cup tournaments

	1995	*2007*	*Change (%)*
Ball-in-play (%)	33	44	33 ↑
Passes	179	224	25 ↑
Rucks/mauls	69	144	107 ↑
Kicks in play	75	56	25 ↓
Scrums	27	19	33 ↓
Lineouts	37	31	16 ↓

A study done in the 1970s predicted that players cover a total of 5.8 km during a match [(29)]. This can be compared to about 5.6 km covered by backline players (and in 19) and 4.2 km by forwards [(10)]. A more contemporary study on elite English players showed that backline players covered more distance than forwards (6.1 km vs. 5.6 km) during a match. This included more high-intensity running (448 m vs. 298 m; backline players vs. forwards). The forwards spend more time doing high-intensity activity (nine minutes) than the backline players (three minutes) [(38)].

Another excellent source of data, which provides an example of how the game has changed, can be obtained from the study of the Bledisloe Cup (1972-2004), an annual competition between Australia and New Zealand [(36)]. The video recordings of 26 matches were coded, with 17 of these matches being played before the start of professionalism and nine matches played after the transition. The ball-in-play time increased by about 20% during the study. This translated to five minutes and 54 seconds. This increase in playing time was ascribed to the decrease in the number of scrums and lineouts, which occurred as a result of a change in the laws. A summary of the average activities are shown in Table 3.

Table 3: Activities for the Bledisloe Cup matches played before 1995 (n = 17) compared to the matches played after the onset of professionalism (1995) (n = 9) [36]

	Pre 1995	***Post 1995***	***Magnitude of effects****
Scrums	33 ± 7	26 ± 7	Unclear
Lineouts	39 ± 6	28 ± 10	Moderate
Rucks	72 ± 18	178 ± 27	Very large
Mauls	33 ± 8	22 ± 9	Moderate
Passes	204 ± 30	247 ± 32	Large
Kicks during play	66 ± 8	46 ± 13	Large
Tackles	160 ± 32	270 ± 25	Very large

*data are interpreted using the magnitude of effects [1]

The study also reported that the dynamics during the scrum were different in the 1972 and 1974 matches. During this early era the front rows stood more direct and further apart. The loose forwards would often join the scrum coinciding with, or following, the engagement of the two front rows. From the 1980s the loose forwards bound and pushed before the opposing tight forwards bound. These changes clearly influenced the forces produced prior to contact of the two front rows.

The very large increase in the number of rucks and tackles during the game (pre vs. post 1995) results in a greater impact stress for each player, resulting in varying degrees of muscle damage. A study has shown that the clinical signs of muscle damage in rugby players are directly proportional to the number of tackles, either delivered or received [45]. It is logical that these findings also apply to the impact stress, which occurs as a result of rucks and other forms of contact. Another point to consider regarding the increased physical contact is that most of the injuries that occur in rugby are associated with this aspect of play [3;37].

Another study that can be used to describe the changing demands of the game compared characteristics of the game before and after the onset of professionalism [17]. The authors studied pre-recorded matches from the Five and Six Nations Championships between 1988 and 2002. The ball was in play 27% of the time before professionalism (1995) compared to 32% of the time after. This represents a mean time difference of 4 minutes and 45 seconds of play. This study also showed that the frequency of rucks has significantly increased in the post-professional era, thereby giving rise to more phases of play.[17].

Another study also showed that ball-in-play time increased significantly over a five-year period (1999-2003) when 496 games were analysed in the Six Nations, Tri Nations, European Cup and Super 12 competitions [47]. The authors concluded that the changes could be mainly attributed to the law changes that were implemented over this period.

Using the data of the 2003 and 2007 Rugby World Cup tournaments it may be concluded that when the game is defined by activity cycles (rucks, mauls, passes and kicks) there is some stability in the game, certainly at the elite level over this 4-year period (Table 4) [23].

Table 4: Summary of activity cycles per match (rucks, mauls, passes and kicks) at the 2003 and 2007 Rugby World Cup tournaments

	2003	***2007***
Rucks/maul	144	144
Passes	241	224
Kicks	52	56

The introduction of the experimental laws variations (ELVs) (2008) have made the game even faster, with the ball in being play for longer than before. The media have reported on elite players intentionally losing body mass prior to the start of the 2008 season in anticipation of the increased intensity of the game played under the proposed new laws. Although preliminary reports suggest that the players run further during a match, this needs to be confirmed with experimental data.

To summarise this section, it is clear that the changing laws have resulted in an increased pace of the game, longer duration of activity, and greater amounts of physical contact requiring strength and power. The game has also evolved to have an increased number of passes, tackles, rucks, tries and ball-in-play time. Overall, these changes have resulted in an increase in the pace of the game and also the amount of physical contact [36]. The next section will show that players have become bigger and stronger, which adds another dimension to the physical demands of the game.

CHANGES IN THE PHYSICAL ATTRIBUTES OF RUGBY PLAYERS

There are many studies which have examined the physical characteristics of elite [4;13;15], amateur [28;34], adolescent [10;11;34;35] and pre-adolescent rugby players [33]. Collectively these studies show that there is a clear distinction between forward and backline players with respect to stature and body mass, and furthermore that average body mass is higher among players of greater proficiency [13].

There has been a significant change in the body mass of elite rugby players over the past 30 years, with the increase being greater than what would be expected for the normal upward trend in the population [32]. This pattern is also shown at the annual Craven Week schools tournament, where the average mass of the players has increased by almost 10 kg (6.6%) since 1968 (Table 5). This is in contrast to stature (Table 6), which has only increased by 1.7% during the same period (Lambert, Colquhoun, and Durandt, unpublished data). It is logical to assume that the accelerated increase in body mass over the past 30 years can be attributed to better knowledge and implementation of programmes involving nutrition, supplements and resistance training.

Table 5: Average mass (kg) of the players at Craven Week. Data are shown as 95% confidence intervals around the mean.

	Mean	***95%-***	***95%+***	***number***
1968	76.9	76.0	77.8	359
1978	78.9	78.0	79.8	478
1988	81.1	80.3	81.9	578
1998	82.9	82.1	83.8	660
2007	85.0	83.7	86.4	346

Table 6: Average stature (cm) of the players at Craven Week. Data are shown as 95% confidence intervals around the mean.

	Mean	***95%-***	***95%+***	***number***
1968	179.2	178.4	179.9	359
1978	180.8	180.1	181.5	478
1988	181.8	181.2	182.5	556
1998	182.0	181.4	182.6	658
2007	182.2	180.3	182.1	334

The Bledisloe study (1972 to 2004) discussed earlier also shows that forwards have become slightly shorter, whereas backline players have become taller. It may be speculated that the decrease in stature of the forwards coincides with the introduction of the law permitting lineout jumpers to be supported in the lineout [36]. This law allows good lifters to overcome slight disadvantages in the stature of the jumper. This law also introduced new requirements for successful lineout play, such as visual acuity, timing, and the ability to coordinate between the jumpers, lifters and hooker throwing in the ball. The body mass of both forwards and backline players increased significantly (7.1% and 12.3%; forward and backline players) during this study [36].

THE ASPECTS OF PHYSICAL CONDITIONING FOR RUGBY

A well conditioned rugby player needs to have attributes such as endurance, speed, agility, power, flexibility and sport-specific skill [13]. Coupled with these characteristics, rugby players competing at a high level also have to have certain morphological attributes depending on their playing position. Within a team these characteristics may vary considerably, making the sport of rugby unusual compared to other team sports, in which the players within a team are generally more similar in their characteristics. This variation also places unique challenges on the strength and conditioning trainer, particularly if the rules of the "specificity of training" are applied within each training session. For example, the physical demands of a prop forward are quite different to the demands of a scrumhalf and it is understandable that their training programmes need to be specifically adapted.

As discussed elsewhere, the reason for training is to induce physiological and morphological adaptations, which either are associated with an increased performance (through either increased muscle power, increased ability to resist fatigue or increased motor co-ordination) or with a reduction in the risk of injury. Although there is generally a positive relationship between training load and the physiological adaptations resulting in improvements in performance, the different aspects of fitness may adapt at different rates. Peak fitness for rugby is attained when there is synchrony between the fitness characteristics identified as being important for the demands of rugby. Whilst fitness will be compartmentalised in the following section for ease of discussion, it bears pointing out that all these aspects should be considered in context.

Strength

Muscle strength is defined as the ability to produce force. Whilst a minimal amount of strength is needed for normal daily activities, the demands of certain sports require well developed strength. In some sports, strength is needed just as a basic component of fitness, while in other sports (e.g. weightlifting) strength is the main outcome variable which determines success or failure in competition. Strength can be increased by systematic resistance training using either specially designed machines or free weights [44]. The manifestation of a player's strength depends on muscle morphology and the motor system [18]. Strength can be increased without any change in muscle size, but in these cases it is dependent on adaptations in the neural system [5]. Increases in strength are transferred to sporting performances in varying amounts. For example, a weight-training programme increased squat one-repetition maximum by 21% and this increase in strength was accompanied by improvements in vertical jump performance (21%) and sprinting speed (2.3%) [48].

Forwards, in particular, need strength and power for performance in the scrums, rucks and mauls. The forces produced during a vertical jump are related to forces produced during scrummaging [13].

Power

Muscle power, which is a function of the interaction between force of contraction and the speed of contraction, is associated with the explosiveness of the muscle. The relationship between force and speed of contraction and the subsequent point at which peak power occurs, varies between athletes [24]. For example, peak power occurs between 50% and 70% of the maximum weight which can be lifted for one repetition (1RM) for the squat and between 40% and 60% of 1RM for the bench press [43]. A fundamental way of increasing muscle power is to increase maximal strength, particularly in untrained players [44].

Speed

Speed consists of a number of components [7;8], all of which are independent qualities; namely acceleration speed, maximum speed and speed-endurance. Performance in the 10 m sprint is influenced by acceleration speed, while performance in the 40 m sprint is dependent on both acceleration speed and maximum speed [8]. Speed can be improved by increasing a player's power to weight ratio. Plyometric training (i.e. countermovement jumps or loaded squat jumps) is effective for improving speed [7], but the effectiveness of this depends on the state of training of the players.

Many of the short sprints in a rugby match do not produce the player's maximum speed, as it takes about 30 m to reach the maximum speed [16;46]. Sprinting activities in rugby have to be considered bearing in mind changing of direction, methods of carrying the ball, and strategies to avoid contact with the opposition players [16]. Attacking players often have to sprint while carrying a ball. This has the potential to reduce their arm drive, an important characteristic of sprinting. A study has shown that players can sprint fastest without the ball, while running with the ball under one arm is slower and running with the ball in both hands is the slowest [46]. The negative effect of slowing down while holding the ball in both hands, has to be weighed up against the advantages of being able to distribute the ball more efficiently when the need arises. All these aspects need to be considered during training and it is not only the player who can run fastest in a straight line who will have fully developed their sprinting advantage.

On average, forwards perform 13 ± 6 sprints per game, compared to be backline players (24 ± 7) [16]. The mean duration of sprints during a match for forwards was 2.5 ± 1.6 seconds compared to the 3.1 ± 1.6 seconds of the backline players. Seventy eight % of all the sprints during a match involved a change of direction [16]. It has been recommended that during training and conditioning, players should accelerate from both standing and moving starts, reaching speeds in excess of 90% of the peak running speed [16].

Lastly, track sprinting technique training is not ideal for rugby as this neglects the need of the players to change direction, carry a ball and prepare for contact [39].

Acceleration

As many of the sprints in a rugby match are shorter than the distance required to reach maximum speed, the ability to accelerate and cover short distances then becomes an important characteristic which distinguishes the proficiency levels of players. Acceleration into the contact zone, and running off a straight line have been identified as important characteristics of an effective ball-carrying performance [39;40]. Both these factors increase the unpredictability of the contact situation, putting more emphasis on the decision-making ability of the defender, and increasing the chance of an incorrect decision by the defender [40].

Muscle endurance

Muscle endurance is dependent on the muscle being able to contract repetitively without developing fatigue. A combination of muscle strength, metabolic characteristics and local circulation in the muscle influence the endurance characteristics. Several tests have been developed to measure muscle endurance. A feature of these tests is that they all monitor the ability of a specific muscle, or group of muscles, to contract repetitively. Examples of these tests are the number of push-ups and abdominal curls in a minute [21;41]. These tests lack specificity and do not differentiate the proficiency level of rugby players [13].

Repeat sprint

The ability to resist fatigue after repeated short-duration, high-intensity sprints is a fitness characteristic which is important for team sports such as soccer, rugby, football, basketball and netball, to name a few. Repeat sprint performance, and by implication fatigue resistance during intermittent, short-duration, high-intensity activities, can be improved by decreasing body mass, specifically body fat, and by increasing strength and muscular endurance, providing this does not result in an increase in body mass [12]. Training which results in improvements in agility and/or aerobic power may also improve the ability to resist fatigue during repeat sprint activities [12]. A field test has been developed to measure this component of fitness [2].

Motor co-ordination (skill)

Apart from the physical characteristics associated with success in rugby, performance also depends on skill, which is the combined interaction of agility, balance, co-ordination, power, speed and reaction time. Another aspect of skill which is difficult to define or measure is the ability of a player to make a strategic decision very quickly and with accuracy. The accuracy of this decision-making contributes to the success of the team. There are examples of players who seem gifted and on most occasions make the correct decision during matches, compared to their less "talented" team mates. Whilst motor co-ordination can be trained, the superior decision-making ability that some players have, and which make them appear more skilled, is probably an intrinsic characteristic rather than being a characteristic acquired by training.

Flexibility

Flexibility represents the range of motion specific to a joint. Flexibility can be dynamic or static. Dynamic flexibility involves the range of motion during movement of muscles around a joint whereas static flexibility defines the degree to which a joint can be passively moved through its full range of motion. Changes in flexibility occur after stretching exercises. Flexibility training is used in the warm-up before training or competition [(42)] and also with the goal of preventing injuries. Although there is theoretical evidence to support the positive link between stretching and lowered risk of musculoskeletal injuries during exercise, the clinical evidence is not so strong [(22)]. Specific joint angle can be measured, as a marker of flexibility for various joints, with a goniometer, or a Leighton flexometer [(26)]. A sit-and-reach field test has also been developed to measure the range of motion of the lower back and hamstring muscles.

Cardiovascular fitness

Cardiovascular fitness, also referred to as cardiovascular endurance or aerobic fitness, refers to the collective ability of the cardiovascular system to adjust to the physiological stress of exercise. Cardiovascular fitness is usually measured in the laboratory during a high-intensity exercise test to exhaustion with a mode of exercise which recruits a large muscle mass and with rhythmic muscle contractions (e.g. cycling, running, rowing). A feature of the test it that it should have a progressively increasing intensity, which continues until the player is exhausted. Oxygen consumption and carbon dioxide produced are measured continuously during the test. The oxygen consumption coinciding with exhaustion is called the maximum oxygen consumption (VO2max). An athlete who excels in an endurance sport generally has a high VO2max. Although endurance training increases the VO2max, and by implication the cardiovascular fitness, the increases are generally moderate (about 15%) [(49)] and are dependent on the level of fitness of the person at the start of the training programme.

A 20 m shuttle test has also been developed to predict cardiovascular fitness in a field setting [(25)]. In this field test, athletes run backwards and forwards between two beacons 20 m apart, maintaining a prescribed pace that gets faster and faster until the athlete is unable to maintain the pace. The stage coinciding with fatigue is directly proportional to VO2max. Although VO2max is not regarded as an important measure in rugby players, studies have shown that forwards have values ranging from 44 to 55 mlO2-1kg-1min-1 whereas backline players range from 47 to 60 mlO2-1kg-1min-1 [(13)].

Body composition

Body composition is defined by the proportions of fat, muscle and bone. Fat occurs beneath the skin and around the internal organs and is also found within tissue such as bone and muscle. Fat can be divided into non-essential and essential compartments. Fat tissue insulates and protects organs and is a storage form of energy and substrates for metabolism. Fat mass may vary from about 6 to 40% of body mass. Endurance athletes who perform at a high level have low levels of fat. Sumo wrestlers are examples of elite athletes who have a high fat content. Many sports have weight categories (e.g. boxing, judo, wrestling), and therefore the manipulation of body mass, in particular fat mass, becomes an important part of these athletes' preparation for competition (19). The body fat of elite rugby players ranges from about 8 to 17% (13). Forwards generally have a greater percentage of body fat than backline players, and it might also be said that as the proficiency level increases, the average percentage of body fat decreases (13). Body fat does not contribute to the generation of muscle power, and therefore excessive amounts of body fat will detract from sprinting ability.

Muscle mass can vary from about 40% (anorexic person) to 65% of body mass (e.g. a bodybuilder with hypertrophied muscle) (27). The main function of muscle, from a sport and exercise perspective, is to contract and generate force. Depending on the sport and the type of training, some muscle is adapted to contract several thousand times per training session without developing fatigue (e.g. endurance activity), whereas other muscle is adapted to generate high levels of power with only a few contractions (e.g. powerlifting, shot-put, weightlifting). This type of muscle fatigues rapidly.

Bone is a specialised type of connective tissue which is also dynamic and responds to stimuli by changing its shape and density, albeit at a much slower rate than fat and muscle tissue (6). Bone mass varies from 10 – 20% of total body mass.

SUMMARY

An important aspect of physical conditioning for rugby is the characteristic of "match fitness". This is the specific fitness acquired from playing matches on a regular basis and becoming adapted to contact. Whilst the physiological demands of matches can be simulated during practice, there are subtle aspects of playing a match that cannot be simulated in practice. These difficult-to-measure characteristics can only be developed from playing. There are no data, other than the experience of coaches and players, which defines how much contact a player needs to have before he is "match fit". This is an important question, as it has important spin-offs on performance and also for the risk of injury. As will be explained in the section on overtraining, there is a fine line between getting sufficient "game time" to develop "match fitness", and playing too much with insufficient time for recovery and regeneration. Another consideration for developing "match fitness" is that the risk of injury is always high during a match compared to a practice.

AUTHOR'S BIOGRAPHY

Mike Lambert is an Associate Professor in the MRC/UCT Research Unit for Exercise Science and Sports Medicine, Sports Science Institute of South Africa, and the Editor-in-Chief of the South African Journal of Sports Medicine.

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