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DISTANCE ON THE YO-YO INTERMITTENT RECOVERY TEST IS ASSOCIATED WITH FLOW-MEDIATED DILATATION IN YOUTH FOOTBALL

Walter Oliveira de Vargas[1]
Katya Vianna Rigatto[1]

ABSTRACT

The Yo-Yo intermittent recovery test evaluates the individual capacity to carry out intermittent exercise leading to a maximal activation of the aerobic system. It has also been shown that aerobic exercise improves endothelial function (FMD). Moreover, studies indicate that there is a positive association between FMD and maximal oxygen uptake, but no data is available about the association with the Yo-Yo intermittent recovery test. Thus, the aim of the present study was to investigate, in young football players, whether the Yo-Yo intermittent recovery test level 1 could also be associated to the FMD. Thirteen young male football players (athletes) and eleven young male non-athletes (control) participated in this study. The FMD and Yo-Yo intermittent recovery test level 1 were measured in each group. FMD and the distance on Yo-Yo intermittent recovery test level 1 were significantly higher (P<0.002 and P<0.001, respectively) in the athletes (FMD=11.5±3.8; Yo-YoIR1= 2009.2 ± 263.8) than in control group (FMD=4.9 ± 5.4; Yo-YoIR1= 1420 ± 423.8). The Pearson correlation between FMD and the distance on the Yo-Yo intermittent recovery test level 1 in the athletes group was r = 0.81 (P<0.005), while in the control group it was r = 0.03 (P<0.005). Our results indicate that there is a positive association between Yo-Yo intermittent recovery test level 1 and FMD in young football players. This association strengthens the Yo-Yo intermittent recovery test level 1 as an effective tool in evaluating the performance of intermittent sports athletes.

Key words: Yo-Yo Intermittent Recovery Test. Endothelial Function. Flow-Mediated Dilation. Football.

1-Pós-graduação em Ciências da Saúde, Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA), Porto Alegre-RS, Brasil.

RESUMO

Distância no Yo-Yo Intermittent Recovery Test está associada com a Dilatação Mediada por Fluxo em jovens jogadores de futebol

O Yo-Yo Intermittent Recovery Test avalia a capacidade individual para realizar exercício intermitente levando a uma ativação máxima do sistema aeróbio. Também foi demonstrado que o exercício aeróbio melhora a função endothelial (FMD). Além disso, estudos indicam que existe uma associação positiva entre a FMD e o consume máximo de oxigênio, mas não há dados disponíveis sobre a associação com o Yo-Yo Intermittent Recovery Test. Assim, o objetivo do presente estudo foi investigar, em jovens jogadores de futebol, se o Yo-Yo Intermittent Recovery Test nível 1 poderia também estar associado à FMD. Treze jovens jogadores de futebol (atletas) e onze jovens não-atletas (controle) participaram deste estudo. A FMD e o Yo-Yo Intermittent Recovery Test nível 1 foram medidos em cada grupo. A FMD e a distância no Yo-Yo Intermittent Recovery Test nível 1 foram significativamente maiores (P <0,002 e P <0,001, respectivamente) nos atletas (FMD = 11,5 ± 3,8; Yo-YoIR1 = 2009,2 ± 263,8) que no grupo controle (FMD = 4,9 ± 5,4, Yo-YoIR1 = 1420 ± 423,8). A correlação de Pearson entre a FMD e a distância no Yo-Yo Intermittent Recovery Test nível 1 no grupo atletas foi r = 0,81 (P <0,005), enquanto no grupo controle foi r = 0,03 (P <0,005). Nossos resultados indicam que há uma associação positiva entre o Yo-Yo Intermittent Recovery Test nível 1 e a FMD em jovens jogadores de futebol. Esta associação fortalece o Yo-Yo Intermittent Recovery Test nível 1 como uma ferramenta eficaz na avaliação do desempenho de atletas de esportes intermitentes.

Palavras-chave: Yo-Yo Intermittent Recovery Test. Função Endotelial. Dilatação Média. Futebol.

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INTRODUCTION

Football is one of the most popular sports and is practiced worldwide. It is practiced by children and adolescents with different performances (Stolen and collaborators, 2005), including professional.

On the other hand, there is a lack of studies showing the physiological effects of this sport in children and adolescents (Henderson and collaborators, 2015).

Moreover, there is no doubt that high values of maximum oxygen uptake (VO_2 max) are necessary in high-performance athletes to manage the cardiovascular function (Stolen and collaborators, 2005).

Traditionally, the capacity of an athlete has been evaluated using continuous exercise tests, such as the VO_2 max test. The VO_2 max is considered the best measure of cardiovascular fitness and exercise capacity (Lear and collaborators, 1999).

On the other hand, this method has been questioned because it does not show appreciable changes for the performance of athlete who practice intermittent exercise (Mohr, Krustrup and Bangsbo, 2005).

In fact, to evaluate this kind of exercise, the Yo-Yo intermittent recovery (IR) tests, one of the most extensively studied fitness tests in exercise physiology, may be recommended (Stolen and collaborators, 2005).

Due to its specificity and practicality many team sports have used this test, such as basketball (Castagna and collaborators, 2008), handball (Hermassi and collaborators, 2014), as well as football (Rampini and collaborators, 2010).

In addition, the Yo-Yo IR tests are a more specific measurement of changing in performance for intermittent sports (Stolen and collaborators, 2005; Bangsbo, Iaia and Krustrup, 2008).

Thus, in order to examine changes in performance, the Yo-Yo IR test provides, with a simple protocol, important information of the ability of an individual to perform repeated intense exercise (Bangsbo, Iaia and Krustrup, 2008).

Bangsbo and collaborators (2008) analyzing 141 subjects, found a positive association ($r = 0.70$; $p < 0.05$) between VO2max and the Yo-Yo IR level 1 (IR1) test in football players. In addition, studies indicate that there is also a positive association between VO_2 max and endothelial function in adolescents (Pahkala and collaborators, 2008) and adults (Buscemi and collaborators, 2013).

It has been shown that aerobic exercise improves endothelial function, measured by the flow-mediated dilation in the brachial artery (FMD) in heart failure (Hornig, Maier and Drexler, 1996), coronary heart disease (Gokce and collaborators, 2002), hypertension (Higashi and collaborators, 1999) and in healthy subjects (Buscemi and collaborators, 2013).

Revising extensively the literature, there is no doubt that aerobic exercise is essential for improving fitness and that exercise has favorable effects on endothelial function (Corretti and collaborators, 2002; Della Rocca and Pepine, 2010; Fagard and Cornelissen, 2007; Sandoo and collaborators, 2010).

Endothelial cells play a key role in the control of vascular function, because they mediate vasodilation and vasoconstriction of the vascular smooth muscle cells (Della Rocca, Pepine, 2010; Sandoo and collaborators, 2010).

The equilibrium between these vasoactive components is atheroprotective, whereas a damaged endothelium can provoke an imbalance in these vasoactive components and induce cardiovascular disease, such as atherosclerosis, hypertension, and heart failure (Corretti and collaborators, 2002).

In the 1990s, a technique that uses ultrasound was evolved to evaluate foot and mouth disease, which stimulates the release of nitric oxide (NO) with subsequent vasodilatation (Laurent and collaborators, 1990). Vasodilatation can be quantified as an index of vasomotor function. However, there are technical and interpretive limitations (Corretti and collaborators, 2002), which can represent an important barrier for its use in the sports evaluation.

Thus, it would be desirable to use a method, such as Yo-Yo IR1 to assess the endothelial and cardiorespiratory function, considering the importance of these parameters for sports performance.

Therefore, the objective of this study was to investigate whether the Yo-Yo IR1 could also be associated with the endothelial function and, thus, provides a valorous

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information about football players performance with a simple, easy and cheap technic.

MATERIALS AND METHODS

The Ethics Committee of the Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) approved the study (CEP/UFCSPA protocol number 562.572).

Subjects were informed about the tests to be performed in the study, after which they provided written informed consent prior to data collection. All study participants underwent three evaluations: evaluation of arterial endothelial function, Yo-Yo IR1 test and anthropometric measurements.

Participants

Thirteen young male football players (athletes; age 16.8 ± 0.8 years) and eleven young males (non-athletes; age 16.4 ± 0.7 years) participated in the study. All football players had at least three years prior specific training, while the control subjects did not practice sports competitively. The endothelial function, distance on Yo-Yo IR and anthropometric data were measured in both groups.

Measures

For arterial endothelial function evaluation, subjects were instructed to attend the Physiotherapy Laboratory of the University where the study was conducted at 7 a.m., fasting. One week later, anthropometric measurements – height, weight, age, body fat percentage and Yo-Yo IR1 – were performed at a football stadium.

Procedures

Assessment of endothelial function

Endothelial function was assessed noninvasively by means of a brachial artery ultrasound probe (GE Medical Systems, Vivid I Ultrasound, Israel) and Doppler ultrasonography, using an instrument equipped with a 7- to 12-MHz high-resolution linear probe (L12-3, GE Medical Systems, Israel). The ultrasonography was performed in a silent, temperature-controlled laboratory room. At rest, the left brachial artery diameter was measured by B-mode ultrasound images to detect reactive hyperemia. Before blood pressure (BP) cuff inflation, a resting scan was performed.

After the resting measurement, the cuff was inflated for 5 min at 50 mmHg above systolic BP (SBP), to occlude the arterial flow. This procedure causes ischemia followed by vasodilation due to auto regulatory mechanisms.

After cuff deflation, a second continuous scan was recorded from 30–120 seconds. The same experienced sonographer performed and analyzed all ultrasound scans.

The sonographer had no information about the subjects. At a fixed position, the vessel diameter was measured offline with ultrasonic calipers at end-diastole and incident with the R wave on an electrocardiogram that it was continuously recorded.

After an interval of 10 seconds and during the period within 30-180 seconds, the dilatation was obtained by the difference from baseline.

After the release of the sphygmomanometer cuff, the value of FMD (%) indicates the increase in blood flow (Corretti and collaborators, 2002).

Yo-Yo intermittent recovery test level 1

The subjects performed 2×20-meters shuttle runs at increasing speeds, interspersed with a 10-second period of active recovery. As described by Bangsbo and coworkers (2008), the distance covered at this point was the result of the Yo-Yo intermittent recovery test level 1 (Yo-Yo IR1).

Body fat percentage

We used the Faulkner protocol (Faulkner, 1968) to calculate the body fat percentage of individuals from both groups. The method uses measurements of four skinfolds: triceps, subscapular, abdominal and suprailiac to perform the calculation, as follows:

$$\text{Body fat percentage} = 5.783 + 0.153\ (\sum \text{ of the four skinfolds})$$

Statistical analysis

The normality and equality of variance of the data were assessed through the

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Shapiro-Wilk and Levene tests. The data were compared through the use of the Student's "t"-test. All analyses were conducted with SPSS software version 10.0 (SPSS Inc., Chicago, IL). The association between variables was assessed through Pearson correlations. The data are presented as means ± SD. A value of P<0.05 was considered statistically significant.

RESULTS

Athletes and control group baseline characteristics are presented in Table 1. There were no significant differences between the two groups regarding age, body weight and height or body mass index. On the other hand, the body fat percentage was statistically different between groups (P<0.001).

Measurements of Yo-Yo IR1 and endothelial function

Distance covered on Yo-Yo IR (m) and endothelial function (%) were significantly higher (P<0.001 and P<0.002, respectively) in the athletes group (2009, SD 264 and 11.5, SD 3.8, respectively) than in the control group (1420, SD 424 and 4.9, SD 5.4, respectively – Table 2).

Table 1 - Physical characteristics of the subjects.

	Athletes Group	Non-athletes Group	p
Weight (kg)	70.3 ± 3.7	74.5± 5.6	0.133
Height (cm)	174.7 ± 5.7	170.1 ± 8.1	0.493
Body mass index	23.43 ± 1.59	25.76 ± 2.33	0.286
Body fat percentage (%)	7.9 ± 0.9	13.7 ± 2.5	0.001*

Legends: *p<0.05 was considered statistically significant. Values are the mean ± SD.

Table 2 - Physical fitness and endothelial function.

	Means ± SD		p
	Athletes Group	Non-athletes Group	
Yo-Yo IR1 (m)	2009.2 ± 263.8	1420 ± 423.8	0.001*
FMD (%)	11.5 ± 3.8	4.9 ± 5.4	0.002*

Legends: *p<0.05 was considered statistically significant. Values are the mean ± SD.

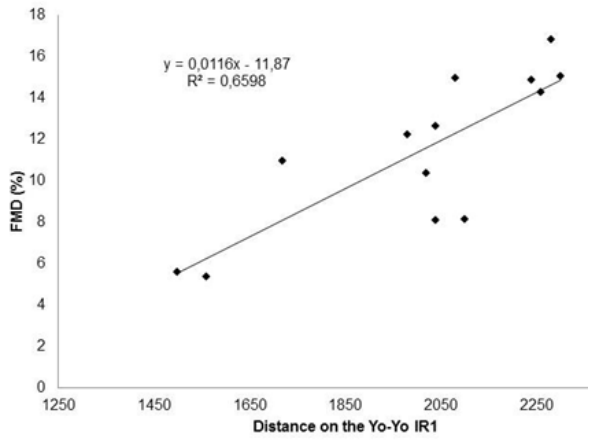

Figure 1 - Correlation and trendline between FMD and the distance on the Yo-Yo IR1 on athletes group.

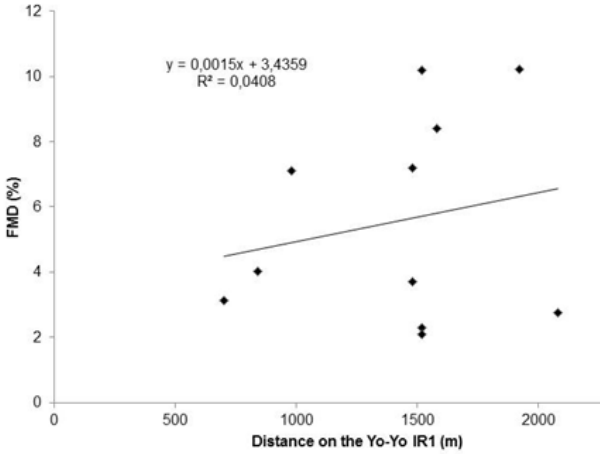

Figure 2 - Correlation and trendline between FMD and the distance on the Yo-Yo on non-athletes group.

The Pearson correlation between the endothelial function and the distance on the Yo-Yo IR1 in the athletes group was r=0.81 (P<0.005; Figure 1). In contrast, for the control

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group, the Pearson correlation was r =0.03 (P<0.005; Figure 2).

DISCUSSION

The main finding of this study is that there was a positive and significant association between endothelial function and the Yo-Yo IR1 in young football players. As expected, such association did not occur within subjects from the control group. Differently of VO_2 max, the Yo-YoIR1 has high sensitivity to detect changes in athlete performance of intermittent sports, and according to our results, it could also be used as an important tool to predict endothelial function. Traditionally, a continuous incremental load exercise protocol has been used to evaluate the VO_2 max of an athlete. However, this test has low sensitivity and it does not respond proportionally to the athlete's performance improvements in intermittent sports. Consequently, the relevance of these protocols has been questioned for those kind of sports (Bangsbo, Iaia and Krustrup, 2008).

Regarding to the well-known advantages of an intermittent protocol to measure a player's performances, our study provides the first evidence that the Yo-Yo IR1 is also related to endothelial function, a crucial measurement that can inform about cardiovascular function.

Our results showed that the better the athlete's performance is in the Yo-Yo IR test, the better the FMD or arterial function are. The application of these results, in terms of sport, lies in the easiness of inferring the endothelial function without performing an additional measurement.

Moreover, it aggregates valuable information about cardiovascular physiology. Importantly, it is crucial to consider that an imbalance in the endothelial function leads to impairment in the cardiovascular function (Kodama and collaborators, 2009) and thus, probably reduces the athlete's performance.

In addition, because of the length of a match, football is mainly dependent upon aerobic metabolism. During a 90-minute game, the average work intensity is normally between 80-90% of maximal heart rate. This condition is close to the anaerobic threshold (Rampini and collaborators, 2010), increasing the capacity and efficiency of the cardiovascular system.

To our knowledge, there are no previous studies demonstrating an association between the Yo-Yo IR1 test and the FMD. However, some studies do have demonstrated a significant association between VO_2 max and FMD (Buscemi and collaborators, 2013; Pahkala and collaborators, 2008).

Since our results showed an association between the Yo-Yo IR1 test and the FMD in athletes, but not in the control group, it demonstrates the specificity of the Yo-Yo IR1 test to evaluate athlete's performance with accuracy. Probably, in healthy subjects, but not trained ones, the FMD and the results of Yo-Yo IR1 test do not go along with the increase in cardiovascular demand.

Guiraud and coworkers (2012) have published a non-systematic review exploring the effects of high-intensity interval training (HIIT) in patients with coronary artery disease. The authors reported an increase in arterial endothelial function in these patients. The HIIT is quite similar to the training performed by intermittent sports athletes, such as football players. This finding further validates our results because, in our study, only the athlete group showed an association between endothelial function and Yo-Yo IR1. According to our findings, the HIIT also improves both physical condition and endothelial function.

Finally, data recently published in a systematic review by Ashor and collaborators (2015) also showed an association between the exercise modalities and endothelial function. They showed that the intensity of aerobic exercise and endothelial function are associated; for every increase in intensity, there is an improvement in FMD. It is well established in the literature that Yo-Yo IR1 is associated to VO_2 max (aerobic capacity). Thus, this finding further strengthens our results since it also confirms the association between Yo-Yo IR1 and FMD.

Due to the fact that it is not invasive, is used widely and allows repeated measurements over time, the FMD technique is attractive for the study of the effectiveness of various interventions. On the other hand, there are some technical and interpretive limitations to the use of this technique. It would require intense training to master the technique in order to minimize the data variability and accuracy (Corretti and collaborators, 2002).

In addition, ultrasound machines are expensive, while the Yo-Yo test is easy to apply and is low cost. Therefore, it has been important to demonstrate the association of the

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Yo-Yo IR1 with a parameter that reflects the cardiovascular function, as FMD.

In conclusion, the reason for considering the Yo-Yo IR1 test as a good alternative lies in the importance of minimizing the problems of performing the FMD technique and also in providing important information about athletes' cardiovascular physiology and performance. Future research is necessary to confirm that important association.

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E-mails dos autores:
walter.efi@gmail.com
krigatto@gmail.com

Corresponding Author:
Walter Oliveira de Vargas
DCBS, Universidade Federal de Ciências da Saúde de Porto Alegre.
Sarmento Leite, 245, Porto Alegre-RS, Brazil.
Zip Code: 90050-170
Telephone: 55 (51) 3303-8753 - Fax Number: 55 (51) 3303-8810

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