Physiological characteristics of junior elite and sub-elite rugby league players

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Title: Physiological characteristics of junior elite and sub-elite rugby league players
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ABSTRACT

While several studies have documented the physiological capacities of senior rugby league players, investigations of the physiological capacities of junior rugby league players are less common. The purpose of this study was to investigate the physiological capacities of junior rugby league players competing at the elite and sub-elite level, and establish performance standards for these athletes. Seventy-six junior sub-elite and 75 junior elite rugby league players participated in this study. Subjects were participants in one of three squads (Under 15, 16, and 17). All sub-elite players were registered with the same junior rugby league club. Elite players held scholarships with the Queensland Academy of Sport Rugby League program, with the majority of players either representing their region, state, or country in junior rugby league. Subjects underwent measurements of body mass, height, muscular power (vertical jump), speed (10m and 40m sprint), agility (505 test), and estimated maximal aerobic power (multi-stage fitness test) at the beginning of the competitive season. Differences in the physiological capacities among teams and playing level were analysed by comparing the true change in performance with the minimum clinically important difference for that variable. The body mass, speed, vertical jump, agility, and estimated maximal aerobic power of players increased with playing age and level. Elite players had significantly greater body mass (79.1 [76.5-81.6] kg vs 72.0 [69.3-74.6] kg), 10m speed (1.85 [1.83-1.88] s vs 2.15 [2.11-2.19] s), 40m speed (5.54 [5.47-5.61] s vs 6.11 [6.02-6.20] s), agility (2.41 [2.38-2.44] s vs 2.76 [2.68-2.84] s), vertical jump (52.7 [50.9-54.4] cm vs 39.5 [37.5-41.5] cm), and multi-stage fitness test results (10.9 [10.6-11.2] level, shuttle vs 9.0 [8.6-9.4] level, shuttle) than sub-elite players. This study found significant differences in the physiological characteristics of junior elite and sub-elite rugby league players. These findings provide normative data and performance standards for junior rugby league players competing at the elite and sub-elite level.

INTRODUCTION

Rugby league is a collision sport played at junior and senior levels by sub-elite and elite competitors. The game is physically demanding, requiring players to participate in frequent bouts of high intensity activity (e.g. sprinting, physical collisions, and tackles), separated by short bouts of low intensity activity (e.g. walking and jogging) (Brewer and Davis, 1995; Douge, 1987; Gibbs, 1993; Meir *et al.*, 1993, 2001a). Depending on the standard of competition, the mean intensity of rugby league matches is reported to be in the range of 78-87% of maximal heart rate, with mean blood lactate concentrations of 5.2-7.2 $mmol.l^{-1}$ being reported (Coutts *et al*, 2003; Estell *et al.*, 1996; Gabbett, 2003). As a result of the high physiological demands, rugby league players require well-developed muscular strength and power, speed, agility, and aerobic power (Meir, 1993; Meir *et al.*, 2001b; O'Connor, 1996).

Several studies have documented the physiological and anthropometric characteristics of senior rugby league players, with the fitness of players increasing as the playing level is increased (Brewer *et al.*, 1994; Gabbett, 2000; Gabbett, 2002ab; Meir *et al.*, 2001b; O'Connor, 1995, 1996). The physiological capacities of senior elite rugby league players are well developed, with estimates of maximal aerobic power reported to be in the range of 48.6-62.6 $ml.kg^{-1}.min^{-1}$ (Brewer *et al.*, 1994; Larder, 1992; O'Connor, 1996). Mean measurements of 10m and 40m speed of 1.71 seconds and 5.32 seconds have also been reported (Baker and Nance, 1999). Conversely, the physiological capacities of senior sub-elite rugby league players are poorly developed, with a recent study showing that muscular power, speed, and aerobic fitness were 20-42% poorer than previously reported for elite players (Gabbett, 2000). Collectively, these findings suggest a relation between physical fitness and the playing level attained.

While several studies have documented the physiological capacities of senior rugby league players, investigations of the physiological capacities of junior rugby league players are less common (Gabbett, 2002b). Gabbett (2002b) reported that the physiological capacities of junior sub-elite rugby league players progressively increased with playing age. However, while the physiological capacities of junior sub-elite rugby league players have been documented, no study has characterised the physiological capacities of junior elite rugby league players and developed performance standards for these athletes. In addition, no study has compared the physiological capacities of junior elite and sub-elite rugby league players. With this in mind, the purpose of this study was to investigate the physiological capacities of junior rugby league players competing at the elite and sub-elite level, and establish performance standards for these athletes.

2. METHODS

Seventy-six junior sub-elite and 75 junior elite rugby league players participated in this study. Subjects were participants in one of three squads (Under 15, 16, and 17). All sub-elite players were registered with the same junior rugby league club, and were competing in the Gold Coast Junior Rugby League competition (Queensland Rugby League, Australia). Elite players held scholarships with the Queensland Academy of Sport Rugby League program, with the majority of players either representing their region, state, or country in junior rugby league. All subjects performed fitness testing at the beginning of the competitive season as part of their respective training programs. Before participation, each subject successfully completed a thorough health risk screening process without any clinically significant findings

Fitness Testing Battery

Muscular power (vertical jump) (Ellis *et al.*, 2000), speed (10m, 20m, and 40m sprint) (Brewer *et al.*, 1994), agility (505 test) (Ellis *et al.*, 2000), and maximal aerobic power (multi-stage fitness test) (Australian Coaching Council, 1988) were the fitness tests selected. Data was also collected on the height, and body mass of subjects. Subjects were instructed to refrain from strenuous exercise for at least 48 hours prior to the fitness testing session and consume their normal pre-training diet prior to the testing session. Players performed two trials for the speed, agility, and vertical jump tests, with a recovery of approximately 3 minutes between trials. Players were encouraged to perform low intensity activities and stretches between trials. The field-testing session concluded with players performing the multi-stage fitness test (estimated maximal aerobic power).

Muscular Power

Leg muscular power was evaluated by means of the vertical jump test (Ellis *et al.*, 2000) using a Yardstick vertical jump device (Swift Performance Equipment, New South Wales, Australia). Players were requested to stand with feet flat on the ground, fully extend their arm and hand, and mark the standing reach height. After assuming a crouch position, each subject was instructed to spring upward and touch the Yardstick device at the highest possible point. No specific instructions were given regarding 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 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 typical error of measurement for the vertical jump test was 0.96 and 3.3%, respectively.

Speed

The running speed of players was evaluated with a 10m, 20m, and 40m sprint effort (Brewer *et al.*, 1994) using dual beam electronic timing gates (Swift Performance Equipment, New South Wales, Australia). The timing gates were positioned 10m, 20m, and 40m cross wind from a pre-determined starting point. Players were instructed to run as quickly as possible along the 40m distance from a standing start (Brewer *et al.*, 1994). Speed was measured to the nearest 0.01 s with the fastest value obtained from two trials used as the speed score. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the 10m, 20m, and 40 sprint tests were 0.95, 0.97, and 0.97, and 1.8%, 1.3%, and 1.2%, respectively.

Agility

The agility of players was evaluated using the 505 test (Ellis *et al.*, 2000) using dual beam electronic timing gates (Swift Performance Equipment, New South Wales, Australia). Two timing gates were placed 5m from a designated turning point. The players assumed a starting position 10m from the timing gates (and therefore 15m from the turning point). Players were instructed to accelerate as quickly as possible through the timing gates, pivot on the 15m line, and return as quickly as possible through the timing gates (See Figure 1). Agility times were measured to the nearest 0.01 s with the fastest value obtained from two trials used as the agility score. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the 505 test was 0.84 and 1.9%, respectively.

Maximal Aerobic Power

Maximal aerobic power was estimated using the multi-stage fitness test (Australian Coaching Council, 1988). Players were required to run back and forth (i.e. shuttle run) along a 20m track, keeping in time with a series of signals on a compact disk. The frequency of the audible signals (and hence, running speed) was progressively increased, until subjects reached volitional exhaustion. All players completed duplicate multi-stage fitness tests, performed one week apart, prior to the commencement of this study. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the multi-stage fitness test were 0.90 and 3.1%, respectively.

Statistical Analysis

Differences in the physiological capacities among squads and playing level were analysed by comparing the true change in performance with the minimum clinically important difference

(MCID) for that variable (Hopkins, 2002). The MCID was defined as the smallest worthwhile change perceived to be physiologically significant to the average athlete. The MCID for the vertical jump, 40m speed, agility, and multi-stage fitness tests was calculated as 1.5cm, 0.10s, 0.06s, and 2 levels, respectively. Data are reported as means and 95% confidence intervals (CI).

RESULTS

Height and Body Mass

There were no significant differences between elite and sub-elite players for height. In addition, there were no significant differences between Under 17 and Under 16 elite and sub-elite players for body mass. However, Under 15 elite and sub-elite players had significantly lower body mass than Under 16 elite and sub-elite players, with an 85-100% probability that the difference was clinically significant. Elite players had greater body mass than sub-elite players, with a 97-100% probability that the difference was clinically significant. Forwards had greater body mass than backs.

Muscular Power

The vertical jump height of players progressively increased as the playing age and level increased. There was a 59-96% probability that the difference in vertical jump between Under 17 elite and sub-elite players and Under 16 elite and sub-elite players was physiologically significant. In addition, there was a 73-88% probability that the difference in vertical jump between Under 16 elite and sub-elite players and Under 15 elite and sub-elite players was physiologically significant. Elite players had greater vertical jump results than sub-elite players, with a 100% probability that the difference was physiologically significant. Backs had higher vertical jump scores than forwards.

Speed

There were no significant differences between Under 17 and Under 16 elite and sub-elite players for 40m speed. However, Under 15 elite and sub-elite players had significantly lower speed than Under 16 elite and sub-elite players, with a 90-100% probability that the difference was physiologically significant. Elite players had greater 40m speed than sub-elite players, with a 100% probability that the difference was physiologically significant. Backs were faster than forwards over the 10m and 40m sprint.

Agility

There were no significant differences between Under 17, Under 16, and Under 15 elite and sub-elite players for agility. Elite players had greater agility than sub-elite players, with a 54-56% probability that the difference was physiologically significant. No significant differences existed between forwards and backs for agility.

Estimated Maximal Aerobic Power

There were no significant differences between Under 17 and Under 16 sub-elite players for the level achieved on the multi-stage fitness test. However, Under 15 sub-elite players reached a significantly lower level than Under 16 sub-elite players, with a 98% probability that the difference was physiologically significant. The aerobic fitness of elite players increased as the playing level increased with an 81-91% probability that differences amongst playing levels was physiologically significant. Elite players had a greater aerobic fitness than sub-elite players, with a 100% probability that the difference was physiologically significant. The level achieved on the multi-stage fitness test was higher in backs than forwards.

DISCUSSION

The present study is the first to investigate the physiological characteristics of junior elite and sub-elite rugby league players. This study found significant differences in the physiological characteristics of junior elite and sub-elite rugby league players, with body mass, speed, agility, vertical jump, and aerobic fitness increasing as the playing age and level increased. These findings provide normative data and performance standards for junior rugby league players competing at the elite and sub-elite level.

The 10m and 40m speed, agility, vertical jump, and aerobic fitness of the junior elite players in the present study were slightly lower than those reported for senior elite players (Brewer *et al.*, 1994; Meir *et al.*, 2001b; O'Connor, 1996). In addition, the physiological characteristics of the junior sub-elite players are consistent with those previously reported for junior sub-elite rugby league players (Gabbett, 2002b). These findings suggest that the present cohort was reasonably representative of junior elite and sub-elite rugby league players. Therefore, the results reported in this study provide normative data for junior elite and sub-elite rugby league players. Conditioning coaches may also use these results to design training programs to enhance player performance and develop realistic performance standards for elite and sub-elite rugby league players. In addition, these results may be used as a tool for talent identification in rugby league (Gabbett, 2002b).

The present study found greater speed, agility, vertical jump, and aerobic fitness in junior elite rugby league players in comparison to junior sub-elite rugby league players. These findings are in agreement with previous studies that found greater speed, vertical jump, and aerobic fitness in senior elite rugby league players than senior sub-elite rugby league players (Gabbett, 2002a). The 8-39% difference in physiological capacities between junior elite and sub-elite players in the present study is consistent with the 20-42% difference in physiological capacities between senior elite and sub-elite rugby league players (Gabbett, 2000). The finding of greater speed, agility, vertical jump, and aerobic fitness in junior elite rugby league players may reflect the higher intensity of elite level competition (Estell *et al.*, 1996; Gibbs, 1993; Gissane *et al.*, 1993; Stephenson *et al.*, 1996). Indeed, recent evidence has shown that the intensity of junior elite rugby league matches is 19.2% greater than sub-elite competition (Estell *et al.*, 1996; Gabbett, 2003). In addition, the poor aerobic fitness of sub-elite rugby league players has been attributed to a low training volume and intensity (Gabbett, 2000). To date, the intensity of training sessions has only been documented in sub-elite rugby league players, with heart rate and blood lactate concentrations during training reported to be similar to those recorded during competition (Gabbett, 2003). While these findings suggest a specific training stimulus to meet the physiological demands of sub-elite competition, it is unlikely that the training stimulus was adequate to induce significant peripheral and/or central adaptations to rival the aerobic fitness of elite level competitors.

The present study found greater body mass and speed in junior elite players in comparison to junior sub-elite players. The intensity of rugby league matches is increased through the large number of tackles and physical collisions between players (Meir, 1993; 2001a). The larger body mass and greater speed of junior elite players would assist in the development of greater impact forces in tackles and physical collisions. Equally, the greater muscular power in the junior elite players is likely to contribute to greater leg drive in tackles and greater play-the-ball speed. It has been demonstrated that physiological characteristics do not discriminate between first grade and second grade players in semi-professional rugby league (Gabbett, 2002a). These findings suggest that although playing performance may be related to the physiological capacities of players, improved fitness may not always equate to improved rugby league playing performance (Gabbett, 2001). However, the finding of higher speed, agility, vertical jump, and aerobic fitness in junior elite players of the present study suggest that improved fitness may be related to improved playing performance. Certainly, the present results demonstrate that measurements of body mass, speed, agility, vertical jump, and aerobic fitness discriminate between junior elite and sub-elite rugby league players.

Although only a select number of field tests were performed, the results of this study clearly demonstrate significant differences in speed, agility, vertical jump, and aerobic fitness of junior elite and sub-elite rugby league players. However, the measurement of additional physiological qualities, such as strength and repeated sprint ability may have provided a more comprehensive description of the physiological characteristics of junior elite and sub-elite rugby league players. While further field tests may have provided additional information on the physiological qualities of junior rugby league players, the time and personnel available and the coaching philosophies employed in the respective squads limited the number of tests included in the field testing battery. Clearly, further studies are required to completely determine the physiological, strength, and anthropometric qualities of junior rugby league players. Additional studies assessing the relationship between the skill and fitness of rugby league players, and changes in the physiological and anthropometric characteristics of rugby league players over the course of a season are also warranted.

In summary, this study found significant differences in physiological characteristics between junior elite and sub-elite rugby league players, with body mass, speed, agility, vertical jump, and aerobic fitness increasing as the playing age and level increased. These findings provide normative data and performance standards for junior rugby league players competing at the elite and sub-elite level.

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Figure 1. 505 agility test.

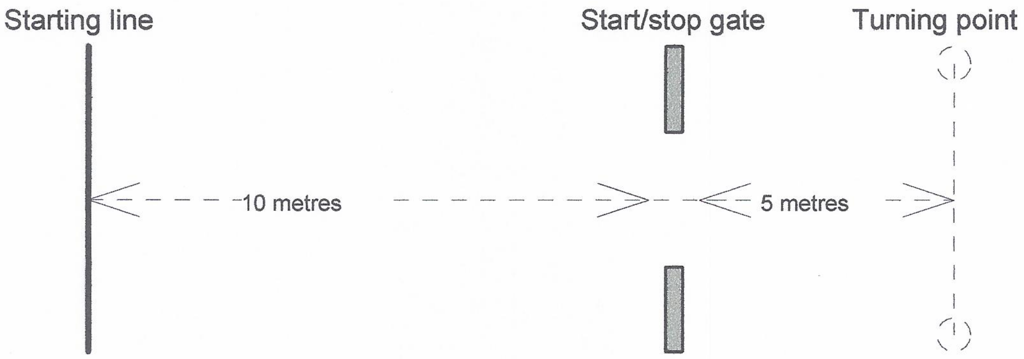

Table 1. Age, playing experience, and body mass of sub-elite and elite junior rugby league players.

	Under 17	Under 16	Under 15	Under 17	Under 16	Under 15
Age (yr)	16.9 (16.8-17.0)	15.6 (15.4-15.8)	14.5 (14.3-14.7)	16.8 (16.7-16.9)	15.8 (15.7-15.9)	14.3 (14.0-14.6)
Height (cm)	177 (174-179)	176 (172-180)	173 (169-177)	177 (173-181)	177 (175-179)	173 (170-176)
Body Mass (kg)	74.0 (70.0-77.9)	73.0 (68.3-77.8)	69.0 (64.2-73.8)	80.1 (74.5-85.6)	82.1 (77.9-86.3)	73.9 (68.4-79.3)

Data are reported as means (95% CI).

Table 2. Vertical jump, 10m, and 40m speed, and multi-stage fitness test results of sub-elite and elite junior rugby league players.

	Sub-Elite			Elite		
	Under 17	Under 16	Under 15	Under 17	Under 16	Under 15
10m (s)	2.08 (2.01-2.16)	2.15 (2.08-2.21)	2.23 (2.18-2.28)	1.83 (1.78-1.88)	1.81 (1.78-1.84)	1.89 (1.85-1.93)
40m (s)	5.92 (5.78-6.06)	6.01 (5.88-6.14)	6.41 (6.26-6.56)	5.46 (5.32-5.60)	5.42 (5.31-5.53)	5.65 (5.55-5.75)
Agility (s)	2.68 (2.60-2.76)	2.85 (2.80-2.90)	2.89 (2.85-2.93)	2.36 (2.28-2.44)	2.40 (2.35-2.45)	2.45 (2.41-2.49)
Vertical Jump (cm)	42.3 (38.5-46.2)	40.3 (37.0-43.6)	35.9 (33.0-38.9)	58.9 (55.1-62.7)	53.1 (49.5-56.7)	50.0 (48.1-51.9)
Multi-stage fitness test (level, shuttle)	9.5 (8.6-10.1)	9.4 (8.8-10.0)	8.0 (7.4-8.6)	12.3 (11.5-13.1)	11.3 (10.6-12.0)	10.6 (10.1-11.1)

Data are reported as means (95% CI).

Table 3. Height, body mass, vertical jump, 10m, and 40m speed, and multi-stage fitness test results of sub-elite and elite junior rugby league forwards and backs.

	Sub-Elite		3. *Elite*	
	Forwards	Backs	Forwards	Backs
Age (yr)	15.6 (15.3-15.9)	15.8 (15.5-16.1)	15.9 (15.6-16.2)	15.9 (15.6-16.1)
Height (cm)	175 (171-179)	173 (169-177)	179 (177-181)	173 (171-175)
Body Mass (kg)	78.1 (74.3-81.9)	66.5 (63.8-69.2)	85.4 (82.3-88.5)	73.3 (70.3-76.3)
10m (s)	2.19 (2.14-2.24)	2.12 (2.06-2.18)	1.88 (1.85-1.91)	1.82 (1.79-1.85)
40m (s)	6.25 (6.10-6.40)	5.98 (5.88-6.08)	5.64 (5.53-5.75)	5.45 (5.38-5.52)
Agility (s)	2.77 (2.72-2.82)	2.76 (2.61-2.91)	2.45 (2.41-2.49)	2.38 (2.34-2.42)
Vertical Jump (cm)	38.2 (35.2-41.2)	40.6 (38.0-43.2)	51.1 (48.9-53.3)	54.1 (51.5-56.7)
Multi-stage fitness test (level, shuttle)	8.5 (8.0-9.0)	9.5 (9.0-10.0)	10.6 (10.3-10.9)	11.1 (10.6-11.6)

Data are reported as means (95% CI).