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ISSN (Online): 2322 – 4479

Original Article

Received: 21/08/2013

Accepted: 29/10/2013

The Relationship between Laboratory, Yoyo, and Hoff Tests in Determining Aerobic Capacity of Players of the National Women's Soccer Team

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ABSTRACT

Aerobic capacity bears importance in soccer. Although laboratory tests are of high credibility to measure the oxygen consumption among soccer players in laboratory conditions, field tests simulating the real need of soccer, without requiring complicated equipment, are necessary. The purpose of the present paper is to study the relationship between Hoff tests, Yoyo intermittent recovery test, and laboratory tests in determining the aerobic capacity of players of the national women's soccer team. Twenty female soccer players have participated in this study. The players executed the laboratory test on treadmill and determining VO_{2max} with the gas analyzer device, Hoff, and Yoyo intermittent recovery test of level two in three separate periods with at least a one-day interval. The aerobic capacity, heart rate, and lactate were measured at the end of every three tests. The lactate level of blood (ICC=0.61) and heart rate (ICC=0.66) had a significant correlation at the end of both laboratory and Hoff tests. The maximal consumed oxygen of Yoyo and laboratory tests didn't have a significant relationship. As for heart rate and blood lactate, no significant relationship was found at the end of the two tests. Also, no significant correlation was found between the results of Hoff and Yoyo tests, and they can't be used interchangeably. According to these results, it can be said that Hoff test is a valid test which easily evaluates VO_{2max} , without requiring the equipment imposing a financial burden on the national team, and whose physiological pressure is similar to the laboratory test.

Keywords: Yoyo, Hoff, Aerobic Capacity, Blood Lactate, VO_{2max} , Heart Rate.

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INTRODUCTION

One of the important factors in physical fitness is cardio-respiratory fitness which is the effective capacity of the heart, vessels, and respiratory system in delivering oxygen and nutrients to the working muscles. To evaluate this capability, measuring the maximal oxygen uptake or the aerobic capability (VO₂max) during exercise is used (1).

Although the precise measuring of aerobic capability is usually done by using complicated equipment with ventilation measurements in the laboratory, this method is not appropriate for evaluating the cardio-respiratory fitness of large populations like a soccer team which may be evaluated at different stages of exercise, besides, not every team does have the equipment to perform such tests. Therefore, some other tests such as running in different distances are used to estimate VO₂max in such circumstances. These tests are viable and inexpensive, and they take less time, and they are executable in large groups. An example of such tests is Yoyo intermittent test (YYIR) which has been designed to at two levels including level 1 for amateur players and level 2 for the professional ones in order to evaluate the aerobic capacity in sports like basketball, badminton, and soccer which have an intermittent nature (2).

On the other hand, athletes perform a variety of moves from standing to running with different intensities in sports like soccer. In these sports, especially soccer, aerobic and anaerobic performances are essential to optimally perform the technical and tactical performance. So, it would be more acceptable and applicable for the athletes to use a test which bears the characteristics of the respective sport and also estimates VO₂max with greater precision. On the other hand, these special tests provide the players with a high motivation level. In this regard, it has

recently been shown that dribbling the ball along a path can be a way to measure aerobic capacity of soccer players. One of these tests whose validity has been verified in some studies is Hoff test (3). For instance, Chamari et al. (2005) evaluated two tests of maximal increment on treadmill and Hoff, finding out that there was a significant correlation between VO₂max, fatigue period in incremental test on treadmill, and traveled distance in Hoff test (4). Also, Nassis et al. (2009) reported a significant correlation between Hoff tests and executing multistage 20-meter shuttle test (5). Anyhow, when Yoyo intermittent recovery and Hoff tests are chosen as the best field tests to evaluate VO₂max of soccer players (6), it should be taken into account that in which test the precision of VO₂max estimation is more in comparison with the laboratory test, and on the other hand, whether the chosen test imposes a similar physiological pressure on body, in comparison with the laboratory reference test, or not.

Although the validity of Hoff and Yoyo tests, which have been done on male soccer players, have been verified (2, 4), it is questioned in women's soccer, particularly in Iran where women seem to have lower physical fitness and skills than men. Considering the importance of the matter, the present survey is going to answer these questions if the results of the laboratory, Yoyo, and Hoff tests in evaluating VO₂max are related, and if the physiological stress (heart rate and lactate) imposed on body by the laboratory, Yoyo, and Hoff tests are related.

MATERIALS AND METHODS

This quasi-experimental study was performed with one sample test model.

Subject. 20 female soccer players who had at least 3 years of membership record and participated in the preparatory camp to

take part in the Asian competitions of Malaysia.

Evaluation of aerobic capability. The following tests have been used to measure the aerobic capability:

Yoyo intermittent recovery test of level 2.

Yoyo intermittent recovery test is common and known to coaches and is used in sports bearing an intermittent nature, such as basketball, badminton, and soccer. This test includes repetitive 2-by-20 shuttle runs between the starting, turning, and ending point, which are performable with the increasing sound of a horn controlled by a recorder. Behind the starting point and in 5 meters, there is another obstacle at which the subjects perform a 10-second active break including slow 2-by-5-meter run after the starting point between each 2-by-20-meter run. During the test, when a subject fails to reach the ending line for two times, the test will be over. The mileage is recorded at this time and the results are shown (6). Eventually, player's VO_{2max} is calculated by this formula:

$$VO_{2max} \text{ (ml/min/kg)} = \text{mileage of the test} \cdot 0.0136 + 45.3$$

Hoff test. Using the endurance tests of soccer which are a combination of running forward, backward, and side-to-side with turning and jumping has become common among coaches. In year 2002, Hoff made this test more special through using dribbling the ball and a field of 290 meter, which become known as Hoff test. This test is performed on a flat surface on which cones and obstacles are placed in certain distances. Currently, this test is executable both in 10-minute and 8-minute runs, and the 8-minute version has been used in the present survey. The subject directs the ball forward by dribbling the cones along the path, then three obstacles are placed with 20-centimeter height over which the subject passes the ball. After that, the subject ends the route. The subject must be over the

longest distance over 8 minutes. Each time the subject reaches the end of the route, he/she must try to run from the starting point again for the time to be up. The total mileage is recorded, and VO_{2max} can be calculated according to that.

The laboratory test. The players warmed up their bodies through stretching and exercising for 5 to 10 minutes, and then, they ran on H/P/COSMED treadmill made in Germany at 6 km/h for 4 minutes. Afterwards, 1 km/h was added up to velocity every minute, and the test continued until the individual was suffering from exhaustion. VO_{2max} was measured by the gas analyzer machine model QUARK B2 made in Germany. It should be noted that the machine was calibrated by an expert after each test. The test was a program defined in the machine, and the criteria for reaching VO_{2max} included the player's exhaustion, reaching the oxygen consumption diagram of the subject to minimum which was displayed on the monitor, reaching the respiratory exchange ratio to a number over that 2.1, reaching the heart rate to an amount over than the maximally predicted heart rate for the subject. If the individual had two of the mentioned factors, the test would end, and his/her maximal oxygen consumption would be recorded (7).

Method of implementation and data collection. Before the test, researchers gave explanations to the players of teams on the importance and necessity of desired tests and how to perform them, obtaining written consents from them. Also, players were asked to avoid extreme physical activities 24 hours before performing the test, confirming with the coaches. On the day of test, the researchers attended the soccer field number 2 in Azadi stadium (national team's camping site) at 9 AM and marked the field in specific areas of Hoff and Yoyo intermittent recovery test with obstacles. They also prepared the sound system for the execution of Yoyo intermittent test. On the day of test,

players were present at the field between 10 AM to 13 PM, and they performed stretching and aerobic exercises for 5 to 10 minutes before tests in order to warm up their bodies and prevent the possible injuries. They were asked to do their bests during the tests, but the purpose of the test was not revealed to them. The players were divided into two groups of 11 people to prevent the possible effect of learning on the execution of tests. The first group performed Hoff test, and the second group did Yoyo intermittent recovery test of level 2. On the second day of test, groups changed positions so that every player performs the desired tests. On the third day, players attended the National Olympic Academy and they were given the laboratory test to measure $VO_2\max$, in addition to measuring height (wall-mounted stadiometer named SECA made in Germany) and body composition (by Body Composition Device model In Body made in Korea). The players did the laboratory test on treadmill, measuring $VO_2\max$ with gas analyzer device, Hoff, and Yoyo intermittent recovery test of level 2 in three separate times with at least a one-day interval. At the end of each three tests, the heart rate was measured with an Oregon stethoscope made by PBC, and the lactate

was measured with lactometer model Lactate Scout made in Germany.

Statistical Analysis. The data analysis of research has been conducted at two descriptive and inferential levels. Normalizing data distribution was determined through using Kolmogorov-Smirnov test. In order to calculate the relationship between the laboratory test as the reference test and field tests, and also the relationship of field tests with one another, in research's variables, ICCs (Intraclass Correlation Coefficients) test was used in two random and hybrid models. Also, this link-evaluation was performed in Pearson's method. If there was a significant relationship between the reference test and each of the field tests in terms of the maximal aerobic capacity, Bland and Altman method would be used to make an agreement between the two tests. It should be noted that the error rate was considered $P < 0.05$ in all cases. All statistical operations were performed with SPSS 16, Excel 2003, and Med Calc.

RESULTS

The anthropometric characteristics of subjects are shown in Table 1.

Table 1. The anthropometric characteristics of survey's subjects (20 people)

	Age (year)	Weigh (kg)	Height (cm)	Fat mass (kg)	Muscle mass (kg)	BMI (kg/m^2)	Fat (%)
Mean± SD	23.2 ± 1.06	57.6 ± 7.49	163.0 ± 5.64	13.7 ± 4.81	24.1 ± 2.98	21.5 ± 2.74	23.4 ± 6.05

The maximally consumed oxygen in Hoff test (42.6 ± 4.15 ml/kg/min) was similar to the laboratory test ($43/6 \pm 5.23$ ml/kg/min), and there was a significant relationship ($ICC=0.83$) between the findings of two tests. Also, there was a significant relationship between the blood lactate ($ICC=0.61$) and heart rate ($ICC=0.66$) at the end of the two tests. There wasn't a significant relationship

between Yoyo and the laboratory test in terms of the maximally consumed oxygen. Regarding the heart rate and blood lactate, no significant relationship was found at the end of the two tests. There wasn't an interactively significant correlation between Yoyo intermittent recovery and Hoff tests in terms of evaluating the aerobic capacity of players of women's national soccer team. Also, no significant relationship was

observed between the blood lactate and heart rate at the end of Yoyo intermittent

and Hoff tests (Table 2).

Table 2. relationship of maximal aerobic capacity, blood lactate, and heart rate

Variable	Test	Mean \pm SD	ICC	P value
Peak aerobic power (ml/kg/min)	Laboratory	43.6 \pm 5.23	0.07	0.213
	Yoyo	50.8 \pm 2.43		
	Laboratory	43.6 \pm 5.23	0.83	0.001**
	Hoff	42.6 \pm 4.15		
Lactate (mmol/L)	Hoff	42.6 \pm 4.15	0.250	0.136
	Yoyo	50.8 \pm 2.43		
	Laboratory	9.5 \pm 2.01	-0.07	0.639
	Yoyo	11.7 \pm 4.64		
Heart Rate (beats/min)	Laboratory	9.5 \pm 2.01	0.61	0.001**
	Hoff	10.4 \pm 2.21		
	Hoff	11.7 \pm 4.64	-0.07	0.620
	Yoyo	10.4 \pm 2.21		
Heart Rate (beats/min)	Laboratory	183.4 \pm 7.60	0.29	0.074
	Yoyo	188.2 \pm 8.86		
	Laboratory	183.4 \pm 7.60	0.66	0.001**
	Hoff	185.3 \pm 9.17		
Heart Rate (beats/min)	Hoff	185.3 \pm 9.17	0.258	0.130
	Yoyo	188.2 \pm 8.86		

** : Significance at $p \leq 0.01$.

DISCUSSION

The results of the study didn't observe any interactively significant correlation between the results of two tests of maximal increment and Yoyo in terms of VO₂max value. According to the findings of the present research, it seems that there is no significant relationship between two tests of laboratory and Yoyo in terms of physiological stress. Perhaps, the reason is the difference between these two tests in terms of relaxation and recovery. The maximally incremental test is a test in which the subject runs continuously, but the Yoyo test includes active relaxation breaks. The observed difference in the results of these tests is probably a reflection of higher practice intensity in Yoyo intermittent recovery test (8). The obtained blood lactate and heart rate at the end of these two tests claims that no interactive correlation was seen between the blood lactate after the laboratory and Yoyo intermittent recovery

test. These findings are inconsistent with what Nicks et al. (2009) and Krusturup et al. (2006) found (8, 9). Nicks et al. studied collegiate female soccer players. The subjects performed Yoyo test of level 1 and 2 and graded laboratory test until failure. These researchers found out that VO₂max had a significant relationship with the execution of Yoyo level 1 and 2. Eventually, they announced that Yoyo tests of level 1 and 2 have a strong relationship with aerobic capacity, a fact which increased the possibility that these two tests are the primitive tests of fitness (9). Having studied on 30 men who had a usual exercise program and performed the incremental test on treadmill (ITT), speed tests, and Yoyo intermittent recovery test of level 2, Krusturup et al. (2006) found that the execution of Yoyo intermittent recovery test of level 2 had a significant relationship with ITT. They suggested that Yoyo intermittent test of level 2 could be used to

evaluate the capability of performing intense intermittent exercises in which energy conversion takes place between an aerobic state and an anaerobic one. They also stated that Yoyo intermittent recovery test of level 2 was a sensitive tool to distinguish the performance of intermittent exercises by soccer players in different seasons and situations of the game (8). Anyhow, all previous findings of the simple correlation (Pearson) were used to analyze their data. However, it has been tried to use a more precise statistical method in the present research. Therefore, ICCs method has been chosen to analyze the findings of this research. Also, in order for the results of the present study to be comparable with the previous studies, the relationship between the measured variables of this research has been calculated through Pearson's method which indicated a poor correlation coefficient ($r=0.24$).

The results indicated that the value of VO_{2max} obtained from the laboratory test had a significant correlation with the one obtained from Hoff test. Also, because of this significant relationship between Hoff test, lactate level, and heart rate at the end of the test, Bland and Altman method was used to make an agreement between two tests, which indicated that the findings of the two tests had a good agreement at standard deviation of ± 2 to/from the mean. This means that the results of two tests are 95% convergent and in agreement with each other.

Therefore, the relationship between two physiological index of blood lactate and heart rate at the end of two tests increases the possibility that physiological stresses of two mentioned tests are similar due to the natural similarity of these two tests.

Chamari et al. (2005) found consistent results with those of the present study. They studied the effect of the endurance training with ball in 18 male soccer players after 8 weeks of training and found that 8 weeks of

training increased Hoff's mileage by 9.6%. They also found that there was a significant correlation between VO_{2max} and fatigue time in the incremental test on treadmill and mileage in Hoff test, having compared these two tests. They also stated that the existence of ball in Hoff test brought a high motivation level to the players, seeming to be effective in increasing the estimation accuracy of VO_{2max} (4). Anyhow, the findings of the present research are inconsistent with those by Nicks et al. (2009). These researchers studied collegiate female soccer players and found that Hoff test didn't calculate VO_{2max} well. Their findings increased the possibility that factors like fitness and sports specific skills had roles in the performance of Hoff test, and this in coordination could be attributed to a lower level of the fitness of subjects who were collegiate soccer players (9).

No significant correlation was found in the results of Yoyo and Hoff tests in terms of VO_{2max} value. Also, no significant relationship was observed between measuring the level of blood lactate after Yoyo and Hoff tests. The findings of the present research are consistent with those by Nicks et al. (2009) (9), while they are inconsistent with the reports by Nassis et al. (2009). Having studied on 19 semi-professional men and performed three 20-meter multi-stage round-trip tests, Nassis et al. studied Bangs Bo and Hoff. They reported a significant correlation between Hoff and the performance of MSRT (5). Although, a multi-stage round-trip test has been used in their research, it resembled Yoyo intermittent recovery test since it was accompanied by running and body mass endurance. The results indicated that these two tests could not be used interchangeably. The subject can continue running at any speed he/she desires in Hoff test, doing things which have been done in trainings many times. Hence, the individual makes a good contact with the test and keeps up

exercising eagerly until the end of the test. It also allows the individual to speed up or slow down wherever he/she needs. This is right that soccer is a sport with intermittent runs, but all performed activities are not limited to running. Yoyo intermittent recovery test only insists on intermittent running. On the other hand, it increases individual's running speed unrealistically (10, 11). But, what happens in reality is different. In the real world of soccer, individuals adjust their own speed, which the intensity of work is often below maximum. It seems that what makes the game continue within 90 minutes also helps verify this fact, because it is not possible that the individual can do the maximal activity for a long time (12). So, according to the findings of the present study, it seems that Yoyo intermittent recovery test is not an appropriate test to evaluate VO₂max at least in the statistical society, and, like the previous findings, it insists on the fact that if a test is used to evaluate VO₂max, the closer it is to the desired sport, the more precise it will measure the aerobic capacity.

CONCLUSION

In the present study, Yoyo overestimates VO₂max rather than the laboratory test. It seems that there is no significant relationship between the laboratory and Yoyo test in terms of physiological stress. No interactively significant correlation was observed between blood lactate and heart rate after the laboratory and Yoyo tests, either. Perhaps, the reason is the difference between these two tests in terms of relaxation and recovery. On the other hand, the observed difference in the results of these tests may be a reflection of the higher intensity of work in Yoyo intermittent test. The results of this study indicated that Hoff test was able to predict the aerobic capacity of players in women's national team, in comparison with the laboratory test. Also, the results obtained from the evaluation of heart rate and blood lactate had a significant relationship at the end of two tests. Therefore, it is suggested that the coaches of women's national soccer team of our country use Hoff test to evaluate the aerobic capacity of female soccer players in this age range.

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مقاله اصیل

تاریخ دریافت: ۱۳۹۲/۰۵/۳۰

تاریخ پذیرش: ۱۳۹۲/۰۸/۰۷

تازه‌های علوم کاربردی ورزش

دوره اول، شماره سوم

صص ۵۷-۶۶، پاییز ۱۳۹۲

ارتباط بین آزمون‌های آزمایشگاهی، یویو و هاف در تعیین توان هوازی بازیکنان تیم ملی فوتبال زنان

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چکیده

توان هوازی در فوتبال حائز اهمیت است. هر چند آزمون‌های آزمایشگاهی دارای اعتبار بالایی برای اندازه‌گیری اکسیژن مصرفی بازیکنان فوتبال در شرایط آزمایشگاهی هستند، اما وجود آزمون‌های میدانی که نیاز واقعی فوتبال را شبیه‌سازی کنند و به تجهیزات پیچیده نیاز نداشته باشند، ضرورت دارد. هدف مطالعه حاضر، ارتباط میان آزمون‌های هاف، بازیافت تناوبی یویو با آزمون آزمایشگاهی در تعیین توان هوازی بازیکنان تیم ملی فوتبال زنان بود. ۲۰ زن فوتبالیست در این مطالعه شرکت کردند. بازیکنان، آزمون آزمایشگاهی بر روی نوارگردان و تعیین VO_{2max} با دستگاه آنالیزور گاز تنفسی، هاف و بازیافت تناوبی یویو سطح ۲ را در سه نوبت مجزا با حداقل یک روز فاصله اجرا نمودند. توان هوازی، ضربان قلب و لاکتات در انتهای هر سه آزمون تعیین شد. اکسیژن مصرفی بیشینه در آزمون هاف و آزمایشگاهی مشابه بود و ارتباط معنی‌داری ($ICC=0/83$) بین یافته‌های دو آزمون بود. سطح لاکتات خون ($ICC=0/61$) و ضربان قلب ($ICC=0/66$) انتهای دو آزمون هاف و آزمایشگاهی نیز همبستگی معنی‌داری داشتند. اکسیژن مصرفی بیشینه در دو آزمون یویو و آزمایشگاهی ارتباط معنی‌داری نداشتند. در مورد ضربان قلب و لاکتات خون انتهای دو آزمون نیز ارتباط معنی‌داری یافت نشد. همچنین همبستگی معنی‌داری بین نتایج دو آزمون هاف و یویو مشاهده نشد و نمی‌توان این دو آزمون را به جای هم بکار برد. بر اساس این نتایج می‌توان بیان کرد که آزمون هاف آزمون معتبری است که بدون نیاز به تجهیزاتی که بار مالی فراوانی را به تیم ملی تحمیل نماید، به راحتی VO_{2max} را مورد سنجش قرار می‌دهد و فشار فیزیولوژیکی آن نیز مشابه آزمون آزمایشگاهی است.

واژگان کلیدی: یویو، هاف، توان هوازی، لاکتات خون، ضربان قلب، VO_{2max} .

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