Yo-Yo IR2 Test and Margaria Test: Validity, Reliability and Maximum Heart Rate in Young Soccer Players

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

The aims of the present study were: i) to evaluate the construct validity of Yo-Yo Intermittent Recovery Test Level 2 (Yo-Yo IR2) and of the Margaria Test (MT) with performance in high intensity exercise during official match play in soccer players; ii) to verify the reliability (test-retest) of the two tests; iii) to compare the values of the maximal individual heart rate (MHR) obtained in those protocols and match play Eighteen soccer players (mean ± SD; age 14 ± 0.8 years, height 172 ± 9 cm, weight 64.3 ± 8.5 kg) belonging to the same team were assessed in test-retest referred protocols and in the percentage of time spent above 85% of MHR (PRT >85%MHR) in two official match play of the U-15 Championship. High correlation was found between performance in the Yo-Yo IR2 and PRT >85%MHR (rs=0.71; p<0.05). There was not correlation between performance in MT and PRT >85%MHR (rs=0.44; p=0.06). The Yo-Yo IR2 was more variable and less reproducible (CV= 11%; CCI [95% IC]=0.38) than MT (CV= 1%; CCI [95% IC]=0.93). The highest value of MHR (p<0.001) occurred in the match play (202 ± 8 beats.min^{-1}). MHR in Yo-Yo IR2 (194 ± 4 beats.min^{-1}) was lower (p<0,006) than MT (197 ± 6 beats.min^{-1}). In conclusion, the Yo-Yo IR2 can be considered more valid to predict maintenance of high exercise intensity during a match, which is an important performance measure in soccer. However, there is need of strict standardization among the evaluation procedures for stability of the measure. MHR should be observed in several situations, mainly competitive, so that the highest individual value can be reached.

Keywords: soccer, exercise intensity, performance, heart rate, field test.

INTRODUCTION

The aerobic capacity evaluation of athletes is useful for the selection, for programs of physical fitness devising and for prediction and monitoring of physical performance in competitions[1]. In the literature, there are many methods described for evaluation of aerobic capacity of soccer players[1]. In laboratory, direct measurement of the maximum oxygen consumption ($\dot{V}O_{2max}$) in exhaustion test on treadmill[2,3] is considered the gold standard since it allows simultaneous evaluations of other important parameters such as threshold of metabolic transition, running economy and cardiac work. This procedure, despite its controversies[4,5], is considered to be valid for soccer, since significant correlation of the $\dot{V}O_{2max}$ with the final classification of the team in the competition[6] and with some performance variables in the match such as: completed distance[6-9], number of performed sprints[6-8], time of activities at high intensity[7,9,10] and number of interactions with the ball by the player has been found[7]. However, an important limitation of this evaluation, especially for team sports, is that the procedures are time-consuming, require trained staff and costly equipment[11,12].

Among the field tests, the Margaria test[13] (MT) has been highlighted in the evaluation of soccer players since it allows adjustments in the distance of the used dislocation, which should be completed in the shortest time possible and with constant velocity for estimation of the $\dot{V}O_{2max}$. Thus, in only one procedure, it is possible to estimate performance by the equations of the 2,400m Copper test[14] or the Weltman test[15]. Another advantage of this procedure is the easy place adaptability and the need of minimal equipment. However, the validity of these tests to soccer can be questioned since they do not reflect the physiological response of the match[3,16] for having straight and continuous movement characteristic and hence do not simulate the competitive load in which the players are demanded in many sudden changes of movement and direction[10,17-19].

The *Yo-Yo Intermittent Recovery Test Level 2* (Yo-Yo IR2) was proposed as a field test of easy applicability and low cost[16,20]. Using back and forth running (20m) with velocity increment of dislocation controlled by a sound sign, its main measurement characteristic is the action intermittence, characterized by recovery interval of 10 seconds between stimuli for new dislocation. The dislocations are carried out until player's exhaustion, which is characterized when the sound signs are not followed anymore in the respective marks. Due to this characteristic, the Yo-Yo IR2 has been recommended as an optimum evaluation measurement for soccer[5,16]. The performance

obtained in the Yo-Yo IR2 test has demonstrated significant correlation with fatigue time in a progressive running test on treadmill, with $\dot{V}O_{2max}$ and strong correlation with maximum dislocation distance completed in five minutes during a match in adult elite players[20]. Another indication for its application is the possibility to observe the maximum heart rate (MHR) of the player during its performance, not presenting difference from the values observed in the exhaustion test procedures carried out on treadmill[16,20]. The information of this variable is an important factor for relativization of load intensities in the training prescription.

Although previous studies such as the previously reported have demonstrated the advantages of the Yo-Yo IR2 for soccer, as far as we are concerned, there is a shortage in studies with young players which try to detect the validity of the construct[21], reliability and suitability of this measurement for the observation of the MHR or even comparison of these aspects with other field assessment procedure. Another issue is the comparison of continuous field protocols with intermittent ones, since both stimuli can be used to facilitate the physiological adaptations and improve performance of soccer players[7,9].

The construct validity and reliability are important factors to be considered by the technical staff at the time of protocol selection. Firstly for the construct validity, since a high level provides correlations with other theoretical propositions. Regarding soccer, it corresponds to a good physiological simulation and can serve as a diagnostic measure for a performance criterion during a match [21]. Likewise, it is through the reliability that it can be compared whether similar results are obtained under the same application circumstances in test-retest, demonstrating that the protocol variation is low and has less sources to measurement error[5], which is an important criterion for reevaluations throughout the season. From the practical point of view, it is interesting that the stimuli of these field tests are also suitable for the MHR acquisition since they result in time gain for the technical staff since there is a need to apply a test specific to this variable, which has been currently much used for revitalization of the effort load in training prescription and control.

Thus, the aims of this study were: i) to assess the construct validity of the Yo-Yo IR2 and the Margaria test by the high intensity exercise performance during official match play in under-15 soccer players; ii) to verify the reliability (test- retest) of the two tests; iii) to compare the MHR values observed in these protocols and in the match play.

METHODS

Participants

Twenty-five male soccer players from a team which participated in regular competitions acknowledged by the Soccer Federation of Minas Gerais State agreed on voluntarily participating in the study. The players who did not participate in the entire matches because they have not been chosen (due to injury; N = 1) or substitution during the match (N = 6), were excluded from the study. The participants (N = 18) were aged between 14 ± 0.8 years, had stature between 172 ± 9cm and body weight of 64.3 ± 8.5kg (mean ± standard deviation). The representation by position on the field was the following: outside midfielders and wingers (N = 3); fullbacks (N = 4); midfielders (N = 7) and forwards (N = 4). The team played in a regular formation of 4-4-2, using four defenders, four midfielders and two forwards.

During the experimental procedures, the participants were in the main competition of the under-15 category of the state of Minas Gerais. They were submitted to one daily training session (physical-technical and tactical training), with approximate duration of 90 minutes, five times per week and participated in an official match per week (70 min.) on Saturdays and Sundays. All volunteers had experience of four ± one year of systematic soccer training and competitions.

The Free and Clarified Consent Form referring to the study was signed by the parents or legal tutors for participation in the study, after it had been approved by the Ethics in Research with Humans Committee of the federal University of Viçosa, following recommendations of the Resolution 196/196 of the National Health Board – MS, Brazil.

Experimental procedures

Initially, the participants were familiarized with the protocols in the Yo-Yo IR2 and Margaria tests, as well as with the use of the heart rate monitors (Polar Team System®, Polar Electro Oy, Kempele, Finland) during training sessions. Heart rate was monitored every five seconds. The Krustrup *et al.*[20] procedrues were followed for the Yo-Yo IR2 performance, in which the players wore the same uniform they had on for the soccer match and the test is performed on natural turf. The sounds signs were sent with the CD which comes along with the Yo-Yo tests kit (www.teknosport.com, Ancona, Italy). The test procedures of the Margaria test[13] were followed adopting the 2,400m distance, set on a 300m round track on an unpaved soccer field, parallel to the natural turf field used for the training. This distance was adopted for being considered usual in track protocols with similar characteristics. From the physiological point of view, this distance requires time longer than five or six minutes, which is the time necessary to keep a high level of stable rhythm (*steady state*) of oxygen uptake[13]. $\dot{V}O_{2max}$ is predicted by the equation (adopted distance + 30[time] / 5[time] + 5)[13].

Reliability was verified (measurement stability)[21] with the two test protocols being performed twice (test-retest), with one-week interval inter-procedure and 48 hours intra-procedure (Tuesdays for Yo-Yo IR2 and Thursdays for Margaria). The tests were performed in the afternoon shift, between 14h00min and 16h00min (same time of the matches), at the beginning of each training session, after 20 minutes of warm-up and stretching typical of soccer. Room temperature during the tests was monitored (TGM 100, Homis®, Brazil) and was not statistically different between procedures (IBUTG = 24.3 ± 0.2°C *vs.* 24.1 ± 0.4°C; p = 0.655, *Wilcoxon Signed Ranks Test*). The subjects were randomly distributed for the tests performance and each player was verbally encouraged to perform their maximum effort.

The performance criterion used during the match was remaining time percentage above 85% of individual maximum heart rate (PRT>85%MHR) obtained in two complete matches, for each player, validated by the Youth Soccer Championship of the State of Minas Gerais. This strategy was defined because the performance capacity of great quantity of activities at

high intensities by the players during the match is expected by coaches and has been currently indicated as the best performance measurement for soccer[8,10,18,22,23]. High-intensity activities have constant behavior between matches[10,17,19,24] and is frequently where the matches are won or lost, since the good trials to score goals are performed at high-intensity[25]. Room temperature during the matches was also monitored and was not statistically different between days (IBUTG = 24.4 ± 1.8°C *vs*. 23.6 ± 2°C; p = 0.585, *Wilcoxon Signed Ranks Test*).

The exercise intensity observed during the matches was of 85 ± 3.7%MHR. This value corroborates what is reported in other studies for players of different categories[7,26-28], demonstrating that the matches were typically played. The PRT>85%MHR observed was of 20.5 ± 5.1%. This measurement showed good reliability (test-retest) through the coefficient of variation (CV) observed (8.6 ± 5.4%) and the intraclass correlation coefficient (ICC = 0.92). Some recent studies[17,22,24] have found CV range from 3 to 9.2% using video-recording or computerized, semi-automatic video match analysis image recognition system method for the classification in high-intensity races of the professional players in official match play. Thus, the PRT>85%MHR strategy may be considered a consistent criterion for performance evaluation in high intensity of exercise in the assessed players.

Heart rate during the matches was monitored with permission from the referees from the Soccer Federation of Minas Gerais State. The assessed matches preceded and followed the application of the Yo-Yo IR2 and Margaria tests in a maximum of two weeks. The individual MHR was defined as the one with the highest peak value obtained during the match play, Yo-Yo IR2 or Margaria test. Since the players live in a boarding system, a pattern nutritional guideline was kept by the technical staff and the players could drink water *ad libitum* during the tests and matches.

STATISTICAL ANALYSIS

The data are presented as mean± standard deviation. Concurrent validity was verified through the Spearman test (rs) for correlation between performance in the tests and in the PRT>85%MHR in the matches, and the mean between the pair of measures in each procedure was considered. The interpretation of the correlation observed followed guideline by Morrow *et al.*[29] with values <0.20; 0.20-0.39; 0.40-0.59; 0.60-0.79; 0.80-1, classified as very low, low, moderate, high and very high, respectively. The concordance threshold between pairs of measurements obtained in test-retest was observed according to the method suggested by Bland and Altman[30]. The coefficient of variation (CV) was also used as a reliability measurement[31]. The CV was set for each subject from the division of the standard deviation of each pair of measurements by their mean values (CV = [(SD / mean) * 100]. Later, the mean CV was calculated from the mean of the individual CV. Moreover, for reliability of the pairs of values obtained in test-retest the intraclass correlation coefficient (ICC) was used[31]. The use of these three approaches follows the guidelines by Atkinson and Nevill[31], since there are advantages and disadvantages for each case. Comparison between the MHR obtained during the Yo-Yo IR2, MT and the match play was possible through the Wilcoxon Signed Ranks Test. Statistical analysis was performed in the Statistical Package for the Social Sciences (SPSS® 15 for Windows, Chicago, IL, USA) and MedCalc *Software*, Mariakerke, Belgium (MedCalc 9.2.1.0) packages. In all cases, the statistical significance level was set at p < 0.05.

RESULTS

High positive correlation (p < 0.05) was found between performance in the Yo-Yo IR2 and PRT>85%MHR during the match (rs = 0.71; p = 0.001) (Figure 1). However, there was no correlation (p > 0.05) between performance in the MT and PRT>85%MHR during the matches (rs = 0.44; p = 0.064) (Figure 2).

Performance in the Yo-Yo IR2 and MT, coefficient of variation (CV), as well as intraclass correlation coefficient (ICC) for all procedures are presented in table 1. It can be observed that the ICC and CV are higher and lower, respectively, for the MT in comparison to the Yo-Yo IR2.

The Bland-Altman plots demonstrating the level of concordance between the pairs of measurements obtained in test-retest are presented in figure 3 for the Yo-Yo IR2 and in figure 4 for the MT. One player was outside the thresholds of concordance in the MT (Figure 4). Despite the low ICC and high CV for the Yo-Yo IR2, the Bland-Altman plotting (Figure 3) revealed that mean differences between test-retest were within the concordance thresholds, as well as for the MT (Figure 4). None of the protocols presented heteroscedastic error. However, the variability in the reproducibility of the measurements was high, once the means of the differences between test-retest were not close to zero in both tests.

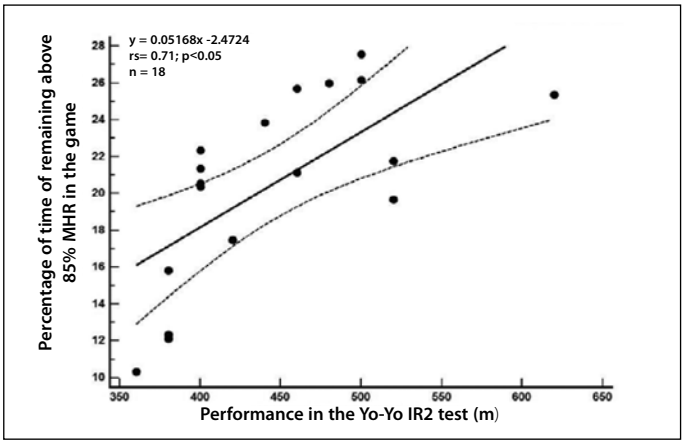

Figure 1. Dispersion and simple regression line corresponding to the performance in the Yo-Yo *Intermittent Recovery Test Level* 2 (Yo-Yo IR2) and the percentage of time of remaining above 85% of individual MHR (PRT>85%MHR) during the game (N = 18; rs = 0.71; p = 0.001). Dotted line denotes the CI95%.

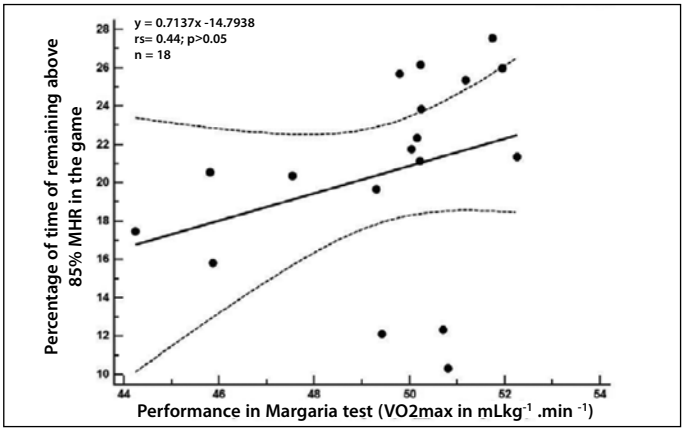

Figure 2. Dispersion and simple regression line corresponding to the performance in the Margaria test and the percentage of the time of remaining over 85% of individual MHR (PRT>85%MHR) during the game (N = 18; rs = 0.44; p = 0.064). Note: dotted line denotes the CI 95%.

Table1. Performance in the *Yo-Yo Intermittent Recovery Test Level 2* (Yo-Yo IR2), in the Margaria test (MT), coefficient of variation (CV) and intraclass correlation coefficient (ICC) with confidence interval of 95%.

	Performance	CV*	ICC (95% CI)
Yo-Yo IR2	445.5 ± 67.8m	11%	0.38 (-0.38-0.80)
MT	49.5 ± 2.2mL.kg^{-1}.min^{-1}	1%	0.93 (0.82-0.97)

*Data expressed as mean ± standard deviation. Number of players: 18.

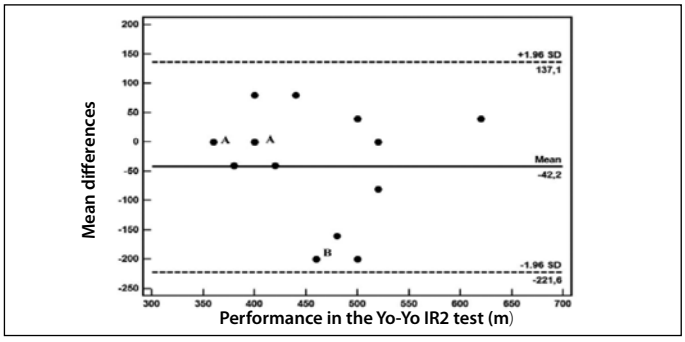

Figure 3. Bias plotting (mean of the differences) and concordance thresholds (±1.96 CI 95%) between the performance obtained in the *Yo-Yo Intermittent Recovery Test Level 2* (Yo-Yo IR2), according to the procedures by Bland-Altman (N = 18). Note: "A" represents overlapping of three players and "B", two players.

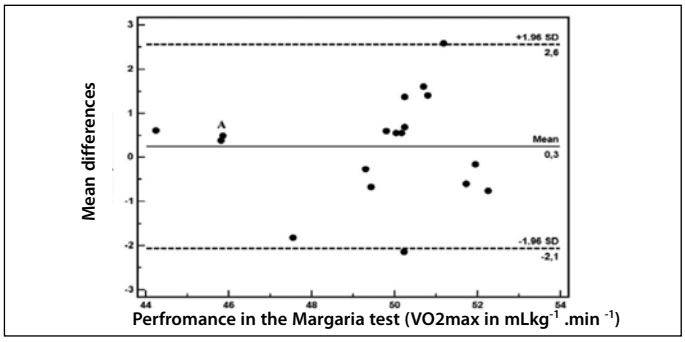

Figure 4. Bias plotting (mean of the differences) and concordance thresholds (±1.96 CI95%) between performance in the Margaria test, according to procedures by Bland-Altman (N = 18). Note: "A" represents overlapping of two players.

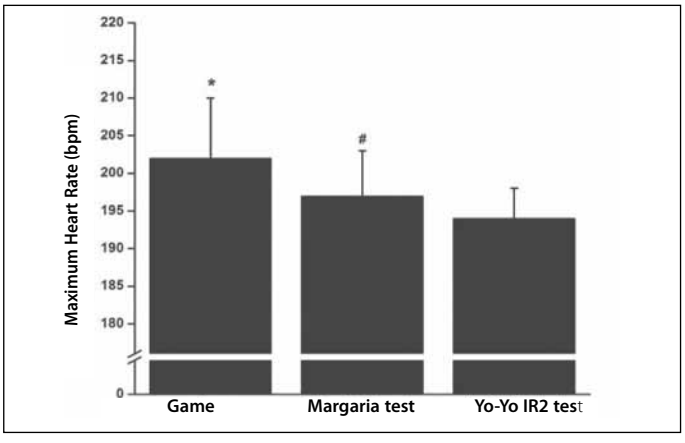

Figure 5. Maximum heart rate observed during the game, Margaria test and *Yo-Yo Intermittent Recovery Test Level 2* (Yo-Yo IR2) (N = 18). * p < 0.05 concerning the remaining situations. # p < 0.05 concerning the *Yo-Yo IR2 test*.

There was difference between the MHR obtained in the different situations (Figure 5). The highest MHR value (p < 0.001) was observed in the match situation (202 ± 8bpm).The MHR obtained in the Yo-Yo IR2 (194 ± 4bpm was lower (p < 0.006) than during the MT (197 ± 6bpm).

DISCUSSION

One of the aims of this study was to evaluate the concurrent validity of two field protocols through the performance correlation of the players in these procedures with high-intensity exercise performance in a match during official matches in under-15 soccer players. High correlation between performance in the Yo-Yo IR2 and the percentage of remaining time above 85% of the individual maximum heart rate (PRT>85%MHR) during the match play (rs = 0.71; p < 0.05) was found (Figure 1), demonstrating that this procedure can be considered more valid than the MT (rs = 0.44; p = 0.06; Figure 2).

Due to the its performance in intermittent stimuli, the Yo-Yo IR2 seems to have facilitated specific morphophysiological adaptations that the players acquire in the soccer $\dot{V}O_{2max}$ and training. The dislocation velocity and its increment combinations at every stage make than the ability to bear stimuli where both aerobic and anaerobic systems are strongly stimulated are assessed in this protocol[16,20]. Thus, performance in Yo-Yo IR2 could better reflect the conditioning of the players for specific soccer activities and present significant correlation with maintenance of exercise high intensity during the matches, which is an important performance measure for soccer[8,10,18,22,23] due to the value the physical component has gained over the last years.

Some studies have found significant correlation between performance in the Yo-Yo IR1 test (another demand level of lighter physical exercise intensity)[16] and performance in high-intensity activities in competition in male elite adult soccer players[32], and female ones[10], in referees in high level soccer competitions[33] and in performance in short-duration races after experimental basketball match with junior players[11]. High correlation (r = 0.74; p < 0.05), comparable to the one found in the present study (figure 1), was observed by Krustrup *et al.*[20] between performance in the Yo-Yo IR2 test and the maximum dislocation distance completed in five minutes during the matches in adult elite players of the Scandinavian region. Additionally, in this study[20] it was observed that the correlation between the Yo-Yo IR2 was higher than the one obtained for the $\dot{V}O_{2max}$ in this same criterion of high-intensity activity during the match play.

From the younger categories, the current soccer training dynamics leads the players to work aerobic aspects combined in the training designing. Long-distance races or typical opportunities for aerobic conditioning are rare, especially in the competition season, moment in which the evaluations of the present study were done. Mohr *et al.*[24] observed that the competition season was the phase in which the professional players present the highest rates of dislocation at high intensity, reflecting the training phase with the most intense, intermittent and close to the match play reality procedures. These aspects can make the protocols which use continuous procedures, such as the MT, weakly specific and valid for evaluation of soccer players, especially at this moment.

Another aim of the study was to evaluate the reliability (test-retest) of the two tests. The analysis of the Bland-Altman plotting for performance in the two protocols showed that they did not present heteroscedastic nor absolute systematic error; that is to say, the difference between test-retest does not bear significant correlation with the magnitude of the measurement nor presents tendency to be systematically positive or negative. Nevertheless, the test-retest analysis of the MT revealed that in two players the

differences between these pairs of measurements were high, close to the acceptance thresholds, proving low reproducibility of the measurement in this sample (Figure 4).On the other hand, the CV for the Yo-Yo IR2 was higher than for the MT (11% *vs.* 1%; Table 1), being hence a measurement with higher level of test-retest variability, being also stressed by the low ICC value (0.38). The variability found in the present study for the Yo-Yo IR2 is very close to the reported one (CV = 9.6 %) in the study by Krustrup *et al.*[20] itself for validation of this protocol.

This higher variability demonstrated by CV, Bland-Altman and ICC in the Yo-Yo IR2 reports the need to adopt strict standardization between the evaluation procedures for this protocol. One can infer hence that the interpretations of possible alterations associated with training or nutritional interventions, for instance, can be compromised by the low stability of the measurement and compromise the validity of a test[21]. The adoption of two or more measurements in the Yo-YoIR2 seems to be necessary to improve its stability. For example, considering that the individual performance correlation results in the Yo-Yo-IR2 with the PRT>85%MHR (results not shown) we found values of rs = 0.53; $p < 0.05$ (first collection) and rs = 0.60; $p < 0.05$ (second collection). It is seen hence that the ponderation of results improved the Yo-Yo IR2 correlation with the PRT>85%MHR (rs = 0.71; $p < 0.05$; Figure 1). Motivation strategies and turf condition can be also sources which will lead to low reliability of this protocol. It is worth remembering that the evaluators were the same and that there was a trail to minimize these factors. Despite of that, Bangsbo *et al.*[16] have considered that the Yo-Yo IR protocols present high reliability since the psychological components involved may alter the results within the test-retest. Since this is an exhaustive test as any other of this characteristic, the results may be dependent on the enthusiasm for high performance.

Low stability of the measurement can be an important limitation in the field tests compared to the procedures performed at controlled laboratory conditions[5]. However, a considerable limitation of the procedures in laboratory is its ecological validity; , once the training and competitions occur on the field, the evaluation procedures should be performed in the same environment as well[12,21]. Nevertheless, the importance of the $\dot{V}O_{2max}$ evaluation procedures on treadmill at laboratory conditions is highlighted, especially medical-sports through simultaneous cardiologic evaluation, making its performance crucial at least twice; one at the beginning of the season and the other in the middle of it, with the field tests being able to be used in other moments as means of control for the technical staff[4].

The main aim of the evaluation procedures in soccer is the simulation of the physiological demands of the $\dot{V}O2_{max}$. From the practical point of view, it is interesting that they are simple for the soccer daily routine. Thus, despite higher test-retest variability had been observed in the Yo-Yo IR2 in the present study, from the practical point of view this protocol presents the advantage of the evaluation time spent being shorter (usually from 5 to 10 min.)[16]. In the present study, the time spent was approximately 6 min. for this protocol and 10 min. for the MT. This may mean time gain when assessing many athletes, being also important for allowing a higher number of evaluations during the season. Moreover, the Yo-Yo IR2 can be performed with the training sessions, on the field, with specific soccer gear, becoming close to the competition conditions. These advantages of applicability may be interesting for the less rich clubs, in the base categories, where the indirect evaluations performed on the field are much used[1].

The last aim of this study to assess which stimulus (Yo-Yo IR2, MT or $\dot{V}O2_{max}$) provides the highest MHR peak value. The highest MHR value was found during the matches (202 ± 8bpm; $p < 0.05$) concerning the Yo-Yo IR2 (194 ± 4bpm) and MT (197 ± 6bpm) (Figure 5). Such fact is in agreement with the result found by Antonacci *et al.*[34] for high level Brazilian soccer players in the youth, junior and professional categories. They observed that the highest MHR value was observed in official match play, compared to the maximum exertion test (1,000m of continuous run) and by the prediction equation 220-age. According to Santos *et al.*[35], there is a string tendency that the MHR is higher in field tests than in laboratory tests. According to these authors[35], the differences between the MHR values obtained in these two environments may be partially explained by the fact that, as the temperature and air humidity are usually higher on the field, it would lead to higher physiological stress load. Moreover, the psychological aspect and the higher motivation for high performance in competition situations seems to be the main reasons which lead the MHR to be observed in competition situations, as also occurs to other modalities of intermittent characteristic such as rugby[36], American football[37] and Gaelic football[38].

In the present study, the MHR during the Yo-Yo IR2 was lower during the $\dot{V}O_{2max}$ and MT ($p < 0.05$) (Figure 5), which could underestimate this variable, and consequently the prescriptions of activities with intensity controlled by the HR. However, some studies recommend that the Yo-Yo IR2 can be a good indicator of MHR, since no differences have been observed ($p > 0.05$) concerning the $\dot{V}O_{2max}$ tests on treadmill[16,20] in adult players. Aspects such as duration of the evaluations in the Yo-Yo IR2 (~5 min), fatigue of lower limbs and motivation may have made the observation of higher MHR values difficult in the subjects of the present study. In the MT, the MHR was also underestimated compared to the one observed during the $\dot{V}O_{2max}$ (Figure 3). The lack of fatigue markers during the tests such as, blood lactate, muscular pH or plasmatic K^+ may be considered a limitation in the present study. These parameters would help to better characterize the tests and monitor the spent maximum effort or not by the players at the moment of the evaluations and differentiate between physiological and/or motivational limitation for such procedure. However, we must highlight that, since they are invasive measurements, the ethics committee sets limitations to them since the volunteers are young individuals.

Four players out of the 18 assessed (~22%) in the present study individual MHR was observed in the Yo-Yo IR2 or in the MT and not necessarily in the $\dot{V}O_{2max}$ situation. It is worth mentioning that the positions on the field have different exertion demand [2,18,19,24] and it can reflect on greater easiness or not in the position in presenting higher MHR value in the $\dot{V}O_{2max.}$ Additionally, we should mention the shortage of studies which shed attention to the relation between the positions taken in the $\dot{V}O_{2max}$ and the MHR. Thus, despite the literature mentioning that the higher MHR values occur in competition situations[34,36-38], it is recommended that this variable is evaluated in other exertion situations in soccer players. Therefore, there is a possibility that the players express the highest individual value, improving the accuracy of

the prescriptions and training control by the MHR. Afonso *et al.*[39] also alert on the circadian influence in the MHR response. Decrease in the MHR was observed in the dark phase of the dark-light cycle in their study using the Bruce protocol on treadmill, which would lead to the need to consider the individual circadian variations in order to observe and prescribe activities having this variable as a parameter, especially at later times.

Some of the limitations of the present study were the total controls of the work load prior to the evaluation procedures and HR habitual variability. The control of these situations is hardly performed in situations with teams in a competition period, since it imposes excessive organization and disturbs the team's regular time and training routine. Despite knowing the HR variability, many other studies were administered in soccer players using this variable to control the exercise intensity. Further studies should be performed with the aim to assess the correlation between other field protocols and/or direct measurement of oxygen consumption with other indicators of high performance during the $\dot{V}O_{2max}$ in order to evidence the more valid and with higher reliability evaluation procedures for young soccer players, which present great limitation of published information.

CONCLUSIONS

The results found in this study demonstrate that the Yo-Yo IR2 is more valid than the Margaria test, obtaining high correlation between performance in this protocol and performance in exercise high intensity during the matches in young players. However, this protocol presented higher variability, leading to the need to adopt strict standardization between the evaluation procedures in order to avoid compromising its reliability. The highest MHR value was found in the $\dot{V}O_{2max}$ compared to the two field tests, demonstrating hence that the competition situation can be the best reference for obtaining this variable.

All authors have declared there is not any potential conflict of interests concerning this article.

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