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REPEAT JUMP ABILITY: PROPOSAL OF A NOVEL TEST TO ASSESS MAXIMAL POWER, MEAN POWER AND FATIGUE INDEX

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Abstract. The capacity to generate and maintain high power levels is relevant in both athletes and active people. A new test, *Repeat Jump Ability* (RJA), was proposed and analyzed to assess maximal power, mean power and fatigue index (FI) in active adults who do not practice competitive sport. Twenty-four volunteers (12 females, 12 males; age: 30.0 ± 7.2 years; mass: 71.5 ± 11.0 kg; height: 171.2 ± 10.4 cm) performed the Wingate, Repeat Sprint Ability (RSA), 30s countermovement jumps (T30s) and RJA tests. For each one, the IF was calculated; additionally, for the Wingate, T30s and RJA tests, the maximum and mean power was determined, while the maximum and mean velocity was determined for the RSA. The RJA results for each variable were correlated with the corresponding obtained for the other tests. An almost perfect correlation was observed for mean power between RJA and Wingate ($r = 0.91$) and between RJA and T30s ($r = 0.93$), and a very high correlation for mean performance between RJA and RSA ($r = 0.73$). For maximum performance, the correlation was very high between RJA and Wingate and between RJA and T30s ($r = 0.87$ and $r = 0.73$, respectively), and high between RJA and RSA ($r = 0.61$). For IF, the correlation was low ($r < 0.30$) in all cases. The RJA could provide a valid and accessible alternative for estimating maximum and mean power in active adults; its convenience would be an advantage over the other tests.

Keywords: Maximum power, mean power, fatigue index, vertical jumps, countermovement jumps.

REPEAT JUMP ABILITY: PROPUESTA DE UN NUEVO TEST PARA EVALUAR POTENCIA MÁXIMA, POTENCIA MEDIA E ÍNDICE DE FATIGA

Resumen. La capacidad para generar y mantener altos valores de potencia resulta relevante tanto en deportistas como en personas activas. Se propuso y analizó un nuevo test, *Repeat Jump Ability* (RJA), para evaluar potencia máxima, potencia media e índice de fatiga (IF) en adultos activos no deportistas. Veinticuatro voluntarios (12 mujeres, 12 varones; edad: 30,0 ± 7,2 años; masa: 71,5 ± 11,0 kg; altura: 171,2 ± 10,4 cm) realizaron los test de Wingate, Repeat Sprint Ability (RSA), 30s de saltos con contramovimiento (T30s) y RJA. Para cada uno se calculó el IF; adicionalmente para los test Wingate, T30s y RJA se determinó la potencia máxima y media, y para el RSA, la velocidad máxima y media. Los resultados del RJA para cada variable fueron correlacionados con los correspondientes de los demás test. Se observó una correlación casi perfecta para la potencia media entre RJA y Wingate (r = 0,91) y entre RJA y T30s (r = 0,93), y una correlación muy alta para el rendimiento medio entre RJA y RSA (r = 0,73). Para el rendimiento máximo, la correlación fue muy alta entre RJA y Wingate y entre RJA y T30s (r = 0,87 y r = 0,73, respectivamente), y alta entre RJA y RSA (r = 0,61). Para el IF, la correlación fue baja (r < 0,30) en todos los casos. El RJA podría constituir una alternativa válida y accesible para estimar la potencia máxima y media en adultos activos; su practicidad supondría una ventaja frente a los demás test.

Palabras clave: Potencia máxima, potencia media, índice de fatiga, saltos verticales, saltos con contramovimiento.

Introduction

Muscular power, in its various manifestations, as well as resistance to fatigue during high intensity efforts, are relevant factors for the analysis of the physical fitness profile, both in athletes and in active non-athletes (Jiménez et al., 2011; López and Fernández, 2022; Martínez, 2002). In the case of athletes, the evaluation of the ability to generate and maintain high power values provides information about their metabolic and neuromuscular characteristics, which is of value for the planning of specialized training and the implementation of optimal strategies in competition. On the other hand, in non-athletic individuals, it has been argued that the ability to generate power represents an important element of muscle fitness, which, in turn, is a crucial component of health-related fitness (Khawaja et al., 2019; Runge et al., 2004; Straight et al., 2015). This is particularly relevant in the elderly, where this ability can play a crucial role in preventing falls and promoting active and healthy aging.

In the field of sports performance, a variety of validated tests are available and frequently used by coaches to evaluate different indicators related to power capacity and fatigue resistance in trained athletes. However, given its characteristics (in terms of physical demand or equipment needed for its evaluation), its use is usually not appropriate for subjects with lower physical condition or fitness objectives.

Recently, our research group conducted a pilot study, in which the authors proposed a new test called Repeat Jump Ability (RJA), to estimate power and muscle fatigue variables (Basín et al., 2019). This study compared, in adult female volleyball players, the maximum power, average power and fatigue index estimated by means of the RJA vs. the Wingate test and the Repeat Sprint Ability (RSA), Campanna Sassi's protocol. The latter consists of performing six 40m sprints, with 20m round-trips, alternating 20s pauses between each sprint (Rampinini et al., 2007). Both tests have been validated and are widely used in sport. Regarding peak power, a very high positive correlation was observed between the RSA test and RJA (r = 0.79) and a moderate positive correlation between the Wingate test and RJA (r = 0.46). Regarding mean power, a very high positive correlation was observed between the RSA test and RJA (r = 0.86) and a high positive correlation between the Wingate test and RJA (r = 0.52).

Regarding the fatigue index, the correlation was low positive between the RSA test and RJA (r = 0.24) and moderate positive between the Wingate test and RJA (r = 0.39).

According to the authors of this study, the RJA would present advantages over the other two tests in terms of practicality and economy, requiring only one device to evaluate jump height, a reduced space and a single evaluator. In addition, the fact of requiring brief and intermittent efforts instead of a continuous effort (as in the case of the Wingate test), could provide information on differential physiological parameters, at the same time that it would be more accessible to people with lower physical condition.

However, and in spite of the possible advantages of the RJA test, the limitations of the aforementioned work (among them, a reduced sample of subjects, n = 10, and the lack of comparison with other jump tests), make that more studies in this sense are necessary. In addition, it is relevant to know if the results found by these authors are replicated in a sample of active subjects, but not athletes, and of both sexes.

For this purpose, the present work sought to determine the correlation between the maximum power, average power and fatigue index recorded by the RJA test, in comparison with those recorded by the Wingate test, RSA and the 30s countermovement jump test (T30s). The results of the present investigation could be a valuable contribution to the sports and fitness field. In this sense, they would provide important information when considering the use of the RJA as an alternative to estimate power variables and fatigability indicators in non-athletes. These data are valuable for coaches and professionals related to Physical Education and fitness, as they allow them to design more effective training programs to improve the performance of the analyzed variables.

Method

Methodological design

The study was carried out using a descriptive and cross-sectional design, employing a quantitative approach methodology. It was performed in full compliance with the principles of the Declaration of Helsinki and received the approval of the Ethics Committee of the Higher Institute of Physical Education of the University of the Republic (Resolution Nº13/2022).

Participants

Convenience sampling was performed, whereby 24 non-athletic active adult volunteers (12 females, 12 males; age = 30.0 ± 7.2 years; mass = 71.5 ± 11.0 kg; height = 171.2 ± 10.4 cm) were selected. Each of them was familiarized with the objectives of the study, where the formalities of the study were explained to them, and they were given an informed consent form, which they read and signed.

The inclusion criteria were: (i) to present a current physical fitness card or health card at the time of the evaluations; (ii) not to have had or have been suffering from any type of injury that could impair performance in some of the evaluations; iii) not to have made any intense physical effort unrelated to the study, at least 48 hours prior to the start of the evaluations and during the time the evaluations were carried out; iv) not to be a smoker or to have quit smoking in the last six months; v) not to consume any drug, stimulant or other substance that could affect the results; and vi) not to practice sports in a federated manner.

Procedures

The study was carried out in four instances, on four consecutive days, always in the morning and under similar conditions of temperature and humidity. The volunteers were previously informed about the objectives of the study and the protocols of the different tests to be carried out. The following instances were dedicated to carry out the corresponding evaluations, as described below.

First instance: First, the height and body mass of each participant were determined. For the former, a SECA 213 portable stadiometer (SECA, Germany), accurate to 1 mm, was used. Regarding the latter, an electronic balance Gama SCG-430 (GA.MA., Italy), with an accuracy of 100g, was used. In all cases, the protocols described by the International Society for the Advancement of Cineanthropometry (ISAK) were followed (Sirvent and Alvero, 2017).

Once these measurements were completed, the subjects performed the RJA test. Before starting, standardized warm-up exercises were performed, which included joint mobility of upper and lower limbs and brief stretching (less than 6s) in static position, with a total duration of 15min. This warm-up was repeated in all other instances under the same conditions. This was followed by a test series of five continuous jumps with countermovement, similar to those subsequently used in the RJA. This allowed for appropriate corrections to be made in terms of movement execution, as well as allowing the subjects to familiarize themselves with the gestures and equipment used.

Subsequently, a complete pause of 5 minutes was given and the test was performed using a contact mat (Projump Wireless, Evaluación Deportiva, Uruguay). Following the methodology described by Basín et al. (2019), the protocol implemented consisted of the execution of six blocks of five vertical jumps with countermovement, keeping the hands on the waist. These jumps were performed continuously and with maximum effort, making sure that the evaluee reached the maximum possible height in each jump and that the contact time with the surface after each fall was minimal. A passive recovery pause of 20 seconds was established between each block. Both the number of blocks and the duration of the pause were established similarly to the Repeat Sprint Ability (RSA) test. Similarly, for the RJA, the number of jumps in each block was set so that its average duration (approximately 8s) was similar to that of each sprint in the RSA test.

From the power value of each individual jump (data provided by the equipment software), the following parameters were calculated: the power of each block (obtained from the average of the five jumps), and particularly that of the block where the highest performance was observed (Pmax); the average power developed in the 6 blocks of jumps (Pmed); and the power of the block with the lowest performance (Pmin) for the calculation of the fatigue index (FI) or percentage of decrease, using the formula: IF (%) = (Pmax - Pmin) /Pmax x 100.

Second instance: the subjects performed the T30s test. The carpet used was the same as that described for the RJA test. To perform the test the subject stood on the carpet in an upright position with hands on the waist and eyes straight ahead. The subjects had to perform 30s of maximum vertical jumps. They were instructed to keep their trunk and lower limbs in an upright position and their hands on their waists during the flight phase. In the fall phase, they were asked to make the first contact with the mat with their feet in plantar flexion, cushioning the impact of the fall (Gutiérrez-Dávila et al., 2015). To calculate the maximum and minimum power, the total duration was divided into six intervals of 5s, and through the power value of each individual jump (data provided by the equipment software), the power of the jumps completed in each of them was averaged. The interval in which the highest power (Pmax) was obtained, usually the first or second, and in which the lowest power (Pmin) was obtained, usually the last, were considered. The average power (Pmed) was calculated from the average power of all jumps completed in the 30s. Analogously to what was done for the YOY, the FI or percentage decrease was calculated using the formula: IF (%) = (Pmax - Pmin) /Pmax x 100.

Third stage: in this stage, the RSA test was performed, according to Campanna Sassi's protocol (Rampinini et al., 2007). This test was held at the Darwin Piñeyrúa athletics track in the city of Montevideo, which has a tartan surface. To determine the distances established by the test protocol, tapes positioned on the track separated by a distance of 20m were used. A manual stopwatch (Casio, HS-80TW-1D) was used to measure the sprint times.

From the recorded values, the speed of each sprint was calculated in m/s, and the following parameters were obtained: maximum speed (vMax), minimum speed (vMin) and average speed (mean) of the six sprint (vMed). As in the case of the previous tests, the IF was calculated using the formula: IF (%) = (vMax - vMin) / vMax x 100.

Fourth instance: the subjects performed the Wingate test. Prior to the start of the session, the operation of the device was explained, the purpose of the measurements and indications on how to execute the pedaling were given. A Cyclus 2 cycloergometer (RBM elektronik-automation GmbH, Leipzig, Germany) was used, associated with the corresponding software (Wingate Anaerobic Test Software, Lode BV). In each case, the height of the seat was individualized according to the length of the subject's lower limbs, so that the upper part of the seat coincided with the maximum height of the iliac crest. Additionally, the device resistance was adjusted to 7.5% of body weight, according to the protocol described by Sands et al. (2004).

Prior to the test, the subjects performed three submaximal efforts of 15s to adapt to the pedaling gesture, interspersed by passive pauses of 1min. This was followed by a passive rest of at least one minute prior to the start of the test. When the subject expressed readiness, an auditory signal was given, after which he/she had to pedal as fast as possible for 30s, maintaining his/her maximum effort during that period. The participant was asked to try to reach the maximum acceleration in the shortest possible time.

To calculate the maximum and minimum power, the total duration (30s) was divided into 6 intervals of 5s, and through the value obtained in each millisecond (data provided by the equipment software), the power of each of them was averaged. The highest power interval (Pmax), usually the first, and the lowest power interval (Pmin), almost always the last, were considered. The mean power (Pmed) was calculated from the average power in the 30s. Analogously to what was done for the other tests, the IF was calculated using the formula: IF (%) = (Pmax - Pmin) /Pmax x 100.

Statistical analysis

Data are presented as mean ± SD. The normal distribution of the data was verified by means of the Kolmogorov-Smirnov test, and the homogeneity of variances by means of the Levene test.

Pearson's correlation coefficient (r) was used to examine the relationships between the indicators of maximum power, mean power and fatigue index for each of the tests. Prior to the application of this statistic, normality was verified using the Shapiro-Wilk test. In addition, the assumptions of linearity and absence of outliers required by the same were corroborated.

The strength of correlation was interpreted according to Hopkins et al. (2009), which establish as poor association values (positive or negative) equal to or less than 0.10; low association values between 0.11 and 0.30; moderate association values between 0.31 and 0.50; high association values between 0.51 and 0.70; very high association values between 0.71 and 0.90; and almost perfect association values equal to or greater than 0.91.

In all cases, a significance level of $p < 0.05$ was established. Statistical calculations were performed with the free software JASP (Version 0.16.4; JASP Team, 2022, University of Amsterdam).

Results

The 24 subjects that initially made up the sample participated satisfactorily in the four planned instances. Consequently, for the purposes of this study, data from the entire sample were considered.

Table 1 shows the results obtained from the Wingate, T30s, and RJA tests, in relation to the variables of average power, maximum power and fatigue index. In addition, the RSA test results for average speed, maximum speed and IF are shown.

Table 1
Results obtained from the Wingate, T30s, RJA and RSA tests.

	YAN (mean ± SD)	T30s (mean ± SD)	RSA (mean ± SD)	Wingate (mean ± SD)
Maximum yield	648,0 ± 282,3 (w)	676,3 ± 379,8 (w)	5.0 ± 0.4 (m/s)	615,6 ± 154,4 (w)
Average yield	610,4 ± 239,7 (w)	555,4 ± 329,6 (w)	4.7 ± 0.4 (m/s)	529,9 ± 129,1 (w)
Fatigue index (%)	21,0 ± 15,1	27,181 ± 15,1	7,6 ± 6,8	22,0 ± 5,7

Abbreviations: SD: standard deviation; Wingate: Wingate test; T30s: 30s jumps with countermovement; RSA: Repeat Sprint Ability test; RJA: Repeat Jump Ability test.

Table 2 shows the correlation values between the RJA test and the other tests analyzed.

Table 2
Pearson correlation values (r) between Wingate, T30s, RJA and RSA test results

	Maximum yield	Average yield	Fatigue index
RJA (w) vs Wingate (w)	0,87	0,91	0,26
RJA (w) vs T30s (w)	0,73	0,93	0,30
RJA (w) vs RSA (m/s)	0,61	0,73	0,19

Abbreviations: Wingate: Wingate test; T30s: 30s jump test with countermovement; RSA: Repeat Sprint Ability test; RJA: Repeat Jump Ability test.

Regarding the relationship between the RJA and Wingate tests, the correlation coefficient for mean power was r = 0.91, interpreted as an almost perfect correlation. In addition, for maximum power, a correlation of r = 0.87 was obtained, which was rated as very high. Finally, the correlation observed in relation to the FI was r = 0.26, interpreted as low.

Regarding the correlation between the RJA test and the T30s test for mean power, an r = 0.93 was obtained, interpreted as an almost perfect correlation. The maximum power between both tests presented an r = 0.73, considered a very high correlation, and as for the IF, an r = 0.30 was obtained, considered a low correlation.

Finally, for the correlation between the RJA and RSA tests, we considered the variables of average, maximum and IF performance. A very high correlation was obtained for average yield (r = 0.73), a high correlation for maximum yield (r = 0.61), and a low correlation for FI (r = 0.19).

Discussion

Muscle power and fatigue are variables of great importance, both in the field of competitive sport and for those who practice sport for recreational and *fitness* purposes. Regarding fatigue, this refers to a decrease in the maximum contraction capacity of skeletal muscle due to sustained effort, influenced by both central and peripheral factors, leading to a decrease in performance (Rosas et al., 2020). As far as muscle power is concerned, it acquires particular relevance in the field of performance sport (García-Manso and Valverde, 2015); although it has also been shown to have a significant impact on health as it is an integral element of the so-called *muscle fitness*. This aspect has been observed both in children and adolescents (Ortega et al., 2008; Steene-Johannessen et al., 2013), as well as in adult subjects (Khawaja et al., 2019), and becomes particularly relevant in elderly people (Runge et al., 2004; Straight et al., 2015).

The present study analyzed the correlation between indicator variables of maximum power, average power and FI obtained from a new test proposal (RJA) and their equivalent indicators in the Wingate, RSA and T30s tests, the latter being frequently used in the field of sport. A high to very high correlation was found for maximum power, a very high to near perfect correlation for average power, and a low correlation for IF. This last finding suggests that the neuro-physiological mechanisms that lead to fatigue in the RJA could be different from those that generate it in the other tests; which could in part be explained by the type of movement involved in the different tests (running, pedaling, jumping) with the concomitant difference in the muscle mass and biomechanics involved, and/or the effect of the pause periods (continuous vs. intermittent effort).

Correlation between RJA and Wingate tests

The Wingate anaerobic test is a supramaximal test developed in the 1970s. It has since been positioned worldwide as a valid and reliable test for the assessment of both power and muscular endurance and fatigue (Özkan et al., 2010). However, its execution requires extreme physical and even mental effort, which has led in recent years to a reduction in its use, even in highly trained athletes (Muriel et al., 2012).

In the work of Basín et al. (2019), the main antecedent of the present work, the authors found a moderate correlation between this test and the RJA in terms of IF and maximum power ($r = 0.39$ and $r = 0.46$, respectively), and a high correlation in terms of average power ($r = 0.52$). This does not agree with what was found in the present study (almost perfect correlation for medium power, very high for maximum power and low for IF).

It is important to mention that a Computrainer Pro model cycloergometer (Racermate Inc., Seattle, USA) was used in the aforementioned study, which does not allow adjusting the load according to the body weight of each participant. For that reason, the authors had to use the same resistance for all subjects. It should be noted that the Wingate test protocol establishes that the load should be adjusted according to the body weight of the person being tested (Inbar et al., 1996), something that was taken into consideration in the present study. We believe that this difference, at least in part, may explain the disparities in the results, the latter having provided a more accurate approximation to the objectives set.

Additionally, unlike the previously cited study, in which the authors examined a relatively small sample of federated volleyball players, this study included a sample composed of a larger number of participants. This provided a broader database for further analysis. It should also be noted that the participants in the present study, although physically active, did not play sports competitively, which may partly explain the weaker correlation found in relation to FI. Unlike the sample used in the aforementioned study, carried out with trained athletes, the participants in the present study could have had a lower tolerance to effort in a test with the characteristics of the Wingate test, which requires maximum and sustained effort.

In previous research, the correlation between the power estimated by means of the Wingate test and that estimated by means of a jump test had already been analyzed. In this context, a positive and significant correlation ($r = 0.446$, $p < 0.0001$) was found between peak power measured with the Wingate test and that measured with a bipodal horizontal jump test (Standing Broad Jump Test) in elite weightlifters, wrestlers and fencers (Krishnan et al., 2017). Likewise, a positive and significant correlation ($p < 0.05$) was observed between the flight time in the countermovement jump (CMJ) and the mean and maximum power obtained in the Wingate test in young adult cyclists with a high level of training (Muriel et al., 2012).

In another study conducted in adolescent and adult female volleyball players (Nikolaidis et al., 2016), the researchers analyzed the correlation between the maximum and mean power estimated through different jumping tests (squat jump, CMJ, Abalakov, Bosco 30-second jump test) and that estimated through the Wingate test. A positive and significant correlation ($p < 0.05$) was observed between the mean power estimated by the Bosco 30-second jump test and the Wingate test. A positive and significant correlation ($p < 0.05$) was also found between the mean and peak power estimated by the Wingate test and that estimated in each of the other jump tests mentioned.

It is relevant to highlight that, in all the mentioned cases, the correlation was higher in adult female athletes compared to juvenile female athletes. In particular, in this study it was found that the correlation between the Bosco 30-second jump test and the Wingate for mean power in adult female players ($r = 0.56$) was very similar to the correlation observed between the RJA test and the Wingate for the same variable in the work of Basín et al. (2019) ($r = 0.52$), who examined a sample of the same population. However, this correlation was lower than that found in the present study in non-athletic adults ($r = 0.91$), as mentioned above.

Another study (Sands et al., 2004) compared the performance in the Wingate test vs. consecutive jumps during 60s (according to Bosco's protocol) in adult athletes of both sexes. The authors found that the correlation in terms of performance in both tests was significantly higher ($p < 0.05$) in male athletes, but not in their female peers. A difference observed with respect to the present study is that in the latter, the analysis did not include a group differentiation according to biological sex. Another difference is determined by the sample, which, in the aforementioned study, corresponds to university track and field athletes. This could explain the choice of the tests used by these authors, since both tests are usually used in trained athletes.

In the present study, the jumping test used (RJA) presents characteristics that make it less demanding than the one used by Sands et al. (2004). Compared to the latter, the former would be more suitable for healthy non-athletes, due to its intermediate pauses and shorter duration of effort between rests. On the other hand, in the Bosco test, the jumps to be performed by the subjects are continuous during the 60s that the test lasts, and approximate knee flexion at 90° is required in the descent phase. In the RJA test, six blocks of five jumps with countermovement are performed, with passive pauses between the blocks and no strict requirement to reach the aforementioned flexion. Even with these differences, significant correlations can be observed in both studies in terms of average and maximum performance.

In sum, the findings of the present work, as well as the antecedents mentioned *ut supra*, would indicate that there is a high correlation between the power, both maximum and average, estimated by means of jumping tests (including the RJA) and the Wingate test, both for athletes and for active non-athletes.

Correlation between the RJA and RSA tests

With respect to these two variables, the results of the present study are similar to those reported by Balsalobre-Fernandez et al. (2015), who related the ability to repeat sprinting using the RAST (*Running-based Anaerobic Sprint Test*) and vertical jumps using the peak performance value in a CMJ. In both the RAST test (consisting of six 35m sprints executed at the maximum possible speed, with 10s of rest between each sprint) and the RSA, interval sprint efforts are performed. The main differences between the two are related to the route, the pause between each sprint and the blocks to be performed. According to the authors, the CMJ test was performed with a countermovement to 90° knee flexion, jumping as high as possible, repeated three times. On the other hand, and as mentioned, in the RJA test, six blocks of five jumps are performed with countermovement, without necessarily reaching this degree of flexion.

In this study, the authors observed a moderate positive correlation in the power produced in the RAST test and the CMJ test ($r = 0.419$, $p < 0.001$), indicating that performance in the latter would be associated with power production in the RAST. Additionally, the authors observed that subjects with lower FI on the RAST had lower loss of performance on the CMJ test.

As for the correlations reported in that study between average and maximum performance, they coincide with those found in the present study between the RSA and RJA tests. It is relevant to note that the protocol used in the RAST test is consistent with that of the RSA (Campanna Sassi protocol).

Correlation between RJA and T30s tests

Regarding this correlation, it is important to note that no precedents were found in the scientific literature reviewed on this subject, suggesting that this aspect may be a novel contribution of the present work. It is interesting to note that the most robust correlation between the two tests was observed for mean power. This implies that the YOR could be considered as a valid alternative to evaluate this parameter.

It should be noted that T30s requires continuous effort, which can potentially demand a greater use of the anaerobic glycolysis energy system. This implies that the individual performing this test must possess a certain level of physical fitness. In contrast, the characteristics of the RJA, which include passive intermediate pauses, would imply a greater involvement of the phosphocreatine system and the oxidative system. As previously mentioned, this may make the RJA more applicable for people with lower fitness levels.

Practical feasibility of the RJA

The characteristics of the RJA make it a versatile test that can be used in a wide variety of settings, regardless of spatial or sociocultural conditions. Its implementation is simple, since it does not require the presence of specialized technical personnel, nor a large space or expensive materials. Only a device is needed to measure the height of the jump, such as a contact mat, for example. If this tool is not available, there are applications available for cell phones and other mobile devices that provide a valid measure, making the test even more accessible. In addition, these materials are easy to transport and the time required to complete the test generally does not exceed 20 minutes, including the warm-up phase.

RJA and the description of the fitness profile

One of the objectives of the study was to contribute to the description of the physical fitness profile of the participants, through the evaluation of capacities that reflect maximum power, average power and Fatigue Index (FI), as well as the analysis of correlations with other tests. This information is valuable for defining the physical condition of each individual, regardless of whether they are athletes or not, and for designing personalized training programs.

It is recognized that muscle power plays an important role not only in the context of sports performance, but also in the field of health-related fitness, as pointed out by Balsalobre-Fernandez et al. (2012) and Izquierdo et al. (2015), among other authors. Therefore, power assessment and training are relevant for both athletes and people who exercise with the aim of maintaining and improving their physical condition and health.

In sum, we think that the RJA could have the potential to become a useful tool to contribute to the description and evaluation of the fitness profile of individuals.

Limitations and future possibilities for intervention

The present work had limitations. Among them, we mention the limited previous experience of the subjects who participated in the study with regard to the different tests performed. Additionally, in reference to the RSA test, it would have been desirable to use photoelectric cells or similar devices for data collection, thus improving the accuracy in determining the speed of each sprint.

As a suggestion for future research, we propose to carry out similar studies, but considering different populations, such as boys, girls and adolescents, as well as exploring differences between biological sexes and comparing athletes from different disciplines. This would provide a more complete and specific understanding of the behavior of the variables analyzed in various groups and contexts.

In addition, it would be interesting to incorporate other analyses, such as the determination of blood lactate, the non-invasive measurement of muscle oxygenation through oximetry, and the evaluation of muscle fatigue through techniques such as tensiomyography and/or electromyography, among others. These complementary methods could provide additional insight and enrich the understanding of the results obtained.

Given the intermittent nature of the RJA, we hypothesized that, compared to continuous tests such as the Wingate test or the T30s, a lower contribution of anaerobic glycolysis metabolism would be observed in the RJA, in favor of a greater participation of phosphocreatine metabolism and oxidative metabolism. Studies incorporating these measurements could help to clarify this hypothesis.

Conclusions

The results of this study suggest that the RJA could be a practical and accessible tool for estimating peak and mean power in active adults of both sexes. This could represent a valuable contribution to the *fitness* field. Further studies are needed to confirm these findings.

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References

Balsalobre-Fernández, C., Del Campo-Vecino, J., Tejero-González, C. M, and Alonso-Curiel, D. (2012). Relación entre potencia máxima, fuerza máxima, salto vertical y sprint de 30 metros en atletas cuatrocentistas de alto rendimiento. *Apunts. Educación Física y Deportes*, *108*(2), 63-69. https://dx.doi.org/10.5672/apunts.2014-0983.es.(2012/2).108.07

Balsalobre-Fernández, C., Nevado-Garrosa, F., Del Campo-Vecino, J., and Ganancias-Gómez, P. (2015). Repetición de sprints y salto vertical en jugadores jóvenes de baloncesto y fútbol de élite. *Apunts. Educación Física y Deportes*, *120*(2), 52-57. https://core.ac.uk/download/pdf/39140641.pdf

Basín, M., Fernandez, E. and Magallanes, C. (2019). *Repeat Jump Ability Test: Estudio piloto para la valoración de la capacidad de salto* [Degree Thesis, Instituto Superior de Educación Física, Universidad de la República]. Repositorio Colibrí. https://www.colibri.udelar.edu.uy/jspui/bitstream/20.500.12008/29775/1/T 764-.pdf

García-Manso and Valverde. (2015). *Potencia muscular y rendimiento deportivo*. Editorial Kinesis.

Gutiérrez-Dávila, M., Giles, M., González, C., Gallardo, D. and Rojas, F. (2015). Efecto de la intensidad del contramovimiento sobre el rendimiento del salto vertical. *Lecturas: Educación Física y Deportes, 119*(1), 87-96. https://dx.doi.org/10.5672/apunts.2014-0983.es.(2015/1).119.06

Hopkins, W. G., Marshall, S. W., Batterham, A. M., and Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise, 41*, 3-13. https://dx.doi.org/10.1249/MSS.0b013e31818cb278.

Inbar, O., Bar-Or, O. and Skinner J. S. (1996). *The Wingate Anaerobic Test*. Human Kinetics.

Izquierdo, M., Redondo, J. C., Oliveira da Silva, L., Lopez, L. M., Marcolin, É., & Sedano, S. (2015). Efectos de dos tipos de entrenamiento complejo en fuerza máxima y potencia en jugadores jóvenes de deportes colectivos. *Revista Brasileira de Prescrição e Fisiologia do Exercício*, *9*(53), 290-302. http://www.rbpfex.com.br/index.php/rbpfex/article/view/803/702

Jiménez, P., Cuadrado-Peñafiel, V. and González-Badillo, J. J. (2011). Análisis de variables medidas en salto vertical relacionadas con el rendimiento deportivo y su aplicación al entrenamiento. *Cultura, Ciencia y Deporte*, *6*(17), 113-119. https://www.redalyc.org/articulo.oa?id=163022532005

Khawaja, A., Sabbagh, P., Prioux, J., Zunquin, G., Baquet, G., Maalouf, G., and El Hage, R. (2019). Does Muscular Power Predict Bone Mineral Density in Young Adults? Journal of Clinical Densitometry, *22*(3), 311-320. https://doi.org/10.1016/j.jocd.2019.01.005

Krishnan, A., Sharma, D., Bhatt, M., Dixit, A., and Pradeep, P. (2017). Comparison between Standing Broad Jump test and Wingate test for assessing lower limb anaerobic power in elite sportsmen. *Medical Journal Armed Forces India*, *73*(2), 140,145. https://doi.org/10.1016/j.mjafi.2016.11.003

López, J. and Fernández, A. (2022). *Fisiología del ejercicio*. (4th Ed.). Médica Panamericana.

Martínez, E. (2002). *Pruebas de aptitud física*. Editorial Paidotribo

Muriel, X., Cámara Tobalina, J., Fernández López, J. R., & Pallarés, J. G. (2012). Validez del test de salto para la valoración del rendimiento anaeróbico y la asimetría en el ciclismo de alto nivel. *Sport TK*, *1*(1), 39-46.

Nikolaidis, P. T., Afonso, J., Clemente-Suarez, V. J., Alvarado, J. R. P., Driss, T., Knechtle, B., and Torres-Luque, G. (2016). Vertical jumping tests versus Wingate anaerobic test in female volleyball players: The role of age. *Sports*, *4*(1), 1-7. https://doi.org/10.3390/sports4010009

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjostrom, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. *International Journal of Obesity, 32*, 1-11. https://doi.org/10.1519/JSC.0000000000000864

Özkan, A., Köklü, Y., & Ersöz, G. (2010). Wingate anaerobic power test. *Journal of Human Sciences*, *7*(1), 207-224.

Rampinini, E., Bishop, D., Marcora, S. M., Ferrari Bravo, D., Sassi, R., and Impellizzeri, F. M. (2007). Validity of simple field tests as indicators of matchrelated physical performance in top-level professional soccer players. *International Journal of Sports Medicine*, *28*(3), 228-235.

Rosas, H., Alcaraz-Caracheo, L. A., & Jimenez, A. (2020). Métodos para determinar el índice de fatiga muscular a través de semg: revisión de la literatura. *Pistas Educativas*, *42*(137), 526-540.

Runge, M., Rittweger, J., Russo, C. R., Schiessl, H. and Felsenberg, D. (2004). Is muscle power output a key factor in the age-related decline in physical performance? A comparison of muscle cross section, chair-rising test and jumping power. *Clinical Physiology and Functional Imaging, 24*(6), 335-340. https://doi.org/10.1111/j.1475-097X.2004.00567.x

Sands, W. A., McNeal, J. R., Ochi, M. T., Urbanek, T. L., Jemni, N. and Stone, M. H. (2004). Comparison of the Wingate and Bosco anaerobic tests. *The Journal of Strength and Conditioning Research*, *18*(4), 810-815. https://doi.org/10.1519/13923.1

Sirvent, J., & Alvero, J. (2017). *La cineantropometría y sus aplicaciones*. Univiersitat d' Alicant.

Steene-Johannessen, J., Kolle, E., Andersen, L. B., & Anderssen, S. A. (2013). Adiposity, aerobic fitness, muscle fitness, and markers of inflammation in children. *Medicine and Science in Sports and Exercise, 45,* 714-721. https://doi.org/10.1249/MSS.0b013e318279707a

Straight, C. R., Lindheimer, J. B., Brady, A. O., Dishman, R. K., & Evans, E. M. (2015). Effects of Resistance Training on Lower-Extremity Muscle Power in Middle-Aged and Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Sports Medicine, 46*(3), 353-364. https://doi.org/10.1007/s40279-015-0418-4

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