A Framework for the Physical Development of Elite Rugby Union Players

Grant M. Duthie

Increased professionalism in rugby has resulted in national unions developing high-performance models for elite player development, of which physical preparation is an important component, to ensure success in future years. This article presents a 5-step framework for the physical preparation of elite players in a development program. Competition movement patterns and the physical profiles of elite players are used as the basis of the framework and reinforce the repeated high-intensity nature of Rugby Union. Physical profiling highlights a player’s strengths and weaknesses in the areas of strength, speed, endurance, and body composition. These qualities need to be managed with an understanding of their interaction. This framework should be implemented within the yearly plan to ensure that benefits are maximized from the training undertaken. The success of the framework in developing elite players’ progression can be evaluated using standardized physical, performance, and competency tests. Key Words: strength, speed, conditioning

Physical preparation is a full-time necessity for success in elite Rugby Union. Moreover, successful unions in the southern and northern hemispheres have established advanced systems for elite-player development typically involving a pathway of talent identification and development from junior to senior programs, comprehensive sports-science support, and innovative coaching. The purpose of this review is to outline a framework for the physical development of elite Rugby Union players that can be used for short- and long-term planning. The information presented is a contemporary interpretation of the current knowledge and future directions in the physical preparation of players for professional rugby.

Physical-Development Framework

Elite success is based on junior development pathways progressing to senior ranks and eventually international competition. In elite competition, there is the tendency to attribute success or failure to immediate or short-term factors including the quality and experience of the team, the availability and injury status of players, and the technical and tactical directions provided by the coach. The physical qualities of players, developed over several years of training and competition, also play an important role in success. The fine-tuning of physical qualities over previous...
seasons is the primary contributor to the current physical profile of a given group of players or an individual player.

Rugby is a highly demanding physical, tactical, and skill-based team sport. Accordingly, substantial resources and emphasis should be directed toward developing and maintaining physical-fitness qualities in players from an early age. Development programs for junior players are often based on the content and practices of elite senior players. The process of simply adopting a training method to prepare future high-performance athletes is a limiting approach. A structured pathway for rugby should entail the development of strength, power, speed, and endurance—all critical to the demands of competition—while also improving the functional capacity of the athletes. In comparison, elite senior players are looking to fine-tune the physical qualities developed over several years within an annual plan involving numerous competitions played at a highly intense level. Although junior players can follow this plan, long-term development requires the establishment of core physical qualities that can be fine-tuned at a later date.

Within the annual plan the season is divided into the preseason, in-season, and off-season phases, with weekly training microcycles involving the manipulation of training loads through the variables of intensity, duration, and frequency. Using a modification of the approaches previously outlined by Gambetta and Pyke, this review provides a framework for the development of physical attributes of elite junior rugby players. The first step in the framework is to collate and interpret knowledge regarding the physical demands of rugby (the sport) and of different positions in the team. An individual profile of each player (the athlete) is established to determine strengths and weaknesses. Once the physical qualities have been recognized the systems for improving individual strengths and weaknesses are developed, and the plan for integration of these systems is established. The outcome of the plan implemented requires regular evaluation and refinement.

**Step 1: The Sport**

Understanding the inherent movement patterns of competition and the related physical demands is critical in developing effective training programs. Evaluation in the field and in the laboratory of the functional capacities of rugby players from a range of ages, levels, and positions also provides information on the physical demands of competition. This has been complemented with video-based time–motion analysis, which is a moderately reliable method of detailing the work-to-rest ratios and total time, frequency, and mean duration of different activities. Collectively, these data illustrate the physical requirements of the game.

**Work Capacity**

Improved aerobic capacity will aid in recovery from high-intensity activity. Despite some inherent methodological limitations, time–motion analysis has repeatedly demonstrated that forwards perform more frequent work activities of longer duration than backs do. Most work periods for all players are less than 4 seconds in duration and rarely extend beyond ~15 seconds. High-intensity efforts can sometimes follow each other, resulting in dense phases of work. The average rest periods in competition are often exaggerated by long breaks in play that occur...
during penalty goals, conversion attempts, and stoppages for injuries. Rest periods are most likely to be 0 to 20 seconds for all players, with the exception of the outside backs, who usually have rest periods of over 100 seconds.  

**Speed**

Speed is fundamental to success in competitive Rugby Union, with backs being approximately 10% faster than forwards. During maximal straight-line sprinting there are 2 partially independent phases classified as initial acceleration and maximal velocity. The acceleration phase is often considered the most important aspect of speed for rugby players, primarily because the duration of sprints observed during competition is only ~3 seconds. It is important to recognize, however, that players accelerate from different starting positions and starting speeds rather than a stationary, standing start. Ideally, players will be exposed to some good speed work either in specific speed sessions or during team skills training. The ability to catch, pass, and run with the ball at speed is also a fundamental component, suggesting that these qualities should form 1 element of a speed-training program for rugby.

**Strength and Power**

Strength expressed in both absolute terms (regardless of body mass) and relative to body mass is critical to Rugby Union success. Strength and power qualities are necessary for improving running velocity, the ability to change direction, and the force produced in the scrum. Rugby Union competition involves a moderate amount of static exertion for the forwards (10% of total time) and backs (2%). This equates to ~70% and ~25% of the work performed by forwards and backs, respectively, during competition. The ability to apply substantial force is crucial in contact situations where forwards express strength in quasi-isometric-type contractions that are best developed using maximal strength training.

**Body Composition**

In Rugby Union, body size and composition play an important role in individual performance because muscle mass influences speed, power, and endurance. Consequently, the assessment of body fat is common in high-level rugby programs. Excessive body fat has a negative impact on performance for 2 main reasons. First, Newton’s second law \( a = F/m \) specifies that increases in fat mass \( m \) without an increase in muscle force \( F \) will reduce acceleration \( a \). Second, displacement of additional fat mass requires extra energy, which increases the relative physical cost of exercise. Therefore, excessive body fat has a negative influence on economy of movement and should be avoided, although some researchers have suggested that body fat acts as a protective buffer against physical force in contact situations.

**Training Implications**

Regardless of position, the development of anthropometric and physical qualities is fundamental to the progression of elite rugby players. The critical elements of improving the physical development of players are increasing work capacity;
improving strength, power, and speed; and optimizing body size and muscularity for specific positions. Following the well-accepted training principle of specificity and game requirements demonstrated in time–motion analysis, the physical preparation of players should revolve around repeated high-intensity work efforts (G.M. Duthie, D.B. Pyne, unpublished data, 2005).

A challenge for fitness trainers and conditioners is to develop a base of endurance or aerobic fitness, together with anaerobic qualities, such that players can attain and reproduce high levels of work output during repeated high-intensity efforts.

**Step 2: The Athlete**

Physical strengths and weaknesses are identified by profiling a player’s athletic status. Pyke introduced a model for presenting the strengths and weaknesses of Australian Rules footballers. Using a range of field tests, one can rate players on their performance and present the results graphically using a standardized $Z$ score, $Z = (x – \text{mean})/\text{SD}$, where $x$ is the player’s observed score, mean is the mean of the group, and SD is the between-players standard deviation. This method then provides a clear indication of how the player ranks against peers of the same level.

When the goal is success at an international level it is appropriate for individuals to be ranked against other elite performers in their respective playing positions in either the same team or level of competition. An example of using elite standardized scores to establish a player’s strengths and weaknesses is provided in Figure 1. The example provided is an elite junior back-row forward who is yet to achieve a high

![Figure 1](image_url) — An individual player’s athletic profile based on $Z$ scores calculated from the mean and SD of fitness-test scores of elite Rugby Union players. Adapted from Pyke.
level of lean mass; however, he has lower levels of body fat compared with the elite players, good initial acceleration, and an excellent endurance capacity based on estimated VO$_{2\text{max}}$. The weaknesses in the player’s profile are poor leg power and maximal velocity.

It is important to recognize that this assessment relates to physical qualities and does not consider the player’s skills. Furthermore, profiles must be used in an individual manner because there will always be exceptions when a player has modest physical qualities and trainability but excels at an elite level because of exceptional skill, playing experience, or motivation.

**Step 3: The System**

The system, in the context of the physical-development framework, refers to the various elements of the training program—work capacity, speed, strength, power, and recovery—and the plan refers to how these elements are integrated. The goal is to maximize performance at a future date while minimizing the risk of fatigue, injury, illness, and overtraining during the period leading up to competition. The training status of an athlete can also have a dramatic effect on improvements in physical qualities. The law of diminishing returns encompasses the idea that the rate of improvement in fitness is inversely proportional to the initial level of fitness.

The basic training principles of overload, specificity, reversibility, and progression should be implemented via a periodized approach through each phase of the season. In general, there is a progressive increase in training load during the preseason phase, maintenance of fitness during competition, and modified training during the off-season to minimize reversibility in fitness levels. The purpose of loading endurance, resistance, and speed training during the preseason period is to have players near peak condition at the start of the season. The density of training (or temporal alignment of training sessions during a given microcycle) should be managed carefully so that players train in an optimal physical state for the volume of work required. For example, weekly microcycles will vary in intensity and volume, and the overall workload generally increases from macrocycle to macrocycle during the preseason phase.

**Work Capacity**

Work capacity forms the foundation for other fitness qualities. Ideally, players will be exposed to an overload in terms of intensity, frequency, or volume of training to induce maximal adaptation. The increase in training load involves a sequential increase in frequency first, then volume or duration, and finally intensity. This approach should permit players to build fitness without increasing the risk of excessive fatigue, illness, and injury.

One limitation of performing frequent high-intensity training is the profound stress it places on the body. Effective recovery is required between training sessions, particularly in elite rugby, in which multiple sessions are often conducted within a day. Recovery encompasses the effective use of nutritional supplements to restore hydration and energy levels. Moreover, despite consistent evidence lacking on the efficacy of hot or cold baths and compression garments, these procedures are regularly used in the training of elite Rugby Union players. Glycolytic
adaptations result in rapid improvement in anaerobic activity during training. Improvements in anaerobic activity are lost very quickly, however, on cessation of training. Supplementary aerobic training can assist in recovery while inducing some physical adaptations. Cardiorespiratory adaptations take longer to occur and are given prominence in the preseason period, typically 8 to 12 weeks in duration. Excessive training volume at high intensity (maximal aerobic and anaerobic intensities) can lead to overtraining.

Speed
Improving speed requires a variety of methods including sprint drills, sprinting against resistance, weight training, plyometrics, and, most important, well-planned and executed short-interval sprint training. Regardless of the methods employed, it has been suggested that poor technique and lack of flexibility are major reasons for the lack of speed; many team-sport athletes have suitable maximal and reactive strength but are unable to show any substantial improvements in speed with training. Unfortunately, the ability to use these strength qualities in an efficient and functional running technique is often overlooked.

The frequency of the short sprints of approximately 3 seconds occurring in rugby competition suggests that acceleration should be the focus of speed development. Rapid acceleration requires excellent balance and spatial awareness, an emphasis on attaining high velocity quickly, and maximizing agility at speed. Despite acceleration predominating, there is also a need to develop maximal velocity so that a player has a higher endpoint of acceleration. Moreover, time–motion analysis has demonstrated that players regularly achieve more than 90% of maximal velocity during competition. The relative distribution of time spent on maximal velocity and acceleration should be similar for forwards and backs, but the backs should spend more absolute total time on improving sprinting speed.

Force production during the propulsive phase of sprinting is related to running velocity, so hip-extensor strength is a primary focus for developing running speed. One method employed to develop hip-extensor strength is resisted sprinting. Resisted sprinting decreases running velocity and therefore increases the opportunity to apply force based on the force–velocity relationship while also providing a greater kinesthetic feel of the correct sprint position. It has been recommended that the resistance (eg, sleds, parachutes, uphill running) should not decrease the runner’s speed by more than 10% because greater knee-extensor and reduced hip-extension activity are observed if speed decrements are too large. In the latter case, not only is the desired training effect not maximized but also excessive resistance might adversely affect technique.

Overall, a good speed program consists of structured exercises to improve the strength characteristics specific to sprinting and includes resistance training, plyometrics, and resisted sprinting; regular exposure to good sprint efforts with technical feedback; and isolated drills to enhance specific components of the sprinting technique.

Strength and Power
Irrespective of the methods used to develop strength, it is critical that the force developed can be applied in a sport-specific movement. It has been argued that
there is a need to train movements and not muscles; that is, rather than training individual muscles in isolation and breaking down the kinetic chain, training sport-specific movements under resistance integrates and improves the overall functionality of the kinetic chain. Therefore, the primary purpose of resistance training is to improve functionality of sporting movements. The degree of functionality during exercise remains debatable, with some suggesting that maximal strength should be developed in the gym, plyometrics and resisted sprinting used to enhance power, and assisted sprinting and sprinting used to improve speed. This theory is based on the difficulty of replicating the contraction type and speed of sprinting in a gym setting, therefore suggesting that the use of heavy-resistance exercises that do not mimic the movement pattern of the sport is purely to develop the ability of the neuromuscular system to develop force. These concepts underpin the contemporary approach with elite rugby players, who typically undertake a combination of gym- and field-based training to improve strength and power.

Supplementary resistance training is required to develop players’ functional strength to assist the application of force in a variety of directions. Additional exercises can be performed within a specific resistance training session or integrated into match-specific training. Exercises involving rotation, balance, and coordination all contribute to the development of general strength and power. Absorbing and applying force during jumping, plyometrics, medicine-ball exercises, and wrestling also improves a player’s general strength and power. Functional training should be performed regularly as part of the athlete’s resistance-training program, along with heavy-resistance training, so that the eventual outcome is a substantial improvement in strength, power, and speed.

Plyometric training requires special consideration in rugby training. It is a common modality employed to develop sport-specific strength and power but must be gradually introduced into the training program because of the high impact and loading experienced during the contact phase of the exercises, which is greatly magnified when considering the body mass of some rugby players. Generally, bilateral exercises involving extended ground-contact times can be used to introduce junior players to the concepts of plyometrics, with subsequent progression to unilateral exercises involving shorter contact times.

**Body Composition**

One primary goal of the physical preparation of Rugby Union players is to attain a high proportion of lean mass. Oftentimes players are in the difficult situation of simultaneously trying to decrease body fat and increase lean tissue. For example, a decrease in overall mass occurs for forwards during the preseason phase of training as they dramatically drop body-fat levels. The reduction in body fat is accompanied, however, by an increase in lean mass. Unfortunately, players prone to high body-fat levels tend to have substantial increases in body fat during lower levels of training, for example, in the off-season. Body-fat levels are decreased by a combination of higher energy expenditure in training and decreased caloric intake. Player education can assist to improve skills in maintaining low body-fat levels during the off-season, thus allowing the training in the following preseason to focus on the key aspects of strength, power, and speed development.
Step 4: The Plan

The wide variety of physical qualities required for Rugby Union underpins a challenging task in developing a plan for the physical preparation of elite players. The priorities for teams, positional groups, and individual players need to be established as prerequisites to a detailed prescription of a training program. Priorities should be based on the assessment of individual strengths and weaknesses, the timeframe for player development, and the annual requirements of a particular group or team.

An understanding of the rates of training adaptations is crucial when developing a physical-preparation framework for elite players. After a training session there is a range of acute physical responses, each following an individual time course. Initially, there is an “immediate” decrease in performance and lowering of work capacity related to acute fatigue. This is a temporary inability of players to express their true underlying capacities, and recovery occurs after rest. Unfortunately, this requires a less-than-optimal training load when players are expected to perform to their maximal potential at all times, thus promoting short-term performance at the expense of long-term development.

Recognizing the immediate decrease in performance and the influence it has on long-term development is crucial for future success. The cumulative effects of training are essential for an athlete’s long-term development and represent the summation of many training sessions or seasons. A long-term continuity of training ensures the development of training residuals, that is, the partial retention of physical qualities when training has ceased or is decreased in frequency, volume, or duration. In detraining, individuals with greater training residuals have slower rates of loss of physical capacity than athletes with smaller training residuals. In retraining, athletes with longer training histories regain physical qualities more quickly.

The overall level of physical fitness is a net effect of all the different training methods undertaken. Each individual element of the training program (eg, strength, speed, or endurance) results in a “partial” training effect. It is crucial to recognize responses to partial training loads and how they affect other fitness qualities and the overall fitness profile. For example, heavy endurance loads characterized by an extensive program of longer, slower running intervals or continuous running can limit maximal strength increases. Coaches must be aware of the possible lag in observable training effects for each training method and that a period of unloading or recovery is required before partial training effects are fully realized.

Long-term adaptations to different training elements also have different rates of gain and loss. Recognizing the time taken for adaptations to occur will help coaches develop a balanced training program in which loss of important physical qualities is less than the adaptations gained, so that overall physical quality is not compromised. The rate of adaptation is linked to both the acute loads placed on the body and the physical processes that are modified with training. In general, the rate of loss of adaptations mirrors the rate of gain, with the substantial loss of peak anaerobic metabolic productivity typically taking only days to weeks, compared with years for loss of maximal strength gains. Consequently, players need to be exposed to a variety of training methods over a long period of time, especially when the aim is to improve characteristics that take many years to develop. Throughout the annual training program it is important that the players’ qualities are not substantially diminished with detraining, so that a short phase of retraining can restore the previous physical state and provide a basis for further progression.
Step 5: Evaluation

One of the most important components for players’ long-term development is the evaluation of progress. Assessment, testing, or subjective evaluation of athletes can serve a variety of purposes such as monitoring long-term adaptations to training, determining the short-term impact of training interventions, selection of players, prescription of individualized programs, and prediction of performance outcomes. Evaluation is also required to monitor individual progress throughout the elite-player development pathway. Regardless of the testing protocols employed, player progress is best monitored by a valid and reliable testing system.

Table 1 outlines a proposed basic field-testing battery for high-level rugby to monitor long-term development of either an individual player or a team. The tests cover a range of physical capacities that can be assessed in isolation or combination. The testing provides an evaluation of body composition, speed, power, strength, and endurance.

### Table 1  Example of a Physical-Testing Battery Used for Australian Super 12 Rugby Union Players

<table>
<thead>
<tr>
<th>Physical capacity</th>
<th>Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropometry</td>
<td>Mass (kg)</td>
<td>Assessment of body mass can be used to monitor changes in lean tissue.²⁴</td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>Useful for assigning taller players to specialist positions.</td>
</tr>
<tr>
<td></td>
<td>Skinfold thickness (mm)</td>
<td>The assessment of body mass and skinfolds can provide a valid measure of body fat and lean mass.³⁸-⁴¹</td>
</tr>
<tr>
<td>Strength</td>
<td>Bench press (kg)</td>
<td>Upper body strength expressed in absolute terms and relative to body mass. Strength results should be allometrically scaled* to normalize for body mass.⁴²</td>
</tr>
<tr>
<td></td>
<td>Squat (kg)</td>
<td>Lower body strength expressed absolutely and relative to body mass.</td>
</tr>
</tbody>
</table>
| Power             | Vertical jump (cm)    | Expressed as the jump height, or taking account of body mass to calculate power: \[
|                   |                       | \begin{align*} \text{vertical jump (cm)} & \times 51.9 + \\
|                   |                       | \text{body mass (kg)} & \times 48.9 - 2007. \end{align*} \]⁴³ |
| Speed             | 40-m sprint (s)       | Pure straight-line speed. Split times taken every 10 m to allow the assessment of acceleration and maximal velocity.¹⁵ Wind readings should be taken when testing is performed outdoors and the speed adjusted appropriately.²⁴ The 10-m time might not be able to monitor worthwhile changes because of the proportionately larger error than in other distances. |
| Endurance         | Multistage shuttle run (level: shuttle) | The multistage shuttle run⁴⁵ involves deceleration and acceleration, which makes it more specific than continuous running tests. Alternatively, the Yo-Yo test⁴⁶ might be more specific to the work demands of team sports such as soccer, rugby, and basketball.⁴⁶,⁴⁷ Repeat sprint tests might also provide a more specific measure of competitive performance,⁴⁸ for example, 10- × 40-m sprints every 30 s. |

*\( S_n = S / m^b \) (muscle strength in kilograms/mass scaled allometrically to 0.67), where \( S_n \) = normalized strength, \( S \) = muscle strength (load lifted in kilograms), \( m \) = body mass (kg), and \( b \) = allometric parameter 0.67.
Conclusion

This framework for developing the physical qualities of elite Rugby Union players quantifies the physical demands of competitive rugby, assesses individual players’ strengths and weaknesses, uses training systems to improve performance, integrates specific training methods for each aspect of physical conditioning, and details methods for assessing individual players’ adaptations to the training.

References


