Sports Science

Comparison of physical fitness and game demands between young female rugby sevens athletes in different sports development contexts

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Abstract - Aim: This study aimed to compare the physical and game demands among young women rugby sevens athletes inserted in a long-term athlete development process (LTAD) and selected to the national team. **Methods:** Twenty-four athletes were recruited in two different contexts: thirteen participants were inserted in the LTAD process (VSR) and eleven Brazilian athletes were selected for the youth national team (BRA). One-repetition-maximum tests, jumping performance, sprint times, and aerobic capacity determined the physical performance and GPS recorded the game demands in the national championship. T-tests for independent samples and Mann-Whitney were used to compare the groups, and effect size (ES) was presented using Cohen's d. **Results:** 10-m sprint time ($p = 0.001$; ES = 1.47), 30-m sprint time ($p = 0.005$; ES = 1.42), sprint distance ($p = 0.030$; ES = 1.14) and distance in zone 5 ($p = 0.040$; ES = 0.92) showed differences between groups, with better results in BRA. Moreover, VSR athletes covered greater distances in zone 1 while BRA had greater distances in zone 4, with moderate ES. The strength, power of lower limbs, and aerobic fitness variables did not present significant differences between the groups. However, VSR had the highest mean in squat jump and countermovement jump, with moderate ES. **Conclusion:** Speed in physical tests and game demands differentiated the groups, and these parameters are essential for selection for the national team. However, the LTAD process can bring physical fitness and time-motion performance closer to benchmark results for the female national youth rugby sevens team.

Keywords: athletic performance, women, movement, adolescent, rugby.

Introduction

Rugby sevens is a team sport that requires speed, strength, power, and aerobic capacity as fundamental physical abilities for performance in the game[1,2]. At large, previous investigations showed differences between competitive levels and age categories in physical fitness and running demands[2-5].

For instance, Sella et al.[2] observed that elite athletes cover greater total and relative distances, perform more sprints and accelerations, and present higher values of maximum speed than non-elite athletes. Furthermore, considering speed zones, differences were found between competitive levels in distance covered[3,4], but only small effect sizes (ES) were found in the comparison between adult and youth categories[5]. Despite the well-defined characteristics concerning game demands in rugby sevens, the results on young female athletes in the Brazilian context are still scarce in the literature.

The same pattern can be seen in regard to performance in physical tests. Regarding the 40 m sprint, previous results identified significantly better values in elite athletes compared to amateur athletes[2]. Australian rugby sevens players showed differences among youth, adult, and elite categories in 10 m sprint time, with moderate ES between categories, as well as in 40 m, with moderate ES between adult and juvenile and large ES between adult and elite[5].

The power of lower limbs was investigated through the vertical jump in Australian athletes of different categories, and moderate ES was observed in the comparison between adults and juveniles and small ES between adults and elite athletes[5]. In Brazil, young girls aged 14.1 ± 0.6 years participated in a 16-week intervention of regular rugby training and showed a significant improvement in squat jumping ($p = 0.018$) when compared to youths who did not perform the training[6]. These findings demonstrate that the power of lower limbs can be influenced by rugby training in development categories, indicating the importance of evaluation through jumps.

As for maximum strength, women's rugby sevens athletes showed an extremely large difference between the values of elite and amateur athletes in a one-repetition

maximum (1RM) bench press test. When observed in elite athletes, differences between forwards and backs are observed in 1RM bench press (moderate ES, Hedges' g = 0.99) and 1RM pull-up (large ES, Hedges' g = 1.34), but no differences were found in 1RM in the front squat (Hedges' g = 0.23)[2]. On the other hand, elite Canadian players did not obtain significant differences between positions in the front squat (p = 1.000), bench press (p = 0.559), and pull-up (p = 0.128)[7] as well as between Australian athletes with high and low accumulated game indexes[8].

Performance on the Yo-Yo Intermittent Recovery Fitness Test Level 1 (YOYOIR1) has been used to assess aerobic capacity in rugby sevens athletes[2]. Australian rugby sevens players from different categories had lower YOYO results for youth compared to the adult and elite categories, with moderate ES between adults and youth, and higher results in the elite category with large ES between adult and elite[5]. In addition, international-level Canadian athletes had significantly higher ($p < 0.01$) distance covered on the YOYOIR1 than developing athletes[4].

The long-term athlete development process (LTAD) has objectives according to progressive steps over time to achieve the best physical performance in a safe and efficient approach[9-11]. Despite the well-defined proposal on LTAD[12], studies that prove the effectiveness of the process are still scarce in the literature, given the complexity of investigating the performance of young athletes during a long-term process that is influenced by several intrinsic and extrinsic factors. Game demand and physical tests have been shown to be important factors for performance since they distinguish athletes of different levels. However, there is no evidence that this occurs in young female athletes. For this reason, the aim of this investigation was to investigate physical performance and game demands in young rugby sevens athletes inserted in the LTAD process and compare them with athletes selected to the Brazilian youth rugby sevens team.

Material and methods

Study design and sample

The cross-sectional study is an observational investigation of physical performance from tests and game demands through rugby sevens matches at the national level. This investigation was approved by the Ethics Committee in Research with Human Beings of the Federal University of Pelotas under protocol number 5,248,661.

The sample comprises twenty-four rugby athletes, divided between the group participating in the project for the development of long-term athletes, Vem Ser Rugby (VSR), and the group selected to represent the Brazilian youth rugby sevens team (BRA) (Table 1). The VSR routine had regular tactical-technical and physical training with three weekly sessions, while the BRA athletes performed three to five weekly sessions of tactical-technical and physical training in their respective rugby clubs. It should be noted that due to the covid-19 pandemic, athletes from both groups remained for approximately eighteen months (between March 2020 and September 2021) without competitions and specific rugby training. During this period, the athletes performed training at home to maintain their physical conditioning. The BRA athletes started systematic training with the Brazilian team's staff after the data collection of the present study. Therefore, the data from this study were not influenced by high-performance training for the BRA group. For both BRA and VSR groups, athletes who were absent on the day of collections and athletes who had injuries that prevented them from performing the assessments were excluded from the sample.

Table 1 - Sample characterization.

	VSR (n = 13)	BRA (n = 11)	All (n = 24)
Age (years)	16.92 ± 0.64	16.82 ± 0.41	16.88 ± 0.54
Experience (years)	2.69 ± 0.86	5.73 ± 2.94*	4,08 ± 2.55
Height (cm)	159.15 ± 6.99	162.75 ± 5.98	160.80 ± 6.66
Weight (kg)	59.78 ± 7.51	66.13 ± 18.77	62.69 ± 13.90

*Different from VSR (p = 0.007). VSR = Vem Ser Rugby group; BRA = Brazilian youth rugby team.

Vem Ser Rugby

VSR is a project that selects girls from public schools with high physical performance for rugby and offers them a training program based on the LTAD process. The selection is carried out from the application of tests related to physical fitness and identification of girls aged 13 to 15 years, who reach the 80th percentile of the database, referring to their age, lower limb power, linear speed, and change of direction speed[6]. The tactical-technical and physical training program has three weekly sessions, planned according to the following stages of the LTAD process: learn to train, train to train, and train to compete[10]. Within the stages, the sports development process involves teaching the game, developing and refining physical abilities, and tactical-technical skills.

Procedures

Physical fitness assessments were performed with appropriate clothing for sports. Field tests were carried out in cleats, on natural grass; strength tests were performed with suitable shoes, and jump tests were conducted with the athletes barefoot. A 10-min warm-up was performed for assessments with mobility exercises and general and specific muscle activation. To minimize the influence of one assessment on the other, the battery of tests will be divided into three days with 72 hours apart from any strenuous physical activity. On the first day, lower and

upper limb strength tests were performed. On the second day, lower limb power tests were performed, as well as linear and change of direction speed. On the third day, an aerobic fitness test was performed. In addition, the participants' menstrual cycle was monitored and all assessments were performed between the proliferative phase and the secretory phase to minimize performance loss due to the menstrual cycle[13]. The choice of tests was based on the physical testing manual proposed by Brazilian Rugby Confederation[14]. The game demands were carried out in a national championship.

Instruments

Two tests of one-repetition-maximum (1RM) were carried out to assess maximum strength: bench press test for upper limb strength and squat test for lower limb strength. The standardized protocol for testing was followed as recommended by a previous study with young people[15]. Thus, a progressive sequence was performed to measure 1RM, with a set of six repetitions with a light load, a set of three repetitions with a moderate load, and finally sets with a single repetition until reaching the load of 1RM. In addition, the trials were spaced by 2 min of recovery[15].

Linear velocity was evaluated through sprint time in 10 m and 30 m, recorded in seconds[16]. Two photocells (Multisprint, Hidrofit®) were positioned at the starting point and at 10 m and later at 30 m of the course to record the sprint time. Two attempts were made and the shortest sprint time in each of the two distances was considered.

The power of lower limbs was evaluated from the vertical jump height and horizontal jump distance. Three types of jumps were performed: squat jump (SJ), countermovement jump (CMJ), and standing long jump (SLJ). The athletes carried out three attempts for each jump, and the best performance was recorded, in centimeters (cm). The SJ and CMJ were performed on a contact mat (Jump System 1.0®, CEFISE, Nova Odessa, Brazil) with hands on the waist and feet parallel, while the SLJ was performed with the help of the upper limbs[17].

Considering the intermittent demand for rugby sevens and the high capacity of repeated high-intensity efforts, the Yo-Yo Intermittent Recovery Test Level 1 (YOYOIR1) was used to assess aerobic fitness[18]. The test started with a speed of 10 km/h, and ended when the athlete could not reach the distance of 20 m before the sound signal for two consecutive times. The total distance traveled to the last complete stage was recorded for analysis.

Game demands were monitored by a global positioning system (GPS) in rugby sevens matches of the Brazilian championship in the youth category under 18 years old held in 2021. The championship was composed of five teams of selected states in the category up to 18 years, and each team played four matches of rugby sevens. To analyze the demands of the game, we used the data that corresponded to the game with the longest participation of the athlete. To avoid biases in the mean of the variables, the individual data recorded for analysis corresponded to the athletes who played at least 50% of the total time of the match. As they did not meet this criterion, five athletes from the VSR and one athlete from the BRA were excluded from the analyses. The athletes wore a vest with a 10 Hz GPS (Playertek, Catapult, United States) attached to the posterior region of the chest. The variables analyzed were: total and per minute covered distance, total and per minute sprint distance, the number of total and per minute accelerations, and distance in the total and per minute speed zones. The speed zones correspond to: zone 1 = 0 - 4 km/h; zone 2 = 4.1 - 8 km/h, zone 3 = 8.1 - 14 km/h, zone 4 = 14.1 - 18 km/h; and zone 5 = above 18 km/h.

Data analysis

Data were considered normal after verification using the Shapiro-Wilk test, with the exception of total and per minute distances in zone 5. To compare the physical fitness between the athletes of the VSR and the BRA, the independent T-test was performed for parametric analysis and Mann-Whitney for nonparametric analysis. The effect size was added in the comparative analysis through Cohen's d, considering the following classification: trivial (up to 0.2), small (0.21 to 0.6), moderate (0.61 to 1.2), large (1.21 to 2.0), very large (2.1 to 4.0), and near perfect (above 4.0)[19].

Results

Table 2 presents the descriptive results and the comparison between the VSR and BRA groups in the variables related to physical fitness. The results showed significant differences between groups only in the 10 m and 30 m sprint velocity variables, both with large effect sizes.

Table 3 shows the game demands recorded by GPS in the national championship. The sprint time and sprint distance determined the difference between the groups. Although without significant differences, the VSR presented greater total and relative distance in zone 1 while the BRA showed greater total and relative distances covered in zone 4.

Discussion

This study analyzed and compared physical performance and game demands among young female rugby athletes inserted in different performance contexts: long-term athlete development programs and youth national teams. The results showed that, statistically, the athletes selected to compose the national rugby sevens team had higher sprint speed, as well as total and relative sprint distances and distance covered in zone 5. It is noteworthy that, considering the time of experience of athletes from the VSR

Table 2 - Descriptive results and comparison of physical performance of young rugby athletes in the VSR and BRA groups.

	VSR (n = 13)	BRA (n = 11)	p value	Effect size
Squat jump (cm)	31.34 ± 5.41	28.94 ± 3.66	0.225	-0.52$^{\#}$
Countermovement jump (cm)	32.12 ± 5.50	30.48 ± 4.69	0.447	-0.32$^{\#}$
Standing long jump (cm)	179.88 ± 15.15	189.55 ± 16.93	0.154	0.60$^{\#}$
10 m sprint (s)	2.02 ± 0.12	1.87 ± 0.08	0.001*	-1.47^{++}
30 m sprint (s)	5.06 ± 0.30	4.64 ± 0.29	0.005*	-1.42^{++}
YOYOIR1 (m)	400.00 ± 186.76	487.27 ± 156.79	0.249	0.51$^{\#}$
1RM Bench press test (kg)	45.08 ± 6.80	44.00 ± 8.19	0.727	-0.14$^{\$\$}$
1RM Squat test (kg)	80.02 ± 16.98	78.98 ± 18.79	0.894	-0.06$^{\$\$}$

*p ≤ 0.005. $^{\$}$Trivial; $^{\$\$}$Small; $^{++}$Large. YOYOIR1 = Intermittent Recovery Test Fitness Level 1; VSR = Vem Ser Rugby group; BRA = Brazilian youth rugby team.

Table 3 - Comparison of game demands means between VSR and BRA.

	VSR (n = 8)	BRA (n = 10)	p value	Effect size
Total distance (m)	1251.51 ± 285.77	1356.49 ± 120.32	0.306	0.48$^{\$\$}$
Sprint distance (m)	75.53 ± 49.46	138.05 ± 59.66	0.030*	1.14^{+}
Accelerations	9.00 ± 4.60	10.00 ± 3.09	0.589	0.26$^{\$\$}$
Distance in zone 1 (m)	210.03 ± 57.20	180.43 ± 34.45	0.192	-0.63^{+}
Distance in zone 2 (m)	603.62 ± 130.75	662.97 ± 81.54	0.255	0.54$^{\$\$}$
Distance in zone 3 (m)	362.34 ± 135.86	375.04 ± 111.87	0.830	0.10$^{\$\$}$
Distance in zone 4 (m)	74.46 ± 47.80	112.12 ± 37.58	0.079	0.88^{+}
Distance in zone 5 (m)	1.07 ± 2.02	25.93± 38.07	0.040$^{\#}$*	0.92^{+}
Distance per minute (m/min)	99.80 ± 8.67	106.41 ± 11.65	0.201	0.64^{+}
Sprint distance per minute (m/min)	6.11 ± 4.05	10.65 ± 4.21	0.034*	1.10^{+}
Accelerations per minute	0.70 ± 0.37	0.78 ± 0.22	0.594	0.26$^{\$\$}$
Zone 1 distance per minute (m/min)	16.81 ± 3.45	14.07 ± 2.22	0.058	-0.94^{+}
Zone 2 per minute (m·min^{-1})	48.41 ± 4.13	51.97 ± 6.60	0.203	0.65^{+}
Zone 3 distance per minute (m/min)	28.48 ± 7.33	29.73 ± 9.99	0.771	0.14$^{\$}$
Zone 4 distance per minute (m/min)	6.02 ± 3.92	8.61 ± 2.41	0.103	0.80^{+}
Zone 5 distance per minute (m/min)	0.09 ± 0.16	2.04 ± 2.81	0.101$^{\#}$	0.98^{+}

$^{\#}$Mann Whitney non-parametric analysis. *p < 0.05. $^{\$}$Trivial; $^{\$\$}$Small; $^{+}$Moderate. VSR = Vem Ser Rugby group; BRA = Brazilian youth rugby team.

and BRA (2.69 ± 0.86 years and 5.73 ± 2.94 years, respectively), the VSR methodology using the LTAD process can be an important strategy in approaching the physical performance of athletes selected for the national team. Recently, it was observed that the physical fitness behavior of female rugby athletes remains throughout the Train to Win stage (above 18 years), indicating that physical evolution takes place in earlier stages[20]. However, further investigations are needed to observe the effects of the LTAD process at different stages on sports performance in young female rugby sevens athletes.

The difference in sprint time performance between sex, positions, and competitive level (amateur and professional) in rugby players is consistent in the literature[21]. The literature review that compared professional and amateur adult female athletes identified a small ES (d = -0.25) in the 10 m sprint, and a large ES (d = -1.50) in the 40 m sprint[2]. In Australian rugby sevens players, differences were found in youth, adult, and elite categories in 10 m sprint time, with moderate ES between categories, as well as in 40 m, with moderate ES between adult and youth and large ES between adult and elite[5]. In the 30 m sprint, elite athletes showed 4.64 ± 0.19 s in backs and 4.74 ± 0.11 s in forwards[2], Australian athletes averaged 4.41 ± 0.13 s[8], while elite Japanese athletes had a mean of 4.69 ± 0.16 s[22]. The present study demonstrated that in the 10 m sprint test, athletes selected for the national team are similar to the results of elite athletes found in the literature, and have better results than VSR athletes. This difference can be explained by the cultural context and the demand for the modality. In the cultural aspect, the literature mostly presents results from athletes whose countries are among the best rugby teams in the world[2,23], while VSR athletes trained in a region of Brazil where the sport is poorly

developed. Furthermore, although BRA and VSR athletes are at the same national level, the group selected to represent the Brazilian team in international competition has well-developed characteristics related to the demands of the modality for high performance, such as linear speed.

Researchers observed that during the initial process of sports development in young people with high physical performance, rugby training seems to improve SJ performance[6], indicating that the power of lower limbs may be an important variable for young rugby athletes. Sella et al.[2] identified a small effect size (ES = 0.44) in vertical jump height and a trivial effect size in standing long jump (ES = 0.10) in elite athletes compared to amateur athletes. Also, a recent study observed that Brazilian Olympic rugby sevens athletes showed superior performance in SLJ (ES = 0.95), SJ (ES = 1.05), and CMJ (ES = 0.88) compared to non-Olympic athletes[24]. The present study did not identify differences between the BRA and VSR groups, but a small ES was observed with a higher mean in SLJ in the BRA, and higher means in SJ and CMJ in the VSR. The difference in SLJ can be explained by the correlation that exists between sprint speed and the power of lower limbs[25]. On the other hand, the fact that the BRA athletes had different training statuses among them and previous inexperience in the tests may have influenced the inferior performance of VSR in SJ and CMJ[26]. Therefore, the VSR athletes had the same strength and power training routine as well as periodically performing SJ and CMJ assessments. Despite the small effect size, the difference was not sufficient to identify significant differences between the groups. Furthermore, the literature needs investigations that present consistent results on the power of lower limbs in young female rugby sevens athletes.

Strength development in rugby sevens athletes offers a protective mechanism for injury risk as well as fatigue-induced performance reduction during repeated efforts[1]. Previous studies have found differences between competitive levels in the upper limb strength test[27]. However, a study with adolescents (boys = 14.48 ± 1.31 years; girls = 14.93 ± 2.76 years) did not identify differences in lower limb strength ($p = 0.164$; ES = 0.30) and upper limbs ($p = 0.729$; ES = -0.07)[28]. The maximum strength results in the present study observed that young female athletes do not have significant differences in either upper or lower limbs strength when compared between the BRA and VSR groups. Although the means are similar to those found in previous studies with young people[28,29], references to the maximum strength profile for young female rugby athletes are still scarce in the literature.

The aerobic capacity has been investigated from the YOYOIR1 determined mainly by the total distance covered. Adult female rugby sevens athletes have shown different results between elite and amateurs with large TE in YOYOIR1[2]. In addition, Australian rugby sevens players from different categories had moderate ES between adults and youth, and high ES between adults and elite athletes[5]. Furthermore, Canadian international and developmental level athletes showed significant differences ($p < 0.010$) between levels in the distance covered by the YOYOIR1[4]. In Brazil, Olympic and non-Olympic athletes were compared in terms of performance in the YOYOIR1, and it was identified that Olympic athletes covered a greater distance, with moderate ES[24]. The mean distance covered in previous studies was higher than those in the present study, in both VSR and BRA groups, probably due to the characteristics of the samples being of different training levels. In addition, unlike what was observed in previous studies, the groups are similar in the performance of YOYOIR1 because they are probably at the same national competitive level. Thus, the aerobic capacity of athletes participating in the LTAD process approaches their performance to the values found in athletes selected for the national team.

Considering the game demands evaluated by GPS, elite athletes cover greater total (extremely large ES) and relative distances (small ES), but forwards and backs seem to be similar in the variables related to game demands[2]. In Australian players, the total distance did not differ between youth, adult, and elite levels, but the relative distance showed moderate ES for the elite level[5]. In Canadian athletes, significant differences were observed either in total or relative distance between elite and developmental athletes[4]. The present study did not identify significant differences between the groups in total and relative distance covered, but identified small and moderate ES, respectively, with higher values for the BRA group. Despite this, the literature has not identified a relationship between distance covered and success in the game[8].

Regarding the speed-related game demands, the literature indicates that elite athletes perform more sprints (very large ES) and accelerations (moderate ES), as well as having higher maximum speed (moderate ES)[2]. In addition, differences between forwards and backs in sprint speed are observed[2,30,31]. In the present study, BRA athletes had significantly greater sprint distance than VSR athletes, indicating that this may be a determining factor in the call-up to the Brazilian rugby sevens team. It is also noteworthy that, although without significant differences, VSR athletes presented greater total (moderate ES) and relative distances in zone 1 (moderate ES), while BRA athletes presented greater total (moderate ES) and relative distances in zone 4 (moderate ES). These results demonstrate that athletes selected for the national team seek to maintain themselves at higher speeds in national matches. Likewise, a previous study observed that athletes from the Spanish national team cover greater distances in speed zones above 14.1 km/h than national-level athletes[3]. Therefore, the data from the present study reinforce the

literature on the importance of achieving greater displacement speeds during women's youth rugby sevens matches.

The results of this research show athletes and coaches the attributes that can be applied as parameters during the selection process for the national team, since it is solidly presented in the context of sports science that strength, speed, power, and aerobic capacity are important for rugby performance[1,2,6,7]. Thus, from a practical application perspective, it is possible that sports professionals can focus their efforts on specific points, optimizing the training process. Furthermore, although there are no differences between the BRA and VSR groups, it is worth mentioning that strength, lower limb power, and aerobic capacity, in addition to field performance, are essential during injury prevention, which leads to a lower number of absences.

This study has some important limitations: small sample size, use of time-movement data from only one match per athlete, and lack of information about the training routine of athletes in the BRA group. However, the sample is considered to be representative, since it had the participation of more than 90% of the population eligible for inclusion in the study. Also, to reduce this bias, we sought to insert in the data the event with the highest number of minutes played by the athletes, considering that the game demands with fewer minutes played may present underestimated values in the variables in question. With regard to the other limitations mentioned, future studies are essential to investigate the demands of play in a greater number of files collected in young female athletes, as well as to observe training methods and routines for young rugby sevens athletes in Brazil. Finally, understanding the strategies for the identification and development of female rugby athletes is essential to improve the national competitive level.

Conclusions

Young athletes who make up the national rugby sevens team presented similar strength, power of lower limbs, and aerobic capacity variables, but superior linear speed to athletes inserted in a long-term athlete development process. Still, in the game demands, the athletes of the national team also presented superior total and relative sprint distance. The results indicate that the LTAD process can enhance the development of the physical capacities of young rugby sevens athletes, but the displacement speed differentiates athletes from the national team.

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