Association between the intermittent recovery Yo-Yo test and a high-intensity intermittent exercise on Argentinian rugby players

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Summary

Introduction: Yo-Yo level 1 intermittent recovery test (YYrec-1) is widely used in team sports, as a measure of high intensity efforts ability. The objective of this study was to relate the performance in YYrec-1 and in an intermittent high intensity run to the fatigue, in amateur rugby players.

Material and method: 26 rugby players with an average 19,3±1,8 years old from the Unión Rugby de Cuyo league were measured 2 times. In the first session, anthropometric measures and YYrec-1 were taken. In the second, players performed a running change of direction protocol (10" work/10" pause) at 100% speed reached individually in YYrec-1 (Int-10x10). The subjects rested four day between both sessions.

Results: in the YYrec-1 final speed was 15,1±0,5 km•h-1 and the accumulated distance 1102,3±342,0 meters. The Int-10x10 results were: 39,6±18,6 repetitions, 1653,1±746,0 meters y 791,5±371,4 seconds. Correlations between YYrec-1 final speed and Int-10x10 variables were: r=0,32 with the accumulated repetitions, r=0,25 with the accumulated meters and r=0,32 with the accumulated time (sec). Correlations between accumulated meters in YYrec-1 and Int-10x10 were: r=0,20 for the accumulated repetitions, r=0,13 for the accumulated meters and r=0,20 for accumulated time.

Conclusion: In this group of amateur players, indicators of performance in YYrec-1 weren't related with indicators used for explain performance in Int-10x10 exercise.

Asociación entre el test Yo-Yo de recuperación intermitente y un ejercicio intermitente de alta intensidad en jugadores argentinos de rugby

Resumen

Introducción: El test Yo-Yo de recuperación intermitente nivel 1 (YYrec-1) es ampliamente utilizado en los deportes de conjunto, para medir la capacidad de repetir esfuerzos de alta intensidad. El objetivo de este estudio fue relacionar el rendimiento entre el YYrec-1 y una carrera intermitente de alta intensidad en jugadores amateur de rugby.

Material y método: 26 jugadores de rugby con una edad promedio 19,3±1,8 pertenecientes a la liga Unión Rugby de Cuyo fueron medidos en 2 sesiones. En la primera sesión se realizaron mediciones antropométricas y se aplicó el YYrec-1. En la segunda sesión realizaron carreras de 10 segundos con un cambio de dirección separadas por 10 segundos de pausa, al 100% de la velocidad individual hasta la fatiga (Int-10x10). Entre las sesiones hubo un descanso de cuatro días.

Resultados: en el YYrec-1 la velocidad obtenida fue 15,1±0,5 km•h⁻¹ y la distancia acumulada 1102,3±342,0 metros. En el Int-10x10 se obtuvo 39,6±18,6 repeticiones, 1653,1±746,0 metros y 791,5±371,4 segundos. Las correlaciones entre la velocidad alcanzada del YYrec-1 y las variables del Int-10x10 fueron; r=0,32 para las repeticiones acumuladas, r=0,25 para los metros acumulados y r=0,32 para el tiempo acumulado. Entre los metros acumulados del YYrec-1 y el Int-10x10 se obtuvo; r=0,20 para las repeticiones acumuladas, r=0,13 para los metros acumulados y r=0,20 para el tiempo acumulado.

Conclusión: En este grupo de jugadores *amateurs*, no se encontró relación entre las variables que explican el rendimiento en el YYrec-1, con las utilizadas para explicar el rendimiento en el Int-10x10.

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Introducción

Traditionally, physical coaches have used maximum oxygen consumption (VO_2max) to monitor the aerobic performance of their athletes[1]. This concept was later replaced by maximum aerobic speed (MAS) measured directly[2] or estimated from the final speed achieved (FSA) with an indirect field test[3, 4].

However, in team sports there is a strong trend towards assessing aerobic performance using an incremental and intermittent test with a rest, based on the 20m-SRT[5]. For example: interval shuttle run test[6], level 1 and 2 intermittent resistance Yo-Yo test, level 1 and 2 intermittent recovery Yo-Yo test[7,8], the 30-15 intermittent fitness test[9], the Carminatti test[10], FOOTEVAL test[11], 45-15 test[12], intermittent Andersen test[13], among others.

From the tests mentioned, in greater measures, literature recommends the level 1 intermittent recovery Yo-Yo test (YYrec-1)[14-22]. This test aims to measure the ability to repeat high-intensity intermittent efforts and/or the capacity to recover from this kind of exercise[14]. For this reason, its validity and applicability has been studied in various team sports; basketball[15,16], football[7,17], rugby union[18], rugby league[19], handball[20], Australian football[21], seven-aside rugby[22] among other team sports.

The validity of YYrec-1 is based on the association obtained between the metres accumulated in the YYrec-1 and the total match performance (total metres covered) and/or the metres covered at high intensity (races over 15.0 km•h^{-1})[14]. The relationships obtained are between r=0.70 and r=0.77 for football[14], r=0.88 for handball[20], and r=0.77 for basketball[15]. These studies assume that the gold method used to assess intermittent effort, is the performance obtained in one or various matches. This way of validating YYrec-1 means we can dispose of the traditional tests that estimated VO_2max and MAS.

On the other hand, other studies have obtained similar correlations using different, non-intermittent tests; Rampini *et al,* observed a correlation of r=0.65 in professional football players between the FSA and the UMTT and the metres covered at high intensity during the match (+14.4 km•h^{-1}), and r=0.64 with the metres covered at very high intensity (+19.8 km•h^{-1})[23]. Castagna *et al* (2010), applied the 20m-SRT and the YYrec-1 on elite football players, obtaining similar correlations to performance in a match; with r= 0.76 for the 20m-SRT and r= 0.74 for the YYrec-1[24]. Buchheit *et al,* applied the MAS-EVAL test on academy footballers and they found r=0.70 between the metres covered at extremely high intensity (+19.0 km•h^{-1}) and field MAS[25]. Swaby *et al*, applied a continuous test of 1,200 metres to professional rugby players and they obtained r=0.75 with the total distance of a rugby match[26].

As shown in mentioned studies, the performance obtained in any of the aerobic tests used, whether intermittent or not, is linked to performance in a match[14,20,22-26]. Therefore, if the strength of the YYrec-1 is associated to this paradigm, other tests, that are not intermittent in nature, should be considered and not assigned exclusively to the YYrec-1.

The study by Swaby[26] is the only study - for now - to associate match performance with an aerobic test. However, the study did not consider high intensity runs. To date, we have not found any studies that associate performance in a rugby match with the performance achieved in the YYrec-1. For this reason if the aim of the YYrec-1 is to find the subjects that tolerate high-intensity effort[14] the best, a simple way of checking this would be to link the YYrec-1 performance with an exercise in which the real capacity of tolerance to this type of effort can be counted, such as, for example; intermittent running protocol with intra-exertion rests, a commonly used method by team sport coaches[2-3]. Based on the above, this study aims to observe the relationship between the performance indicators achieved in the YYrec-1 and the capacity to perform during intermittent exertion till exhaustion (10 seconds of work with 10 seconds of rest) at 100% of the YYrec-1 speed, among 1st division amateur rugby players.

Material and method

Design and study sample

The study had a cross-cutting and non-probabilistic correlational design. The players were chosen for their availability. The assessments were performed at the club during normal training hours between 20:00 and 21:00 (evening), during the post-season phase (2 weeks after finishing the annual championship). Measurements were taken over 2 sessions. In the first session, anthropometric measurements were taken, and the YYrec-1 test was applied. In the second session, high-intensity intermittent exercise was applied (100% of the speed achieved in the YYrec-1) to exhaustion, with direction change (50% of the distance out and 50% of the distance back). There was a 4-day rest period between the 1st and 2nd sessions. In all the assessments, the subjects wore the same clothing (t-shirt and shorts) and footwear (boots). On-field assessments were carried out on a grass pitch. The subjects did not perform any exercise in the 48 hours prior to the tests.

Subjects

26 rugby players belonging to the Cuyo Rugby Union were recruited for this study. All the players were aged between 18 and 25 years. The following were excluded from the study: a) minors aged under 18 years, b) subjects with any kind of neuromuscular injury and/or cardiorespiratory disease, and c) less than 3 years of experience as a club player. Before signing the informed consent, the subjects were notified verbally and in writing about the procedures, the benefits and the risks of participating in this study.

Procedures

Anthropometrics: Body mass and standing height were measured. The measurements were carried out in accordance with the International Society for the Advancement of Kinanthropometry[27]. Body Mass Index (BMI) was calculated by dividing the subject's body weight by the height expressed in square metres.

Level 1 intermittent recovery Yo-Yo test (YYrec-1): This consists in running for as long as possible between two lines separated by 20 metres, out and back, with a 10-second pause every 40 metres. The running pace is marked by a beeping sound. The subject must step behind the 20 m line with one foot at the same time as the beep sounds. The test ends when the subject stops due to exhaustion or when he/she fails twice consecutively to step over the line before the beep sounds. The total distance covered is used to assess the subject's performance, despite the stage not being completed[14]. The final speed achieved (FSA) was also registered, even though the final stage had not been completed. Before starting the test, the subjects performed a 5-minute warm up, which consisted in joint mobility, and low-intensity running. All the players were familiarised with this test.

High-intensity intermittent exercise with 180º direction change (Int-10x10): the exercise consisted in running for 10 seconds with 1 direction change (5 seconds out, 5 seconds back) at 100% of the FSA of the YYrec-1, with a 10-second passive rest. The work-rest ratio was 1:1. The exercise was performed till exhaustion, determined in the following ways: a) when subjects stopped because they could no longer keep running, or b) because on two consecutive occasions they did not make the distance in time. The intensity used was the FSA of the final stage of the YYrec-1 (complete or incomplete)[14]. This work mode based on the YYrec-1 can be observed in various studies and trainers[28-30]. A beep was used to mark the work pace and rest. Each player had an individual track marked out with the corresponding distance. Example: for the subject that reached the speed of 15.0 km•h^{-1} in the YYrec-1, there is a corresponding 10-second run of 41.7 metres, in two stretches of 20.8 metres.

Statistical analysis

The data was analysed using the statistics package (SPSS) 22.0. Beforehand, the Kolmogorov-Smirnov test and the Levene test were performed to corroborate the presence of normality and homoscedasticity in the study sample. Next, descriptive statistics were applied to calculate the frequencies, average, standard deviation and confidence interval. To establish the statistically significant differences between the positions (forwards and backs), the ANOVA one-way parametric test was used for the YYrec-1. To establish the differences between the positions in the Int-10x10, the non-parametric Mann-Whitney U test was applied, as normality was not observed. The relationship between the YYrec-1 and the intermittent exercise was calculated using the Pearson correlation coefficient, with the following criteria: 0.1 very low; 0.1-0.3, low; 0.3-0.5, moderate; 0.5-0.7, good; 0.7-0.9, very good; and 0.9-1.0, perfect[31]. The Spearman Rho rank correlation coefficient was applied between the positions occupied by each player in each of the variables (YYrec-1 and Int-10x10). In all cases, an alpha level of $p<0.05$ was accepted.

Results

Table 1 describes the physical characteristics of the rugby players and the field test performances.

In the YYrec-1 the confidence interval was 14.9-15.3 km•h^{-1} for the speeds reached and 972-1,239 metres for the accumulated distances.

In the Int-10x10 the confidence interval was 33-46 for the repetitions achieved, 1,391-1,929 metres for the accumulated distance and 661-932 seconds for the accumulated time.

Table 1. Anthropometric and field values.

Variables	Average ± SD All (n= 26)	Average ± SD Backs (n= 13)	Average ± SD Forwards (n= 13)	p>
Descriptive data				
Age (years)	19.3 ± 1.8	19.6 ± 2.4	18.9 ± 0.9	Ns
Height (m)	1.74 ± 0.07	1.71 ± 0.07	1.77 ± 0.05	0.05
Body Mass (Kg)	72.5 ± 11.6	65.10 ± 8.04	80.1 ± 9.7	0.05
BMI (kg•m^2)	24.0 ± 3.4	22.3 ± 2.2	25.6 ± 3.6	0.05
YYrec-1				
Speed (km•h-1)	15.1 ± 0.5	15.5 ± 0.5	14.8 ± 0.4	0.001
Accumulated Distance (m)	1102.3 ± 342.0	1301.5 ± 290.1	903.1 ± 271.3	0.001
Intermittent exercise 10x10				
Repetitions (no.)	39 ± 18	32.1 ± 8	47 ± 23	Ns
Distance (m)	1653.1 ± 746.0	1383.8 ± 357.6	1922.5 ± 935.1	Ns
Time (s)	791 ± 371	643 ± 160	940 ± 462	Ns

p: significant differences between Backs and Forwards.
BMI: Body Mass Index.

Significant differences were observed between forwards and backs in height, body weight, BMI, speed achieved and accumulated distance in the YYrec-1 (p<0.05)

Table 2. Correlations obtained.

	Exercise Intermittent 10x10 (rep)	Exercise Intermittent 10x10 (m)	Exercise Intermittent 10x10 (s)
All (n= 26)			
YoYo rec-1 (km·h-1)	-0.32	-0.25	-0.32
YoYo rec-1 (m)	-0.20	-0.13	-0.20
Backs (n= 13)			
YoYo rec-1 (km·h^{-1})	0.28	0.38	0.28
YoYo rec-1 (m)	0.39	0.48*	0.39
Forwards (n= 13)			
YoYo rec-1 (km·h^{-1})	-0.30	-0.25	-0.30
YoYo rec-1 (m)	0.05	0.07	0.05

* p< 0.05 significant correlation.
rep: repetitions. m: metres. s: seconds

Differences were not observed in the amount of repetitions, the work time and the metres accumulated in the Int-10x10.

Table 2 displays the correlations obtained between the performance of the YYrec-1 and the Int-10x10. The correlations were not significant except when the analysis was performed separately by positions, in which the backs obtained a low but significant correlation between the metres covered in the YYrec-1 and in the Int-10x10.

The correlations obtained between the BMI and the YYrec-1 were as follows: r=0.43 for the speed of the YYrec-1, and r=0.40 for the metres accumulated. Between the BMI and the Int-10x10 they were: r=0.23 in the repetitions accumulated, r=0.19 for the metres accumulated, and r=0.23 for the time accumulated.

Figure 1 displays a dispersion graph with 3 axes. Axis "y" shows the metres accumulated in the Int-10x10. The double "x" axis shows the metres accumulated in the YYrec-1 and the speed of the stage to which it belongs. The dotted vertical lines describe the start of one stage and the end of the other. This double x axis was graphed with the aim of reflecting how in a single stage, the participants accumulate different metres, given that the YYrec-1 takes into account incomplete stages.

Figure 1. Relationship between the Int-10x10 and the YYrec-1. White circles: Forwards (n= 13). Black circles: Backs (n= 13).
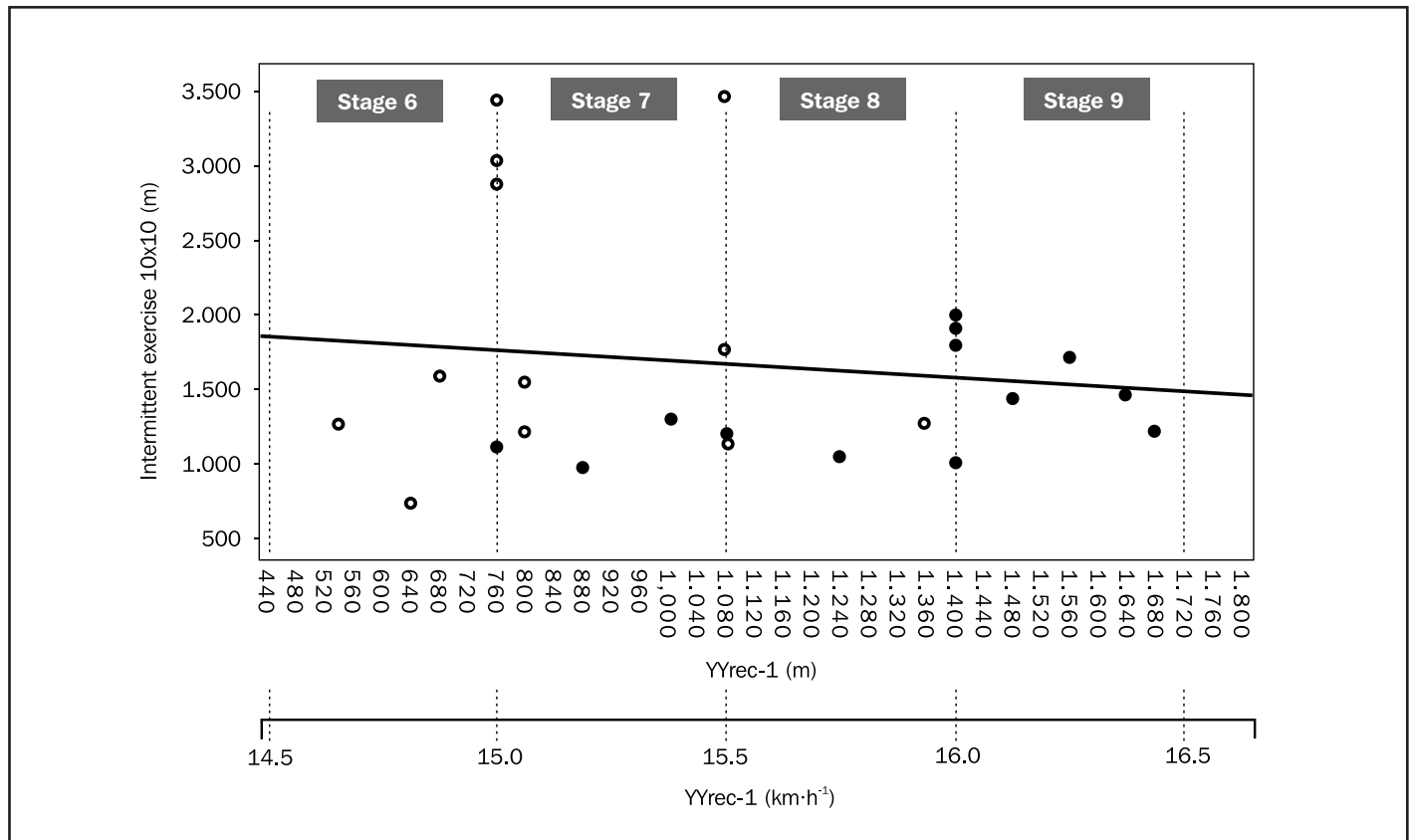
Table 3. Position of each player, depending on performance in the YYrec-1 and the Int-10x10.

Player	Position based on	
	YYrec-1 (m)	Int-10x10 (m)
1	15th	1st
2	23rd	2nd
3	21st	3rd
4	22nd	4th
5	5th	5th
6	6th	6th
7	8th	7th
8	9th	8th
9	13th	9th
10	3rd	10th
11	24th	11th
12	18th	12th
13	2nd	13th
14	4rd	14th
15	16th	15th
16	10th	16th
17	26th	17th
18	19th	18th
19	1st	19th
20	12th	10th
21	14th	21st
22	20th	22nd
23	11th	23rd
24	7th	24th
25	17th	25th
26	25th	26th

YYrec-1: Level 1 intermittent recovery Yo-Yo test. Int-10x10: non-linear intermittent exercise of 10 s of work and 10 s of rest. m: metres accumulated.
(Spearman's Rho = 0.03).

Discussion

The main study finding was the observation of a weak relationship between the YYrec-1 performance and performance of the Int-10x10 in this group of amateur rugby players. The subjects that accumulated greater distances in the YYrec-1 were not those that performed better in the Int-10x10 (Figure 1). Taking into account the objective proposed by Bangsbo[14], these results generate certain confusion; in theory the subjects who obtained the highest performance in the YYrec-1, should present a greater capacity in this kind of effort. To gauge a deeper understanding of this point of discussion, Table 3 displays all the cases ordered from highest to lowest performance achieved in the Int-10x10 (metres accumulated).

It can be observed that the player who accumulated the most metres in the Int-10x10 came in 15th place in the YYrec-1 (m). Likewise, the subject who performed the best in the YYrec-1 (m) came in 19th position in the Int-10x10. There may be various reasons behind this disparity between performance, mentioned below.

Greater dispersion was observed in the Int-10x10 values compared to those of the YYrec-1. This can be seen in Figure 1, in the confidence interval described. The physical conditions of the players can also influence the test performance. Various players could not complete the sixth stage of the YYrec-1 (Figure 2).

The first 5 stages are considered specific to the warm up, and from the sixth stage the test is started; accumulating 320 metres per stage (8 x 40 metres)[14]. Even so, these players could cover similar or greater distances in the Int-10x10, compared to other players that achieved higher stages in the YYrec-1. This can be seen in Figure 1. This disparity between performances in the two tests is due to the fact we are measuring and comparing two different concepts. YYrec-1 has the following characteristics: it is a progressive, maximum test, performed to exhaustion, with an out and back route of 20 metres (similar to 20 m-SRT), discontinuous (rest every 40 metres), and the speed increases every 320 metres (8x40 metres). In any case, it still remains a test that, given its protocol, is similar to aerobic power tests. For this reason, various studies have discovered similar correlations between performance in a match with other field tests like the YYrec-1[23-25]. Confusion occurs when Bangsbo expresses that YYrec-1 measures capacity[14]. By capacity we understand the total capacity of available energy in a metabolism given to a specific speed[32]. An example of this is the time limit, which measures the work capacity (aerobic resistance) to a percentage of the MAS continuously. First the MAS (incremental test) is located, then the time limit is measured (resistance test). Between these two variables (MAS and time limit), the correlations are moderate to weak[32]. The same occurs in our study; the YYrec-1 represents the incremental test, and the Int-10x10 represents the aerobic capacity to tolerate intermittent work, at a stable speed.

We were unable to find an identical study to ours in literature, applied to rugby players. In any case, there are two studies that we feel are worth discussing, as they share the same objective. Dupont et al, directly measured the aerobic performance of amateur footballers using a portable gas analyser, with two field tests; the UMTT and the YYrec-1[33]. Next, an intermittent running exercise was applied until exhaustion, which consisted in running in a straight line for 15 seconds with a 15 second rest (Int-15x15), at the same speed for all the footballers: 21.0 km•h[-1]. The authors discovered an r=0.76 between the MAS of the UMTT and the time accumulated in the Int-15x15 and r=0.74 between the speed of the YYrec-1 and the time accumulated in the Int-15x15. It was concluded that the speed of both tests was related to the performance of the Int-15x15. An incremental test (UMTT) or out and back with rests (YYrec-1) obtains the same degree of relationship as an Int-15x15. This observed relationship is due to the design used. In contrary to our study, the speed established in the Int-15x15 was the same for all the footballers (21.0 km•h[-1]), regardless of the speeds obtained in the tests. Among the players, this represented a percentage range of between 114 and 144% of the MAS of the UMTT, and a percentage range of 123 and 138% of the YYrec-1 speed. The faster the speed achieved by the players in the UMTT and/or YYrec-1 tests, the lower the intensity represented in the Int-15x15. For this reason, the players with the highest MAS benefitted during the Int-15x15, as speeds above 120% of the MAS

significantly compromised other energy substrates in producing energy[34]. The second study was applied to amateur and professional footballers[35]. The athletes were measured with the YYrec-1 and in an intermittent exercise of 10 seconds of work and 20 seconds of rest (Int-10x20) at the same intensity: 18.0 km•h[-1]. The authors found that the footballers that produced the most lactate during the Int-10x20, covered less distance in the YYrec-1 (r=0.81). Both in the Dupont[33] and Rampinini[35] studies, they associated performance in the YYrec-1 with high-intensity intermittent exercise, just as in our study, but on football players. We believe that this should also be considered when analysing the results. Unlike football, hockey or basketball, in rugby performance is closely linked to the number of contacts per match (tackles, rucks, mauls, scrums); they increase in amount and intensity depending on the position and level of play[36]. Therefore, not necessarily, the results found in this study should be similar to those found in other studies that used athletes that perform differently in the field. This is important to mention, as it is the first study to associate both tests using rugby players as the study subject.

With regards to positions, the differences found in the YYrec-1 performance between the positions coincide with other studies. Santana[18] and Nakamura[37] observed differences in the performance of the YYrec-1 between forwards and backs (Table 4). Furthermore, the performance in the YYrec-1 obtained in this study is only similar in one study[18] and is lower than a further 2 studies[36-37]. On a national level we were unable to find a published bibliography. For this reason, Table 4 only displays YYrec-1 performances of a single club from the province of Buenos Aires (Alumni Association), the current champions of the 2018 tournament of the URBA top 12 (personal communication). As it can be appreciated, performance is higher in the players in this study, in both positions. Even if the reality of the sample reflects the characteristics of the amateur league, the performances in the YYrec-1 are low compared to the studies mentioned.

Figure 2. Description of the YYrec-1 protocol and the performance achieved by the players.

Stage		Speed (km•h[-1])	Metres accumulated							
			1	2	3	4	5	6	7	8
W	1	10	40							
	2	12	80							
	3	13	120	160						
	4	13.5	200	240	280					
	5	14	320	360	400	440				
S	6	14.5	480	520	560	600	640	680	720	760
	7	15	800	840	880	920	960	1000	1040	1080
	8	15.5	1120	1160	1200	1240	1280	1320	1360	1400
	9	16	1440	1480	1520	1560	1600	1640	1680	1720
	10	16.5	1760	1800	1840	1880	1920	1960	2000	2040
	11	17	2080	2120	2160	2200	2240	2280	2320	2360
	12	17.5	2400	2440	2480	2520	2560	2600	2640	2680
	13	18	2720	2760	2800	2840	2880	2920	2960	3000
	14	18.5	3040	3080	3120	3160	3200	3240	3280	3320
	15	19	3360	3400	3440	3480	3529	3560	3600	3640

W: stages with the aim of warming up; S: stages where the test starts.

Table 4. Performance obtained in the YYrec-1 in different studies and superior studies.

Studies	n=	Level	Position	YY rec-1	
				(km•h[-1])	(m)
Pook P. [37]	3	Professional	McCaw R. *	19,0	3400
			Williams SN. *	19,0	3360
			Smitch C. *	19,0	3480
Arcuri CR. **	13	Amateur	1st lines	14,9±0,9	-
	7		2nd lines	15,5±1,4	-
	17		3rd lines	16,3±1,3	-
	4		½ Scrum	16,4±0,6	-
	6		Opening	16,3±1,3	-
	15		Centre	16,5±1,0	-
	8		Wing	16,6±1,6	-
	6		Full Back	16,0±1,2	-
Santana[18]	29	Amateur	All	15,4±1,2	972±394
			Forwards	14,9±0,9	792±277
			Backs	16,4±0,8	1283±312
Nakamura[38]	25	Professional	Forwards	-	1802±231
	17		Backs	-	2305±361
This study	26	Amateur	All	15,1±0,5	1102±342
	13		Forwards	14,8 ± 0,4	903 ± 271
	13		Backs	15,5 ± 0,5	1301 ± 290

*Rugby Elite Selection New Zealand (All Blacks).
** Superior Rugby Institution, Alumni Association Club Alumni, Top 12 URBA Tournament, Buenos Aires, Argentina (personal communication).

To conclude, certain limitations should have been considered, which we have observed throughout the study. Expanding the sample, taking into account the position of play. Measuring other physical condition components, which would enable us to explain the correlations found, such as, for example; strength levels (1RM) levels of muscle power (jumps with and without loads), speed (long sprints), acceleration (short sprints), body composition (muscle mass and adipose), agility (505 test, t-test), MAS (aerobic power), anaerobic reserve (difference between MAS and sprint speed), among others.

We conclude that in this group of players (amateur rugby), the performance achieved in the YYrec-1 is not related to performance in a high-intensity intermittent exercise with 10 seconds of work and 10 seconds of rest.

Practical applications

The YYrec-1 can be used to describe and categorise the rugby players. Furthermore, the speed of the YYrec-1 can be used to plan aerobic training sessions. On the other hand, if the sports coach is interested in measuring the work capacity during high-intensity effort (intermittent resistance), the protocol applied in this study could be used (Int-10x10) or another variation of it.

Conflict of interest

The authors claim to have no conflict of interest whatsoever.

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Campeón del Mundo en 20 km. marcha (Pekín, 2015)
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