Middle-East Journal of Scientific Research 18 (11): 1557-1562, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.18.11.12454

The Investigation of Heart Rate Variation on Endurance of Professional Soccer Players

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Abstract: The main aim of the present study was to determine whether performance on the Yo-Yo intermittent endurance test can predict the real match performances, or not. The sample of players consists of elite professional soccer players (age 23.02±4.49 years, soccer experience 10.04±4.2 years, body mass 73.61±6,15 kg, height 1,79 ±0,52 m, body mass index 19,12 ±0,4 kg m^2, body fat 8,32 ±2,96 %) who were the members of the Turkish Soccer Federation. For assessment of aerobic endurance performance used, the Yo-Yo intermittent endurance test level 1 was performed. Heart rate was recorded by a Polar Vantage NV heart rate monitor placed around the chest for continuous heart rate recordings throughout selected stages of the test. Descriptive statistics were calculated. Data are expressed as means and standard deviations for each variable. It is seen that the research group uses 83 % of MaxHR in average Heart Rate according to minimum, average and maximum HR values obtained according to max HR values of the research group. As a conclusion, it is understood that heart rate is an important factor obtained from the yo-yo test that the soccer players show similar efforts during the competition. So the heart rate values taken from this test used as intermittent test has the quality to estimate the players match performance.

Key words: Heart Rate · Yo-Yo Intermittent test

INTRODUCTION

The activity profile and physiological demands of team sports such as soccer have been studied extensively over the last 3 decades [1, 2].

Soccer is an intermittent sport characterised by sustained movement incorporating frequent bursts of high-intensity activity interspersed with regular recovery periods [3-7].

Soccer also involves low intensity running interspersed with high-intensity actions over 90 min [8]. It has been reported that youth soccer players cover distances of approximately 6-9 km during competition [9, 10].

In soccer match-play, over 90% of energy is provided by the aerobic metabolism and the average intensity of exercise is close to the anaerobic lactate threshold [11].

Soccer match-play performance is affected by players' aerobic metabolism and previous research has shown that aerobic endurance performance is affected by several factors, including maximal aerobic capacity (VO2max), exercise economy, lactate threshold and oxygen uptake kinetics [12].

Improved aerobic endurance of soccer players has been reported to improve physical performance in match-play. Players run greater overall distances, so perform more actions with the ball and demonstrate similar technical performance despite performing at significantly higher exercise intensity [10].

Assessment of aerobic endurance performance in youth soccer players on a regular basis is important to monitor their fitness, the effectiveness of physical conditioning programmes and prepare for further training content. Intermittent aerobic endurance field tests that simulate the exercise pattern of soccer have been developed with the aim of assessing players' aerobic endurance performance [13, 14].

A variety of laboratory and field tests are currently used in elite soccer in order to evaluate physical performance, such as treadmill tests for determination of maximal oxygen uptake VO2 max and free running tests performed in the field [15-19].

In soccer the exercise is intermittent and performance is related to the players' ability to perform bouts of short, high-intensity exercise punctuating longer periods of low-level, moderate-intensity exercise. It has been shown

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that the quality of performance in soccer is correlated with the amount of high-intensity exercise performed throughout a match [1, 20, 4, 5, 21]. Thus, it seems logical to assess the players' ability to perform high-intensity exercise repeatedly after prolonged intermittent exercise [9].

Based on the rationale that existing continuous tests lacked relevance and specificity to intermittent team sports such as soccer [22, 23, 24, 17], the Yo-Yo intermittent recovery (Yo-Yo IR) and endurance tests (Yo-Yo IE) were developed [25].

The Yo-Yo intermittent endurance tests (YYIET) are frequently used by elite soccer clubs and have recently been used to evaluate game induced fatigue patterns in elite female soccer players [6]. Thus, the YYIET still needs to be examined to determine whether it is a reproducible and a sensitive tool to evaluate the intense intermittent exercise performance of elite soccer players in different performance levels, playing positions and if it relates to match performance.

The validity of YYIET has been widely studied [26, 27], whereas the Yo-Yo intermittent endurance test has received little attention. Previous studies reported moderate to high correlations (r =0.47-0.65) between peak VO2 values obtained during treadmill running and the YYIET in adolescent soccer players aged approximately 16-18 years [26, 28]. Despite the fact that the validity of the YYIET in young soccer players has yet to be shown, it has been used in several studies to assess aerobic endurance performance in soccer players aged 11-15 years [29, 30].

[26] suggested that performance on the YYIET, which as an aerobic endurance performance test, is not solely determined by maximal aerobic capacity in adolescent soccer players, but there is no information available in the literature on the association between the YYIET and other physical capacities, such as soccer dribbling endurance performance and power performance in young soccer players.

Recent observations suggest that heart rate measurements during sub-maximal versions of the YYIET could provide useful information about the fitness level of elite soccer players [31].

[32] established that heart rate, expressed as a percentage of maximal values obtained after 6 min of the YYIET was found to be inversely correlated to the performance of the YYIET. Furthermore, elite male soccer player's heart rates were found to be consistently higher throughout a Yo-Yo IR test performed at the start of the pre-season compared with the start of the competitive season [27].

Heart rate recordings and analyses of muscle and blood samples obtained during match-play suggest that the aerobic loading is high throughout matches and the anaerobic energy turnover is extensive during intense periods of the game [24, 2, 33, 34].

However, no research to date has evaluated the heart rate response to sub-maximal versions of the YYIET. It would be of interest to establish if non-exhaustive YYIET could be used alternatively by elite soccer clubs to evaluate training status of players, to predict match performance and to determine the effect of training interventions.

Therefore, the main aim of the present study was to determine whether performance on the Yo-Yo intermittent endurance test can predict the real match performances, or not.

MATERIALS AND METHODS

Participations: Research groups consist of 3 professional male soccer players ($n_{forward}$=13; $n_{defence}$=25; $n_{midfield}$=24) participated in the study during the regular season. Players were instructed to give their maximal efforts during all tests. The sample of players consist of elite Professional soccer players (age 23.02 ±4.49 years, soccer experience 10.04±4.2 years, body mass 73.61±6,15 kg, height 1,79±0,52 m, body mass index 19,12 ±0,4 kg/m^2, body fat 8,32 ±2,96 %) who were members of the Turkish Soccer Federation.

Measurements: Height and body mass were measured with shorts and a t-shirt before the test procedure, Height was measured with an anthropometer to the nearest 0.1 cm; Body mass was measured to the nearest 0.2 kg with a digital scale that was calibrated daily. The body mass index (BMI, kg.m^{-2}) was calculated for each player.

For assessment of aerobic endurance performance used the Yo-Yo intermittent endurance test level 1 (YYIET) was performed. Following the pre-recorded acoustic signals of the YYIET, players run for 20 m, turn around and then run to the starting line. Then, the players jog and turn back in a 2.5-m shuttle during the 5 s of active recovery. The test was terminated when a player was unable to maintain the required speed. The distance covered in the shuttles was recorded for analysis, but the distance covered during rest was excluded [26].

Heart rate recordings during and in recovery from a given number of shuttles was used as a marker of performance. Heart rate was recorded by a Polar Vantage

NV heart rate monitor (Polar Electro Oy, Kempele, Finland) placed around the chest for continuous heart rate recordings throughout selected stages of the test. Heart rate was recorded every 1 s during the test using Polar Vantage NV heart rate monitor (Polar Electro Oy, Kempele, Finland). All testing sessions were performed outdoors on a grass surface marked by cones.

Statistical Analysis: All statistical analyses were conducted using SPSS for Windows 17.0. Descriptive statistics were calculated. Data are expressed as means and standard deviations for each variable. Normality assumption was checked using the Kolmogorov-Smirnov test and from visual inspection of the normality plot.

RESULTS

The statistical analysis results belonging to some parameters obtained from the players in the research group are given as tables below.

The mean and standard deviations (SD) values belonging to some parameters are given in the Table 1.

When examining the Table 1, the values MaxVO^2 53.36±6.42 and MaxHR 196.10±4.75 were obtained from the YYIET that the players run average 2040.20±458.66 m.

The mean, standard deviation values belonging to the players' minimum, average and maximum HR numbers and percentages were given in the Table 2.

When examining the Table 2, it is seen that the research group uses 83 % of MaxHR in average HR and also uses 49 % of MaxHR in minimum HR obtained according to maxHR values of the research group.

The players' percentage ranges of using HR and time and percentages of passing above threshold are given in the Table 3.

When examining the Table 3, it is determined that the players run maximum between the rates of 90% and 100 % and run above the threshold during the time more than the half of their total run distance according to the players' Max HR values during YYIET.

The soccer players' HR mean and standard deviation values of run and rest (5sec.) in different speeds are given in the Table 4.

The soccer players' HR mean and standard deviation values of run and rest (5sec.) in different speeds are given in the Chart 1. When examining the Table 4 and Chart 1, it can be said that 5 seconds of rest HR after the loadings in different speeds show linear increase and exhaustion of the players results from insufficiency of rest pulse. The values of rest pulse are close to loading HR (For load; y=4,565x+124,2; R^2=0,83; For rest; y=4,331x+127,5; R^2 = 0,837).

Table 1: The run distance of the soccer players, max VO^2, max HR and loading time mean and standard deviation values

Variables	Mean	SD
Run Distance (m)	2040.20	458.66
Max VO^2 (ml/kg/min)	53.36	6.42
MaxHR (beat)	196.10	4.75
Loading Time (min:sec)	21:11	04:09

Table 2: The mean, standard deviation values belonging to the players' minimum, average and maximum HR numbers and percentages

HR	Minimum	Average	Maximum
Mean	97,67	163,95	192,17
SD	19,01	11,99	8,59
HR Percentage	Minimum %	Average %	Maximum %
Mean (%)	0,49	0,83	0,98
SD (%)	0,10	0,07	0,05

Table 3: The players' percentage ranges of using HR and time and percentages of passing above threshold

HR	50-59	60-69	70-79	80-89	90-100	Above threshold
Mean (min:sec.	02:22	02:08	01:59	04:41	10:00	11:03
SD (min:sec)	02:17	01:15	01:06	02:50	04:46	04:45
HR Percentage	50-59 %	60-69%	70-79%	80-89%	90-100%	Above threshold %
Mean (%)	0,11	0,10	0,09	0,22	0,47	0,52
SD (%)	0,11	0,06	0,05	0,10	0,20	0,19

Table 4: The soccer players' HR mean and standard deviation values of run and rest (5sec.) in different speeds

Run Speed	Mean (beat)	SS (beat)	Rest Mean (beat)	Rest SS (beat)
10 kmh	111,15	23,31	119,71	26,45
11,5 kmh	123,03	26,98	124,94	27,89
13 kmh	128,53	29,55	130,11	30,63
13,5 kmh	133,56	34,99	134,55	35,74
14 kmh	145,78	30,84	148,06	30,08
14,5 kmh	163,22	19,58	164,23	18,76
15 kmh	173,55	12,85	173,95	12,69
15,5 kmh	176,84	15,14	176,94	15,73
16 kmh	178,70	20,62	178,78	20,88
16,5 kmh	180,97	19,03	181,41	17,39
17 kmh	184,48	11,32	184,60	11,26
17,5 kmh	185,07	10,60	185,07	10,56
18 kmh	185,76	10,44	185,85	10,37
18,5 kmh	184,63	10,02	184,50	10,07
19 kmh	184,70	10,87	184,71	10,93
19,5 kmh	190,37	10,27	190,33	9,07
20 kmh	192,15	10,05	192,44	10,57
20,5 kmh	195,27	9,36	195,55	9,27

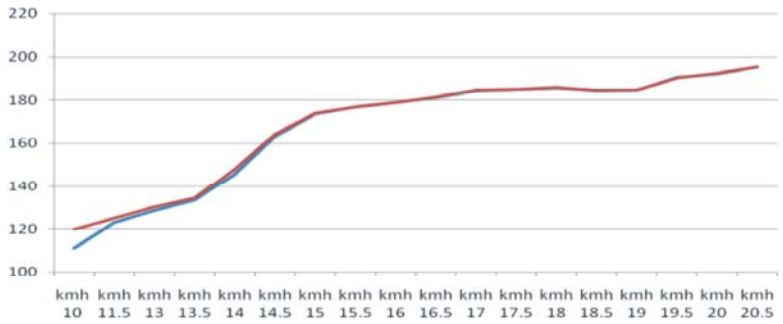

Chart 1: The soccer players' HR mean and standard deviation values of run and rest (5sec.) in different speeds

DISCUSSION

It was not possible to establish significant relationships between YYIET performance (distance covered) and treadmill VO^2peak. This means that YYIET performance is not solely determined by an individual's maximal aerobic power [26]. In the present study, there was a high correlation between distance covered in the Yo-Yo intermittent endurance test and HRmax. The previous research's finding is in disagreement with our study that hearth rate values show maximal aerobic power output.

The ability to accelerate, decelerate and turn may contribute to performance during the YYIET has given that this type of activity is observed in competitive soccer [35]. It could be speculated that players with better YYIET performance may be more efficient during actual match play. However, this could be only confirmed with physiological measurements coupled with match and time motion analyses.

The YYIET evaluates an individual's ability to repeatedly perform intermittent exercise with a high aerobic component towards the end of the test; whereas during the YYIET, both the aerobic and anaerobic energy systems are highly taxed. Both of them evaluate the individual's ability to recover from intense exercise [36].

A number of studies have shown the sensitivity of the YYIETs' in discriminating players' performance at various competitive levels, among different playing positions and after periods of different types of training. In addition, their reliability and validity are well known and strong correlations were found, for example, between YYIET performance and the amount of high-intensity running during a soccer game, The YYIETs' can be used to determine athlete's ability to perform intense intermittent exercise. Sports characterised by intermittent exercise can examine seasonal changes in athlete physical capacity in a simple and effective manner [36].

The previous studies were reported for the effectiveness of intermittent exercise heart rate has important factor. These findings suggest that heart rate can provide information about the capacity of an individual, if the yo-yo test is of sufficient duration.

That heart rate measurements can be utilized is supported by the observation that the heart rate, expressed as a percentage of maximal heart rate, during the YYIET was inversely related to work performed at a high intensity during a soccer game [32].

The study being about heart rate of the Danish National soccer players preparing for EURO2004 was suggest that heart rate measurements during a submaximal version of the YYIET provide useful information about the fitness level of an individual [3].

The present study has shown similar results that during the test a majority of heart rate values were seen above threshold.

The investigations results showed that during the YYIET the aerobic energy system is heavily taxed and that the neuromuscular requirements caused by the direction changes could be similar to those involved during actual match play. These characteristics could suggest that the YYIET can be used as indicator of aerobic-specific endurance more than generic aerobic power. [17, 21] found in adult professional soccer players good correlations between test performance (distance covered) and physical match-performance during actual match-play.

YYIET can be used to rapidly determine the maximal heart rate of an individual. Such measurements are useful in the evaluation of heart rates obtained during training. YYIETs' are therefore stimulating the aerobic system maximally [27, 33]. These studies support our findings that MaxHR and average HR both of them affect the aerobic capacities. Also the researches propose that the tests should be above threshold HR in a similar with our findings.

CONCLUSIONS

As a conclusion, it is seen that heart rate is an important factor obtained from the yo-yo test that the soccer players show similar efforts during the competition. So the heart rate values obtained from this test used as intermittent test has the quality to estimate the players match performance.

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