REPEATED SPRINT ABILITY AND RECOVERY PERIOD: COMPARISON OF TRAINED AND UNTRAINED INDIVIDUALS

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ABSTRACT

The purpose of the study was to investigate the effects of training both in repeated sprint ability (RSA) and during the recovery after sprint. Soccer players playing in regional amateur league (n=14, age: 21.86±2.35 years, height: 180.14±4.54 cm, body mass: 72.57±5.03 kg, training age: 8.71±1.86 years) and students from faculty of sport sciences that played soccer in the past (n=13, age: 23.77±2.65 years, height: 178.54±4.67 cm, body mass: 74.54±10.52 kg) participated in this study as trained and untrained group, respectively. The groups were tested using Yo-Yo intermittent recovery test level 1 (YIRT1) and maximum oxygen uptake (VO_{2max}) was calculated using a formula from distance covered in YIRT1. Groups performed a repeated sprint ability (RSA, 6x6 s of Wingate test protocol + 30 s of rest) test after 48 h. Blood lactate level and heart rate of groups were recorded at rest, immediately, 5, 15, and 30 min after RSA test. The absolute peak power and relative mean power in repeated sprints and the VO_{2max} values were significantly higher in trained group than in untrained group ($p<0.05$). The absolute values of mean power was also significantly higher in trained group compared to that of the untrained group, except for the first sprint ($p<0.05$). On the other hand, it was observed that blood lactate level at 30 min and heart rate at 15 and 30 min of the recovery after testing was significantly lower in trained group than those of untrained group ($p<0.05$). The performance and metabolic results showed that VO_{2max} level would be effective both in maintaining repeated sprint ability performance and for the acceleration of the recovery period.

Key words: Blood lactate, heart rate, Wingate test

TEKRARLAYAN SPRİNT PERFORMANSI VE TOPARLANMA SÜRECİ: ANTRENMANLI VE ANTRENMANSIZ BİREYLERİN KARŞILAŞTIRMASI

ÖZET

Çalışmanın amacı antrenmanlı olmanın tekrarlayan sprint performansı ve sprint sonrası toparlanma sürecine etkisini araştırmaktı. Çalışmaya bölgesel amatör ligte oynayan futbolcular antrenmanlı grup (n=14, yaş: 21.86±2.35 yıl, boy: 180.14±4.54 cm, vücut ağırlığı: 72.57±5.03 kg, spor yaşı: 8.71±1.86 yıl), geçmişte futbol oynamış spor bilimleri fakültesi öğrencileri antrenmansız grup (n=13 yaş: 23.77±2.65 yıl, boy: 178.54±4.67 cm, vücut ağırlığı: 74.54±10.52 kg) olarak alındı. Grupların maksimum oksijen tüketim seviyesi ($MaksVO_2$) Yo-Yo aralıklı toparlanma düzey 1 (YATT1) testindeki koşu mesafesinden formül kullanılarak hesaplandı. Her iki gruba Yo-Yo testinden 48 saat sonra 6x6 sn tekrarlayan sprint testi (aralarda 30 sn dinlenmeli Wingate test protokolü) uygulandı. Grupların dinlenim, sprint test bitimi, test sonrası 5, 15 ve 30 dk sonunda kan laktat düzeyi ve kalp atım hızları kaydedildi. $MaksVO_2$ değerleri antrenmanlı grupta antrenmansız gruptan yüksekti ($p<0.05$). Tekrarlayan tüm sprintlerde elde edilen mutlak ve rölatif zirve güç değerleri antrenmanlı grupta antrenmansız gruptan daha yüksekti ($p<0.05$). Mutlak ortalama güç değerleri ilk sprint dışında diğer tüm sprintlerde ($p<0.05$), rölatif ortalama güç değerleri ise tüm sprintlerde antrenmanlı grupta antrenmansız gruptan daha yüksekti ($p<0.05$). Diğer yandan kalp atım hızı toparlanmanın 15 ve 30 dk'sında, kan laktat düzeyi ise 30 dk'da, antrenmanlı grupta antrenmansız gruptan daha düşüktü ($p<0.05$). Bu sonuçlar maksimum oksijen tüketim seviyesinin tekrarlı sprint performansının sürdürülmesinde ve sprint sonrası toparlanmada etkili olabileceğini göstermiştir.

Anahtar kelimeler: Kan laktat, kalp atım hızı, Wingate testi

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INTRODUCTION

Repeated sprint ability (RSA) is the ability to regenerate for the next sprint and maintain maximal performance during consecutive sprints in team sports (Glaister et al., 2005). It has been well-known that repeated sprints are performed generally in team sports with 2-3 s and 10-20 m (Spencer et al., 2005). Sprint protocols have been shown in literature with 5-7 repetitions of 4-6 s or 30-40 m distances and with 19-25 s rest interval, consistent with the nature of team sports (Wragg et al., 2000; Bishop et al., 2001; McGawley and Bishop, 2006; Spencer et al., 2006). In recent studies focusing on the analyses of RSA and the recovery period after RSA, it was demonstrated that RSA was related to the number of repetition and sprint time (Spencer et al., 2006; Kohler et al., 2010; Glaister et al., 2005; Dupont et al., 2007; Bogdanis et al.,1996; McGawley and Bishop, 2006). RSA is influenced by many different factors, such as maximum oxygen uptake (Aziz et al., 2000), hydrogen ion buffer system (Bishop and Edge, 2006), and muscle glycogen concentration (Balsom et al., 1999). RSA depends on continuous ATP resynthesis by PCr system and anaerobic glycolysis. During this metabolic process, the removal of intracellular inorganic phosphate and oxidized lactate from the cell and ATP resynthesis by aerobic energy system is highly important. It has been widely accepted that higher aerobic power (VO_{2max}) can improve recovery and RSA due to shorter rest interval. At the same time, there is contradictory evidence related to this view. It was previously reported that there was a relationship between VO_{2max} and repeated sprint performance (Aziz et al., 2000). In another study, it was demonstrated that VO_{2max} did not affect repeated sprint performance (Aziz et al., 2007). Similarly, it was reported in another study that VO_{2max} did not relate to repeated sprints under 40-m or 6 s (Da Silva et al., 2010). Conflicting results in the current literature indicate that more research is needed to investigate the effect of maximum aerobic power on a shorter recovery time between repetitions and the high exercise intensity in RSA. Thus, the purpose of the study was to examine the effects of training on recovery period after RSA and RS performance.

MATERIALS AND METHODS

Subjects

Football players who play football in the regional amateur league and another group who played football in the past but have not played for at least one year participated voluntarily in the study, as the trained group and the untrained group, respectively. Height (precision 1 mm) and body mass (precision 100 gr) of the players were measured using height-mass measurement device (Seca 704 s, UK) (Table 1).

Yo-Yo intermittent recovery test level

The YIRT1 consisted of repeated 2 x 20-m shuttles between the starting, turning, and finishing line at a progressively increased speed controlled by audio beeps from a tape recorder. Between each running bout, the subjects had a 10-s active rest period, consisting of 2 x5 m of jogging. The YIRT1 included a total of

4 shuttles in 10-13 km/h running speed in the first level of the test, and the second level of the test had 7 shuttles in 13.5-14 km/h running speed, and the following levels had 8-shuttle cycles with increases by 0.5 km/h in speed in every level. If the athlete failed to arrive at the finishing line on time twice consecutively, the test was ended and the distance covered in YIRT1 was recorded (Krustrup et al., 2003).

Maximum oxygen uptake

VO_{2max} was calculated using following equation from the distance covered in YIRT1 (Bangsbo et al., 2008).

VO_{2max} (ml/dk/kg) = YIRT1 covered distance (m) × 0.0084 + 36.4

Repeated sprint test

Both groups performed repeated sprint test (Wingate test protocol) 48 h after YIRT1. Groups performed stretching for 5 min after they warmed up in 50 W workload and 50 rpm speed in bicycle ergometer for 5 min. After warm-up, subjects performed pedaling at a workload of 75 g/kg for 6 s in maximal pedal speed, as it is in Wingate Test. Sprints were repeated six times with 30 s intervals. Peak and mean power values were recorded for every sprint.

Blood lactate and heart rate

Blood lactate level of the subjects in rest, post sprint test, and 5th, 15th, and 30th min after sprint was determined in 13 s using a lactate analyzer (L+, Nova Biomedical, USA) with the blood (0.7 µL) taken on the strip-shaped kit from fingertip. The analyzer was calibrated to make accurate measurements using solution of quality control in two different levels (level 1: 1.0-1.6 mM; level 2: 4.0-5.4 mM). Heart rate (HR) was simultaneously recorded using telemetric system (Polar RS800CX monitor, Polar Electro OY, Kempele, Finland).

Statistical analysis

Data were presented as mean (± SD). Two-way (group x time) repeated measures analysis of variance (repeated ANOVA) was used to analyse the differences between groups after homogeneity and normal distribution of the data were tested using Levene test and Kolmogorov Smirnov, respectively. Post-hoc Bonferroni was used for pair wise comparisons when a significant effect was found for factors in repeated ANOVA. YIRT1 and VO_{2max} results of the groups were compared using t-test for independent samples. The level of significance was set at 0.05.

RESULTS

Physical characteristics, values of anaerobic power, VO_{2max}, blood lactate and heart rate of trained and untrained individuals were presented in Table 1, Table 2, and Table 3. No significant physical differences were found between the two groups, but the greatest running velocity and the distance during Yo-Yo test and VO_{2max} values were significantly greater in the trained group than the untrained group (Table 1).

Table 1. Results of Yo-Yo test and maximum oxygen uptake

	Trained[§] (n=14)	**Untrained (n=13)**	**t-value**
Age (years)	21.85±2.34	23.76±2.65	1.98
Height (cm)	180.14±4.53	178.53±4.66	0.90
Body mass (kg)	72.57±5.03	74.53±10.51	0.62
Running distance (m)	1985.7±350.7	1464.6±366.1	3.78*
Running speed (m/s)	16.75±0.70	15.92±0.60	3.26*
HR max (beats/min)	186.0±3.46	188.1±4.15	1.41
VO_{2max} (ml/kg/min)	53.08±2.95	48.70±3.07	3.77*

[§]Training age = 8.71±1.86 years
*p<0.05

A significant interaction (group x time) was found between absolute and relative peak power values ($F_{(5,125)}$=7.00, p<0.05; $F_{(5,125)}$=6.52, p<0.05, respectively). This interaction showed that there was a significant difference between groups with regard to peak power values (Table 2). When pair wise comparisons were performed, both absolute and relative peak power were significantly greater in trained than untrained group in all sprints (p<0.05). In addition, a decrease was shown in peak power values during repeated sprint in both groups (p<0.05), but it remained constant during 3th and 4th sprint in trained groups (p>0.05).

Table 2. Peak power (PP) and mean power (MP) values in repeated sprint test (RST)

PP		**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Abs power (W)	Trained	910.5 ±80.8[a,c]	854.9±76.2[a,c]	777.2±79.2[b,c]	722.7±97.9[b,c]	658.2±115.2[a,c]	597.0±126.9[a,c]
	Untrained	823.5±107.5[a]	740.3±108.8[a]	600.2±85.7[a]	495.7±53.6[a]	431.2±52.7[a]	393.5±51.7[a]
Rel power (W/kg)	Trained	12.6±1.3[a,c]	11.8±1.2[a,c]	10.7±1.1[b,c]	9.9±1.5[b,c]	9.1±1.6[a,c]	8.2±1.8[a,c]
	Untrained	11.1±1.3[a]	10.0±1.4[a]	8.2±1.4[a]	6.7±0.9[a]	5.8±0.8[a]	5.3±0.7[a]
MP		S1	S2	S3	S4	S5	S6
Abs power (W)	Trained	806.6±71.9[d]	767.3±65.2[c,e]	690.9±66.9[c,f]	628.9±75.5[a,c]	591.7±90.7 [a,c]	538.1±99.0 [a,c]
	Untrained	747.9±95.5	644.5±92.6	533.2±68.8	456.6±50.5	395.2±55.1	357.2±50.4
Rel power (W/kg)	Trained	11.2±1.2[c,d]	10.6±1.0[c,e]	9.5±0.9[c,f]	8.7±1.1[a,c]	8.2±1.3 [a,c]	7.5±1.5 [a,c]
	Untrained	10.1±1.1	8.70±1.1	7.2±1.1	6.2±0.7	5.3±0.7	4.8±0.6

[a] p<0.05 significant difference than the other sprints within groups
[b] p<0.05 significant difference than S1,S2,S5,and S6 within groups
[c] p<0.05 significant difference than untrained group in same sprint
[d] p<0.05 significant difference than S3,S4,S5,and S6 within groups
[e] p<0.05 significant difference than S4,S5,and S6 within groups
[f] p<0.05 significant difference than S1,S4,S5,and S6 within groups

Also, a significant interaction (group x time) was found between absolute and relative mean power values ($F_{(5,125)}$=7.44, p<0.05; $F_{(5,125)}$=6.89, p<0.05, respectively). According to the interaction, there was a significant difference between groups in mean power values, and mean power values were significantly greater in the trained group (p<0.05), except for the first sprint (Table 2). Similarly, relative mean power values were significantly greater in the trained group (p<0.05). It was determined that mean power decreased in untrained group for all sprints but that in trained group, it decreased significantly only in the 4th, 5th, and 6th sprints (p<0.05).

Table 3. Values of blood lactate and heart rate after and before repeated sprint test (RST)

		Rest	After RST	After RST 5 min	After RST 15 min	After RST 30 min
Blood lactate (mmol/L)	Trained	1.93±0.26	12.66±1.98[b]	11.75±2.54[b]	10.07±2.45[b]	6.61±1.97[a,c]
	Untrained	2.05±0.40	11.78±2.08[b]	11.81±1.88[b]	11.61±1.66[b]	10.89±1.44[b]
Heart rate (beats/min)	Trained	62.21±1.96[a]	184.57±2.37[a]	123.28±3.79[a]	98.14±2.76[a]	85.92±3.17[a,c]
	Untrained	69.69±1.70[a]	183.15±2.30[a]	122.38±4.77[a]	101.15±3.46[d]	97.92±3.25[d]

[a] p<0.05 significant difference within groups
[b] p<0.05 significant difference than rest within groups
[c] p<0.05 significant difference than untrained groups
[d] p<0.05 significant difference than rest, post RSA, and post RSA 5 min within groups

A significant group x time interaction was found in blood lactate ($F_{(4,100)}$=12.01, p<0.05). The blood lactate level was significantly lower in the trained group than untrained group in 30th min post sprint (p<0.05). On the other hand, there was a significant group x time interaction for HR values ($F_{(4,100)}$=22.82, p<0.05). HR values were significantly lower in trained group than untrained group in rest, 15th, and 30th min post sprint (p<0.05).

DISCUSSION

The effect of the training on RSA and recovery after RSA was investigated in this study. The endurance performance of the groups was determined using YIRT1 protocol before RSA. It was observed that VO_{2max} calculated from distance covered in YIRT1 was higher in the trained than the untrained. YIRT is a valid and reliable test developed to evaluate high intensity intermittent exercise and cardiovascular fitness in football (Krustrup et al., 2003, 2006). It was demonstrated that there was a high relationship (r = 0.70) between YIRT1 and VO_{2max} (Bangsbo et al., 2008). Higher VO_{2max} in trained group found in the present study is an expected result, similar to the studies in literature (Edge et al., 2006). In this study, Wingate test protocol with 6x6 s was used for the evaluation of anaerobic power. It was known that short bicycle tests were frequently used in testing of RSA in team sports (Rampinini et al., 2009; Edge et al., 2006). However, the validity of RS tests measured in laboratory for team sports was questioned in recent years. In studies analyzing the correlation between the two different test protocols by developing running based tests similar to Wingate anaerobic test protocol, it was reported that peak power, mean power, and fatigue index values showed high correlation in both test protocols (Zacharogiannis et al., 2004; Zagatto et al., 2009). On the other hand, it was demonstrated in another study that there was a difference between running-based anaerobic tests and Wingate anaerobic test in terms of metabolic responses and power values (Keir et al., 2013). In this study, peak and mean power in RSA were found to be higher in trained group than untrained group. At the same time, a continuous decrease in power was observed in untrained group during all repeated sprints, but it remained unchanged in trained group. It was demonstrated in a study focusing on the effect of maximum oxygen uptake on RSA that there was a moderate correlation between maximum oxygen uptake and 8x40 m sprint performance (Aziz et al., 2000). However, it was reported in another study that there was no correlation between RSA (6x20-m) and maximum oxygen uptake (Aziz et al., 2007). Similarly, it was reported that maximum

oxygen uptake had no an effect on RSA under 40 m or 6 s (Da Silva et al., 2010). In another study, in which the effectiveness and their relation to aerobic system of two different repeated sprint tests (12x20 m and 6x40 m) was investigated, it was demonstrated that a high number of sprints with short distance (12x20 m) were more effective in sustaining anaerobic power in adolescent football players than a low number of sprints with long distance (6x40 m) (Meckel et al., 2009). It was demonstrated in a study which compared RSA (6x40 m) professional and amateur football players with similar VO_{2max} that RSA was higher in professional players, and that there was a less decline in RSA in professionals than in amateurs (Rampinini et al., 2009). The results revealed in literature that maximum oxygen uptake was more effective in RSA with longer time and distances. Although shorter time (6x6 s) repeated sprint protocol was used in evaluation of anaerobic power in this study, higher anaerobic power values were found in the trained group. Blood lactate was lower in trained group at 30^{th} min after RSA; similarly, HR is lower in trained group pre RSA, at 15^{th} 30^{th} min after RSA. Lower lactate (La^-) and hydrogen ion concentration (H^+) and higher bicarbonate ($HCO3^-$) values were reported in professional football players. It was revealed that RSA would be decreased as a result of suppression of the low pH on muscle contraction and glycolitic activity in amateur players (Rampinini et al., 2009). In the study examining responses to repeated bicycle test (5x6 s) in endurance sports, team sports, and sedentary individuals, it was demonstrated that greater power was produced by players in team-sport during bicycle test; that lactate was higher than endurance and sedentary group and higher buffer capacities after exercise; and that maximum oxygen uptake was higher in team sport players and endurance athletes than sedentary individuals (Edge et al., 2006). In both studies, it was revealed that players in team sport showed relatively higher power output in RSA compared to the untrained and athletes in different training regimes, which was supported by lactate, hydrogen ion concentration and bicarbonate buffer system, which play an effective role in anaerobic metabolism.

CONCLUSION

The finding in this study that RSA and recovery after RSA in the trained group was higher compared to untrained group could be accounted for by the frequent repetition of high-intensity exercises with intervals during training and matches in team-sport players.

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