Physiological characteristics of junior and senior rugby league players

T J Gabbett

Objectives: To investigate the physiological characteristics of subelite junior and senior rugby league players and establish performance standards for these athletes.

Methods: A total of 159 junior (under 16, 15, 14, and 13, n = 88) and senior (first grade, second grade, and under 19, n = 71) rugby league players (forwards, n = 80, backs, n = 79), competing at a subelite level, underwent measurements of body mass, muscular power (vertical jump), speed (10 m, 20 m, and 40 m sprint), agility (Illinois agility run), and estimated maximal aerobic power (multistage fitness test). Data were also collected on match and training frequency and playing experience.

Results: There was a significant effect (p < 0.05) of age and playing level on playing experience, body mass, muscular power, speed, agility, and estimated maximal aerobic power, with the physiological capacities of players increasing as the playing level increased. Forwards were heavier than backs for all junior and senior teams. Forwards and backs had similar estimated maximal aerobic power, except for under 16 players, for whom significant (p < 0.05) differences were detected (mean (95% confidence intervals) 42.9 (40.1 to 45.7) vs 49.5 (46.4 to 52.6) ml/kg/min for forwards and backs respectively). Scores for speed, muscular power, and agility were not significantly different between forwards and backs for any of the junior or senior teams.

Conclusions: The results show that there is a progressive improvement in the physiological capacities of rugby league players as the playing level increases. These findings provide normative data and performance standards for subelite junior and senior rugby league players. Further studies on the sociological, physical, psychological, and personal predictors of talent in rugby league are warranted.

Rugby league is an international sport played at junior and senior levels by amateur, semi-professional, and professional competitors. The game is physically demanding requiring players to participate in frequent bouts of intense activity—for example, sprinting, physical collisions, and tackles—separated by short bouts of low intensity activity—for example, walking, jogging. As a result, rugby league players must draw upon several fitness components including muscular power, speed, agility, and aerobic power.

The physiological characteristics of professional rugby league players are well developed, with estimates of maximal aerobic power (V\textsubscript{O\text{\textsubscript{MAX}}}) reported to be in the range 48.6–62.6 ml/kg/min. Mean measurements of 10 m and 40 m speed of 1.71 seconds and 5.32 seconds have also been reported. Conversely, the physiological characteristics of amateur rugby league players are poorly developed, with a recent study showing that muscular power, speed, and estimated V\textsubscript{O\text{\textsubscript{MAX}}} were 20–42% poorer than previously reported for professional rugby league players. Interestingly, there is a progressive decline in the physiological capacities of professional, semi-professional, and amateur rugby league players, with estimated muscular power, speed, and V\textsubscript{O\text{\textsubscript{MAX}}} of semiprofessional rugby league players superior to amateur players but inferior to professional rugby league players. These findings suggest a relation between physical fitness and the playing level attained.

Before the age of 13, junior rugby league players compete under modified rules, with a reduced emphasis on physical collisions and increased emphasis on skill development. After the age of 13, the physiological demands placed on junior players are increased, with players required to compete under the same rules and regulations as senior players, with only slight variations in the duration of matches between junior (60 minutes) and senior (80 minutes) players. However, whereas the physiological characteristics of amateur, semi-professional, and professional rugby league players have been developed, no study has investigated the physiological profiles of junior rugby league players. In addition, no study has compared the physiological profiles of junior and senior rugby league players. With this in mind, the purpose of this study was to investigate the physiological characteristics of junior and senior rugby league players competing at the subelite level, and establish performance standards for these athletes.

METHODS

Subjects

A total of 159 healthy male subjects participated in the study. All subjects were registered players from the same subelite rugby league club, and were competing in the Gold Coast Junior Rugby League competition (Queensland Rugby League, Australia) or the Gold Coast Group 18 Senior Rugby League competition (New South Wales Country Rugby League, Australia). Subjects were participants in one of seven teams. Teams competing in the junior rugby league competition consisted of under 16, 15, 14, and 13 players (n = 88). Teams competing in the senior rugby league competition consisted of first grade, second grade, and under 19 players (n = 71). All teams were placed within the best four teams of their respective competitions at the time of the field testing. In addition, all teams but one (under 19) had reached the finals of their respective competitions in the previous season. All subjects received a clear explanation of the study, including the risks and benefits of participation, and written consent was obtained. Parental or guardian consent was obtained before junior players were permitted to participate. The Griffith University ethics committee approved all experimental procedures.
Sprint) was recorded for group 2. Group 3 performed the agility (vertical jump), while speed (10 m, 20 m, and 40 m sprint) measurement of body mass. Ad libitum fluid intake was permitted after the exercise for at least 48 hours before the field testing session as part of their team's physical conditioning programme. Players were requested to refrain from strenuous exercise for at least 48 hours before the field testing session and consume their normal pretraining diet before the testing session. At the beginning of the field testing session, body mass was recorded for all subjects using calibrated analogue scales (Seca, Hamburg, Germany). Scales were calibrated to the nearest 0.01 second, with the fastest value obtained from two trials used as the agility score. The intraclass correlation coefficient for test-retest reliability and technical error of measurement for the vertical jump test was 0.93 and 4.54% respectively.

Muscular power
Lower leg muscular power was evaluated by means of the vertical jump test. A board, covering a 150 cm vertical distance, was mounted to a wall during the vertical jump test. Subjects were requested to stand with their feet flat on the ground, extend one arm and hand, and mark with chalk the highest point reached. They were asked to hold the chalk between the tips of the index and middle fingers. Each subject was instructed to spring upward from a crouch position and touch the wall mounted board at the highest possible point. No specific instructions were given about the depth or speed of the countermovement. Vertical jump height was calculated as the distance from the highest point reached during standing and the highest point reached during the vertical jump. Vertical jump height was measured to the nearest 0.1 cm, with the highest value obtained from two trials used as the vertical jump score. The intraclass correlation coefficient for test-retest reliability and technical error of measurement for the vertical jump test was 0.93 and 4.54% respectively.

Speed
Running speed was evaluated from a 10 m, 20 m, and 40 m sprint using electronic timing gates (Speed Light model TB4, serial no 4921001; Southern Cross University Technical Services, Lismore, Australia). The timing gates were positioned 10, 20, and 40 m cross wind from a predetermined starting point. On the command “Go”, subjects sprinted from a standing start. They were instructed to run as quickly as possible along the 40 m distance. Speed was measured to the nearest 0.01 second, with the fastest value obtained from two trials used as the speed score. The intraclass correlation coefficient for test-retest reliability and technical error of measurement for the 10 m, 20 m, and 40 m sprint tests were 0.88, 0.89, and 0.92, and 2.07%, 1.52%, and 1.25% respectively.

Agility
Agility was assessed using the Illinois agility run. On the command “Go”, subjects sprinted 9 m, turned, and returned to the starting line. After returning to the starting line, they swerved in and out of four markers, completing two 9 m sprints to finish the agility course. Times were recorded using a hand held stopwatch to the nearest 0.01 second. The fastest value obtained from two trials was used as the agility score. The intraclass correlation coefficient for test-retest reliability and technical error of measurement for the Illinois agility run were 0.86 and 2.02% respectively.

**Table 2**

<table>
<thead>
<tr>
<th>Team</th>
<th>Matches played</th>
<th>Match duration</th>
<th>Training sessions a week</th>
<th>Training session duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First grade</td>
<td>8</td>
<td>76.3*</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Second grade</td>
<td>9</td>
<td>65.6*</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Under 19</td>
<td>10</td>
<td>60.0</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Under 16</td>
<td>7</td>
<td>60.0</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Under 15</td>
<td>7</td>
<td>60.0</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Under 14</td>
<td>8</td>
<td>60.0</td>
<td>2</td>
<td>70</td>
</tr>
<tr>
<td>Under 13</td>
<td>8</td>
<td>60.0</td>
<td>2</td>
<td>60</td>
</tr>
</tbody>
</table>

*At the time of the field testing, first grade players had competed in six 80 minute matches, one 70 minute match, and one 60 minute match. Second grade players had competed in five 70 minute matches and four 60 minute matches.
Table 3  Age, body mass, and playing experience of junior and senior rugby league forwards and backs

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Playing experience (years)</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forwards</td>
<td>Backs</td>
</tr>
<tr>
<td>First grade</td>
<td>25.1 (23.0 to 27.2)</td>
<td>23.4 (20.9 to 25.9)</td>
</tr>
<tr>
<td>Second grade</td>
<td>23.8 (22.0 to 25.6)</td>
<td>21.9 (19.5 to 24.3)</td>
</tr>
<tr>
<td>Under 19</td>
<td>17.8 (17.2 to 18.4)</td>
<td>17.3 (16.8 to 17.8)</td>
</tr>
<tr>
<td>Under 16</td>
<td>15.4 (15.1 to 15.7)</td>
<td>15.6 (15.3 to 15.9)</td>
</tr>
<tr>
<td>Under 15</td>
<td>14.5 (14.2 to 14.8)</td>
<td>14.6 (14.3 to 14.9)</td>
</tr>
<tr>
<td>Under 14</td>
<td>13.5 (13.0 to 14.0)</td>
<td>13.7 (13.4 to 14.0)</td>
</tr>
<tr>
<td>Under 13</td>
<td>12.5 (12.1 to 12.8)</td>
<td>12.3 (12.0 to 12.6)</td>
</tr>
</tbody>
</table>

Values are reported as means (95% CI). Significant team differences (p<0.05) between like superscripts. *Forwards significantly different (p<0.05) from backs. Forwards (n=80; first grade, n=11; second grade, n=16; under 19, n=10; under 16, n=12; under 15, n=11; under 14, n=7; under 13, n=13). Backs (n=79; first grade, n=9; second grade, n=13; under 19, n=12; under 16, n=9; under 15, n=12; under 14, n=10; under 13, n=14).

Table 4  Times for the 10 m, 20 m, and 40 m sprint for junior and senior rugby league forwards and backs

<table>
<thead>
<tr>
<th>Distance</th>
<th>Forwards</th>
<th>Backs</th>
<th>Forwards</th>
<th>Backs</th>
<th>Forwards</th>
<th>Backs</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m (s)</td>
<td>2.05 (2.00 to 2.10)</td>
<td>2.01 (1.97 to 2.05)</td>
<td>3.38 (3.28 to 3.48)</td>
<td>3.28 (3.18 to 3.38)</td>
<td>5.86 (5.76 to 5.96)</td>
<td>5.69 (5.58 to 5.80)</td>
</tr>
<tr>
<td>20 m (s)</td>
<td>2.14 (2.09 to 2.19)</td>
<td>2.10 (2.05 to 2.15)</td>
<td>3.50 (3.40 to 3.60)</td>
<td>3.40 (3.30 to 3.50)</td>
<td>6.09 (5.99 to 6.20)</td>
<td>5.90 (5.79 to 6.00)</td>
</tr>
<tr>
<td>40 m (s)</td>
<td>2.22 (2.17 to 2.27)</td>
<td>2.19 (2.15 to 2.24)</td>
<td>3.71 (3.61 to 3.81)</td>
<td>3.61 (3.51 to 3.71)</td>
<td>6.29 (6.19 to 6.39)</td>
<td>6.10 (5.99 to 6.20)</td>
</tr>
</tbody>
</table>

Values are reported as means (95% CI). Significant team differences (p<0.05) between like superscripts. Forwards (n=80; first grade, n=11; second grade, n=16; under 19, n=10; under 16, n=12; under 15, n=11; under 14, n=7; under 13, n=13). Backs (n=79; first grade, n=9; second grade, n=13; under 19, n=12; under 16, n=9; under 15, n=12; under 14, n=10; under 13, n=14).

Table 5  Vertical jump, agility, and estimated VO2MAX for junior and senior rugby league forwards and backs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Forwards</th>
<th>Backs</th>
<th>Forwards</th>
<th>Backs</th>
<th>Forwards</th>
<th>Backs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical jump (cm)</td>
<td>48.7 (42.1 to 55.3)</td>
<td>50.9 (47.5 to 54.3)</td>
<td>17.2 (16.6 to 17.8)</td>
<td>17.4 (16.7 to 18.1)</td>
<td>50.0 (47.6 to 52.4)</td>
<td>50.1 (47.4 to 52.8)</td>
</tr>
<tr>
<td>Agility (s)</td>
<td>41.0 (37.8 to 44.2)</td>
<td>42.9 (39.3 to 46.5)</td>
<td>18.1 (17.6 to 18.6)</td>
<td>17.7 (17.3 to 18.1)</td>
<td>45.5 (42.8 to 49.2)</td>
<td>45.0 (41.5 to 48.5)</td>
</tr>
<tr>
<td>VO2MAX (ml/kg/min)</td>
<td>37.9 (33.1 to 42.7)</td>
<td>40.0 (35.1 to 44.9)</td>
<td>18.3 (17.5 to 19.1)</td>
<td>17.9 (17.2 to 18.6)</td>
<td>43.9 (40.3 to 47.5)</td>
<td>46.1 (42.3 to 49.9)</td>
</tr>
</tbody>
</table>

Values are reported as means (95% CI). Significant team differences (p<0.05) between like superscripts. *Forwards significantly different (p<0.05) from backs. Forwards (n=80; first grade, n=11; second grade, n=16; under 19, n=10; under 16, n=12; under 15, n=11; under 14, n=7; under 13, n=13). Backs (n=79; first grade, n=9; second grade, n=13; under 19, n=12; under 16, n=9; under 15, n=12; under 14, n=10; under 13, n=14).
Ramsbottom et al. When compared with treadmill determined VO$_{2\text{MAX}}$, it has been shown that the multistage fitness test provides a valid estimate of VO$_{2\text{MAX}}$.

Table 6 shows the multiple logistic regression analysis that was developed to predict which players would be suitable as forwards or backs. Body mass and age were the only variables that contributed significantly ($p<0.05$) to the predictive model.

### Muscular power, speed, agility, and estimated VO$_{2\text{MAX}}$ of junior and senior players

Tables 4 and 5 show the mean (95% CI) results for muscular power (vertical jump), speed (10 m, 20 m, and 40 m), agility (Illinois agility run), and estimated VO$_{2\text{MAX}}$ tests (multistage fitness test), for junior and senior players. There was a significant effect ($p<0.05$) of age and playing level on muscular power, speed, agility, and estimated VO$_{2\text{MAX}}$, with the physiological capacities of players increasing as the playing level increased. Scores for vertical jump and agility were not significantly different between forwards and backs for any of the junior or senior teams. Although backs were faster than forwards during the 10 m, 20 m, and 40 m sprint, differences between forwards and backs were not significantly different for any of the teams tested. Under 16 backs had significantly higher ($p<0.05$) estimated VO$_{2\text{MAX}}$ than forwards.

### Multiple logistic regression analysis

Table 6 shows the multiple logistic regression analysis that was developed to predict which players would be suitable as forwards or backs. Body mass and age were the only variables that contributed significantly ($p<0.05$) to the predictive model.

### DISCUSSION

Although previous studies have investigated the physiological profiles of amateur, semiprofessional, and professional rugby league players, no study has investigated the physiological characteristics of junior and senior rugby league players competing at the subelite level. These results show that there is a progressive improvement in the physiological capacities of rugby league players as the playing level increases. Furthermore, they extend the findings from professional rugby league players by providing normative data and performance standards for subelite junior and senior rugby league players. Coaches and sports scientists may also use the present results as a tool for talent identification in rugby league. Although the physiological characteristics of these subjects provide performance standards to assist the identification of rugby league talent, several other factors—for example, sociological, physical, psychological, and personal—may also influence ability to play competitive team sport. These factors should be considered when developing talent identification programmes for rugby league. In addition, although playing performance may be related to the physiological capacities of players, improved fitness may not always equate to improved performance.
league talent should include a skills performance test that assesses a player's ability to use developed skills and make decisions under low pressure, high pressure, and fatigued situations. In this study, higher muscular power, agility, speed, and $V_{O2\max}$ were found in senior teams than junior teams. These findings are consistent with most previous studies on other team sports (such as Australian football, soccer, and field hockey) which have found higher physiological capacities as the playing level increased. However, although the different physiological capacities between junior and senior teams are consistent with findings from Australian football, soccer, and field hockey, most of the previous studies were conducted on elite athletes. As a result, the physiological capacities of the present sample of subelite junior and senior rugby league players are considerably lower than those from other team sports. In addition, the relative difference (24.0% to 40.3%) in muscular power, agility, speed, and $V_{O2\max}$ between the junior and senior teams of this study was considerably greater than previously reported for other team sport athletes (0.3% to 15.2%). The smaller relative differences in the physiological capacities of elite junior and senior Australian football, soccer, and field hockey players may reflect a greater access to specialised coaching and conditioning for both junior and senior competitors of these sports.

This study found a progressive improvement in agility, speed, muscular power, and $V_{O2\max}$ scores with increasing age and playing level. In addition, playing experience and body mass also progressively increased from junior players through to senior players. It is likely that the improvement in physiological capacities from junior to senior players reflects a normal adaptation associated with the onset of puberty and moderate increases in age. However, it is also possible that the progressive improvement in physiological capacities from under 13 players through to first grade players is due to the greater training load and higher playing intensity at the higher playing level. Indeed, the longer matches and training sessions (table 2) and higher match intensity experienced by senior players may explain, at least in part, their superior physiological capacities. The recent finding of no significant differences in preseason muscular power, agility, speed, and $V_{O2\max}$ scores between first grade and second grade players, despite considerable (2.7% to 18.4%) differences in these variables during the competitive phase of the season in the present study (tables 4 and 5), lends support to the hypothesis that the duration and intensity of matches has an important effect on the physiological capacities of rugby league players.

The subjects in this study trained for two days a week and played one 60 minute (under 13-under 19), 70 minute (second grade), or 80 minute (first grade) match every seven days. The training and match frequencies are similar to those of senior amateur rugby league players, but lower than those described for professional rugby league players. Although the physiological characteristics of the senior rugby league players in this study are lower than those of professional players, the present results are superior to those reported for amateur rugby league players. In addition, the speed, muscular power, and $V_{O2\max}$ results for the junior players are similar (under 14, under 15) or superior (under 16) to those reported for amateur rugby league players. Given the similar training and match frequencies of the present subjects and amateur rugby league players, the superior physiological characteristics of the present subjects are probably due to a higher intensity of training sessions and matches. However, given the relatively moderate—that is, two days a week—training frequency of the present participants, it is possible that elite—for example, representative—junior and senior players would have superior physiological characteristics to the present sample of subelite junior and senior players. Nevertheless, the present results could be used as a guide to objectively monitor improvements in the physical fitness of subelite junior and senior rugby league players.

Consistent with previous results from amateur, semiprofessional, and professional rugby league players, this study found higher body mass in forwards than backs. In addition, body mass was a significant predictor in correctly classifying players as either a forward or back. These findings emphasise the importance of large body size in dominating the ruck and tolerating the heavy tackles and collisions associated with forward positions. Of interest were the lack of consistent significant differences between forwards and backs for the 10 m, 20 m, and 40 m speed tests. Previous studies have reported similar 10 m sprint times between forwards and backs, with backs having significantly faster 20 m and 40 m speed than forwards. These findings are consistent with most previous studies on other team sports. In addition, the relative difference (24.0% to 40.3%) in muscular power, agility, speed, and $V_{O2\max}$ between the junior and senior teams of this study was considerably greater than previously reported for other team sport athletes (0.3% to 15.2%).

Take home message

This study found significant differences in the physiological capacities of subelite junior and senior rugby league players. These findings provide normative data and performance standards for rugby league forwards and backs competing at the subelite level.
greater speed, muscular power, and body mass of senior players would contribute to greater impact forces in tackles, and perhaps contribute to the higher injury rates of senior players. However, at present there is little scientific evidence to support the hypothesis that physiological capacities influence the injury rates of rugby league players. Clearly, further studies investigating the influence of physiological capacities on the incidence of injuries in junior and senior rugby league players are warranted.

Although body mass and age were the only variables to contribute to the classification of players into their correct position, it is possible that other physiological variables may have added to the predictive power of the logistic regression model. Strength, 11 phosphate recovery, 12 and flexibility11 are physiological parameters that have been identified as important qualities used by rugby league players. Furthermore, anthropometric measurements—for example, height, sum of skinfolds 13—may have provided a more complete description of the physical characteristics of the present sample of junior and senior rugby league players. However, although further field tests may have provided additional information on the physiological and anthropometric characteristics of junior and senior rugby league players, the time and personnel available limited the number of tests included in the field testing battery.

In conclusion, the results of this study show that there is a progressive improvement in the physiological capacities of rugby league players as the playing level increases. Furthermore, the findings provide normative data and performance standards for subelite junior and senior rugby league players. Further studies investigating the sociological, physical, psychological, and personal predictors of talent in rugby league are warranted.

REFERENCES
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