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Original Article

The level of aerobic capacity in elite youth soccer players and its comparison in two age categories

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Abstract
Purpose The main purpose of this study was to compare total run distances, which is an indicator of a player's aerobic capacity, in U16 and U17 junior categories in intermittent recovery Yo-Yo test. The secondary purpose was to find out physiological responses (maximum heart rate and maximum oxygen consumption value) in Yo-Yo intermittent recovery test (Yo-Yo IRT).
Material and method The monitored groups consisted of U16 category (n = 14, age = 15.5 ± 0.2 years, body height = 173.6 ± 7.8 cm, body weight = 64.5 ± 6.8 kg) and U17 category (n = 16, age = 16.4 ± 0.3 years, body height = 178.8 ± 6.4 cm, body weight = 70.6 ± 8.3 kg) players. To examine maximum aerobic capacity, Yo-Yo IRT was used. This field test is focused on assessment of run distance, VO_{2max} and heart rate (HR). For statistical verification of research data, we used parametric t-test for independent samples, same variances, which were verified by Leven's test for equality of variances. Probability of rejecting null hypothesis was set at the level of $p<0.05$.
Results The average run distance in U16 players 1594.3 ± 287.1 m and U17 = 2002.5 m ± 331.9 m.
This difference was statistically significant $t_{28} = -3.58$; $p<0.01$ and equalled 20.4 %. The maximum value of heart rate (HR_{max}) in the younger players was HR_{maxU16} = 198.9 ± 6.6 beat .$min^{-1}$and HR_{maxU17} = 194.8 ± 6.8 heart rate.min^{-1}. The maximum oxygen consumption value (VO_{2max}) was $VO_{2maxU16}$ = 49.4 ± 2.7 ml.kg^{-1}.$min^{-}$and $VO_{2maxU17}$ = 52.8 ± 3.2ml.kg^{-1}.min^{-1}
Conclusions These results are in accordance with theoretical knowledge which indicates that the players are able to achieve better performance in Yo-Yo IRT with increasing age or quality of competition.
Key words: soccer, Yo-Yo IRT, youths, aerobic capacity, VO_{2max}, HR_{max}

Introduction

A soccer match is the culmination of a one-week micro-cycle which should contain fitness, technical, tactical and psychological components. In terms of the fitness component, we should focus on load intensity during the match, movements typical for soccer and demands on individual soccer positions (jumping, agility, etc.). The soccer match is characterized by intermittent physical load in which periods of high intensity are alternated with periods of low intensity. Some authors (Bangsbo, 1994; Bangsbo et al., 1991; Reilly et al., 1976; Mohr et al., 2003) found out that, according to time – motion analysis, players are able to run 9 – 12 km during a match. High load intensity is a crucial element distinguishing players of elite and lower levels. Elite level players perform 2 – 3 km higher in running intensity (> 15 km/h) and 0.6 km in sprint (> 20 km/h) (Iaia et al., 2009). The rest of the match, which totals approximately 80 – 90 % of performance, takes place in lower or medium activities (Bangsbo, 1994, 1997; Rienzi et al., 2000). Even players, have to exhaust themselves excessive echelon which brings lots of physiological changes as per the intensity of the football match. In terms of fundamental issue of soccer science, the level of intensity, effort and physiological changes during the match should be considered (Pawar et al., 2011).

Field tests that provide specific information about components of sport training are used for identifying components of physical fitness preparedness. The main reasons for testing soccer players are the following: monitoring the effect of training programmes, motivation for higher effort in training, obtaining feedback about fitness level, competitiveness in a team or in a match, return on the performance level during recovery and convalescence, identifying player's weaknesses and planning short-term or long-term training programmes (Bangsbo et al., 2006). Bangsbo et al. (2008), Krustrup et al. (2001) state that Yo – Yo IRT is used for assessing players' aerobic capacity. The players perform high intensity running over short distances with the focus on quick restoration of the organism in a short period. In a soccer match, which is characterized by intermittent physical load, high demands are put on aerobic capacity. Yo – Yo IRT and physical performance during a soccer match significantly correlate in the number of high intensive running parts (Krustrup et al., 2003). One of the

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most important determinants for assessing aerobic capacity in soccer is VO_{2max} (Helgerud et al., 1990; Hoff et al., 2002). Players with a high level of VO_{2max} have high glycogen stores which are necessary for energy release during activities performed in high load intensities or in sprints (Bangsbo et al., 1988). Smaros (1980) add that the value of VO_{2max} is crucial especially towards the end of a match (the last 20 minutes), which is considered to be a decisive phase of the match. High values of VO_{2max} play an important role in regeneration processes after the match or intensive training units where a player's speed increases (Bangsbo et al., 1988; Ekblom, 1986). Average heart rate during the match is approximately 85 % of HR_{max} and maximum heart rate is about 98 % of HR_{max} (Ali et al., 1991; Bangsbo, 1994; Ekblom, 1986; Krustrup et al., 2005). Heart rate during a (common) match featuring elite players does not decrease under 65 % of HR_{max} (Bangsbo et al., 2002; Krustrup et al., 2004), unless an unexpected situation appears and the game is stopped for a longer time (player's severe injury, fans' improper behaviour). A very important factor in a player's performance during a match is the ability to repeatedly perform intermittent, high intensive activity (Krustrup et al., 2001; Krustrup et al., 2005; Mohr et al., 2003; Mohr et al., 2005).

To increase players' fitness level by performing high intensity activities during a match, it is important to create targeted training and testing strategies and monitor its progress (Impellizzeri et al., 2006; Rampini et al., 2007).

The main purpose of this study was to compare total run distances in junior U16 and U17 categories in intermittent recovery Yo-Yo test. The secondary purpose was to find out physiological responses (HR_{max} and VO_{2max}) in Yo-Yo IRT.

Methods

Participants

The screened sample consisted of junior soccer players of U16 and U17 categories, who compete in top competitions in their categories. Both teams have five training units and one match during a common one-week micro-cycle. TheU16 group was composed of 14 players (1 goal keeper, 5 defenders, 5 midfielders and 3 attackers) and the U17 group consisted of 16 players (1 goalkeeper, 5 defenders, 6 midfielders, 4 attackers). The players' characteristics are stated in Table 1 for U16 category and in Table 2 for U17 category.

age (years)	15.5±0.2
body weight (kg)	64.5±6.8
body height (cm)	173.6±7.8
body fat (%)	9.3±2.1

Table 1 Characteristics of U16 players

age (years)	16.4±0.3
body weight (kg)	70.6±8.3
body height (cm)	178.8±6.4
body fat (%)	9.5±2.1

Table 2 Characteristics of U17 players

Test protocol

Field testing was performed in outdoor conditions on artificial grass and the average temperature ranged between 22 – 24 ˚C and humidity between 60 – 70 %. The test was carried out in the middle of the season. Prior to the testing, the players performed a warm-up (15 min) which was composed of running, stretching and 6 sprints over a distance of 10 m. The period between the warm-up and the test was 45 min long and players performed activities focused on speed and agility. The players' HR was monitored before, during and after the test by means of a Polar RS400 heart rate monitor (Polar, Kempele, Finland).

To examine maximum aerobic capacity, Yo-Yo IRT was used. This field test is focused on (according to Krustrup et al., 2003; Bangsbo et al., 2008; Castagna et al., 2003) assessment of run distance, VO_{2max} and HR. Yo-Yo IRT consists of repeated lengths 2x20 m, when players are running back and forth according to an audio signal.

Each player was tested in his own area which was 2 m wide, 20 m long and 5 m for active recovery. This area was marked by cones. The total time of testing did not take more than 20 minutes.

After finishing 2×20 m, players had 10 s for active recovery which consists of 2 × 5 m walking or jogging. If the player does not reach the line two times in the given time interval, the test is finished for him and his total distance is recorded.

Yo-Yo IRT has two different levels (level 1 and 2). In our study, level 1 was used. Level 1 is composed of 4 runs (2x20 m) at 10 – 13 km.h^{-1} (0 – 160 m) and the next seven runs at 13.5 – 14 km.h^{-1} (160 – 440 m); after that the speed is increased by 0.5 km.h^{-1} after each 8 runs (it means after 760, 1080, 1400, 1720 m, etc.) up to vita maximum. For calculation of VO_{2max}, we used prediction equations according to Bangsbo et al. (2008):

VO_{2max} (ml.kg^{-1}.min^{-1}) = IR distance (m) × 0.0084 + 36.4

Players were given instructions about the test, prior to test commencing.

Statistical analysis

For statistical verification of research data, we used parametric t-test for independent samples, same variances, which were verified by Leven's test for equality of variances. Probability of rejecting null hypothesis was set at the level of $p<0.05$. Results were processed by means of IBM SPSS v.19.0.

Results

The average elapsed distance in players U16 = 1594.3 ± 287.1 m and U17 = 2002.5 ± 331.9 m. This difference was statistically significant t_{28} = -3.58; $p<0.01$ (Table 3, Figure 1) and made 20.4 %. The values of maximum heart rate in the younger players were HR_{maxU16} = 198.9 ± 6.6 beat.min^{-1} and HR_{maxU17} = 194.8 ± 6.8 beat.min^{-1}. The values of maximum oxygen consumption after finishing Yo-Yo IRT were $VO_{2maxU16}$ = 49.4 ± 2.7ml.kg^{-1}.min^{-1} and $VO_{2maxU17}$ = 52.8 ± 3.2 ml.kg^{-1}.min^{-1}.

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Yo-Yo IRT1	0.27	0.61	-3.58	0.00	-408.21	114.15	-642.04	-174.39

Table 3 Statistical significance of different performance in Yo-Yo IRT1 between categories U16 and U17

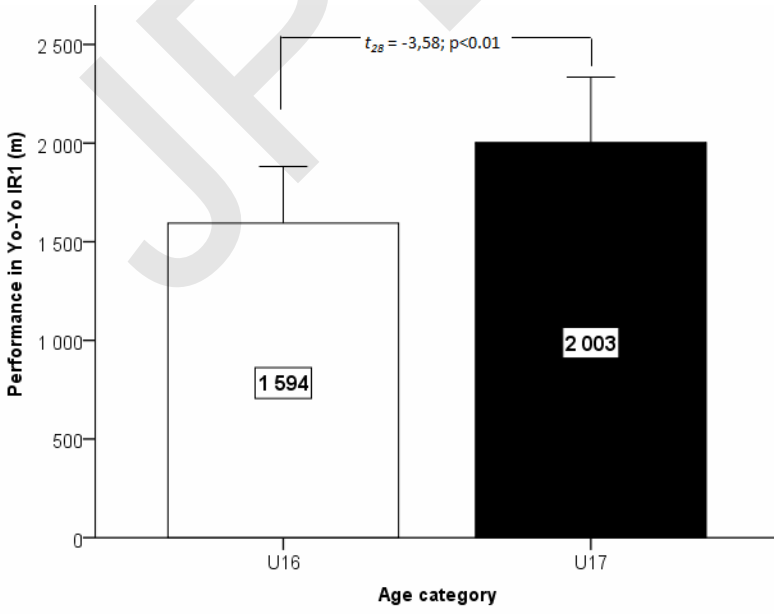

Figure 1 Graphical expression of the mean and variability (standard deviations) in Yo-Yo IRT1 between the examined groups

Discussion

The results of the study indicate that players of the U17 category perform more intensive runs in Yo-Yo IRT than U16 players. The ability to produce and accelerate regeneration processes after high intensity load during a soccer match is important for quality performance in terms of fitness predispositions (Bangsbo, 1994; Ekblom, 1986; Fitzsimmons et al., 1993). When comparing results of the U16 category with Australian elite

soccer players of the same category (1910 m, n=20) in Yo-Yo IRT they are significantly behind. The U17 category achieved similar results. Elite U16 players in Czech soccer have similar results as the same category in Australian soccer but at a lower performance level (1438 m, n=20) (Veale et al., 2010). The results are in accordance with another study (Stroeyer et al., 2004), which found that the load intensity during a match gradually increases in young players with age. U17 category players achieved a greater distance in the test than U16 players. In comparison to U14 players (842 m; n=21) (Castagna et al., 2009) it means significantly greater total distance for U16 and U17 categories. When comparing U16 and U17 categories with adult players, a decisive variable is not age, but rather the player's level (players from national teams, professional competitions, amateur competitions, etc.). Elite international level players (national teams, European cups) cover the greatest distance (2420 m; n=25) in Yo-Yo IRT1. Elite level players in national competitions (the best teams) covered 2190 m (n=71). Lower performance players in national competitions (2030 m; n=89) run a greater distance than semi-professional players (1810 m; n=29) (Mohr et al., 2003; Krustrup et al., 2003; Castagna et al., 2006). Elite players perform more high intensity runs during matches than players of lower performance level (Iaia et al., 2009; Mohr et al., 2003) and results in Yo-Yo IRT shows this clearly. U17 players in the highest Czech competition of this category may, according to results from Yo-Yo IRT, compete with common adult players in national competitions in the number of high intensity activities. U16 players are significantly, concretely, behind adult players in terms of total distance, by 34.1%, 27.2%, 21.5% and 11.9 % according to the player's level. For players who perform more high intensity load, it is important to supply more energy in anaerobic way because during a match, they utilize 80 – 90 % of their energy from their aerobic energetic system. A player can then work at a high intensity level for a longer period of time. Glycogen stores are thus spared and players may work at high intensity level towards the end of game time (Bangsbo et al., 2008). Values of VO_{2max} identified in Yo-Yo IRT are lower than values measured in a graded running test on a treadmill up to vita maxima (Bangsbo et al., 2008; Krustrup et al., 2003). However, assessment of the VO_{2max} parameter in Yo-Yo IRT is not as precise as graded running tests up to vita maxima carried out in laboratory conditions (Bangsbo et al., 2008; Castagna et al., 2006). The reason is that this test assesses anaerobic load and recovery processes during the test to a large extent. This test better reflects the ability to repeatedly perform intensive load than VO_{2max} (Krustrup et al., 2001; Krustrup et al., 2003). In a training process, results can serve as a continuous indicator of fitness level, but not as the indicator for individualization of load intensity (Dupont et al., 2010).

Professional players (n=9) performed Yo-Yo IRT during pre-season training and their VO_{2max} was 55.3 ± 1.3 $ml.kg^{-1}.min^{-1}$ (Barbero Alvarez et al., 2007). Krustrup et al. (2003) also tested professional soccer players (n=10) in the pre-season period and values of VO_{2max} were 51.3 ± 1.1 $ml.kg^{-1}.min^{-1}$. These values indicate that adult professional players have different values of $VO_{2max.}$at the beginning of the season. U17 category players achieved similar values of VO_{2max} as players tested in the study by Krustrup et al. (2003), however, the test was carried out in the middle of the season. U16 category players have remarkably lower values of VO_{2max} measured in the middle of the season than both categories of players in pre-season training.

Heart rate frequency gradually increases during the test and reflects gradually increasing oxygen consumption. At the end of Yo-Yo IRT, we monitor maximum heart rate with a standard deviation 99 ± 1 %, or similar to maximum heart rates that players achieved on a treadmill (Krustrup et al., 2003; Krustrup et al., 2006). Therefore it is possible to find out individual values of HR_{max} during training units without any demanding equipment and organization.

Young soccer players should not be considered as little adults because in the U16 category we may observe differences in fitness and anthropometric variables. When comparing the U17 category with adult players (players of average performance in their categories) there is a considerable equability in physical predispositions but there are still deficiencies in anthropometric parameters. However, it is inevitable to constantly create pressure on fitness coaches so that technical and tactical skills could be developed together with fitness predispositions. It is important that players will be later able to cope with the demands during a match and transition to an adult category (Reilly et al., 2000). The results prove that young players, similarly to their older colleagues, need well developed physical predispositions during a match (especially intermittent, high intensity endurance) in order to be competitive in their age category (Stroyer et al., 2004). Data obtained by means of Yo-Yo IRT may lead to a higher quality training process focused on high intensity load. By means of physiological testing of players, sport sciences may analyse factors determining sport performance (health state, genetic predispositions or the way a player works in training) and provide information of the player's strengths and weaknesses (Svensson et al., 2005).

Conclusion

The field test, Yo-Yo IRT1, confirmed our presumption that U17 category players were, in terms of total covered distance and values of $VO_{2max,}$ better than U16 category players. Values of HR_{max} proved that great demands were put on aerobic energetic system during Yo-Yo IRT up to vita maxima.

The diagnostic test, Yo-Yo IRT1, may be considered as a very beneficial tool for coaches of youth categories or fitness coaches of adults. It includes elementary movement skills which often appear in a match (reaction,

acceleration, deceleration or turning). The results of the test are useful for a coach from the perspective of feedback about soccer players' fitness level. The results of this study may serve for continuous development of fitness abilities of soccer players during long term monitoring. The advantage of this test is that we can test players during the season and simultaneously not omit a training unit at the expense of testing. Testing players during training units may be considered a full-value form of training.

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Conflicts of interest - The authors have declared that no conflict of interest exists.

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