ACUTE EFFECT OF TABATA WORKOUT ON HEART RATE AND BLOOD LACTATE ACCUMULATION OF FEMALE FUTSAL PLAYERS

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ABSTRACT

Introduction: *Tabata training programs are characterized as high-intensity interval training. The compatibility of the physiological load created by this exercise program on futsal players with the characteristics of futsal is still being debated. This study aims to investigate the acute effect of Tabata training on heart rate and blood lactate accumulation in female futsal players.*

Materials and methods: *A total of 12 female athletes (age: 20.33±0.89 yrs.) participated in the study. Subjects performed 2 sets (segments) of Tabata exercises, each of which consisted of 4 different movements of 20 seconds, with 10 seconds recovery intervals. The heart rate (HR) and blood lactate (BLa) levels of the athletes were measured before (pre) and after (post) each set of Tabata workout. Paired sample t-test was used to compare the difference in HR responses and BLa accumulation between the before-after of sets in Tabata exercise. Significant level was defined as p ≤0.05.*

Results: *A significant difference was found between the mean HR pre and post both sets (P<0.01). Participants' exercise pre-test heart rate values increased from approximately 60% to 95% of HRmax%. There was a significant difference in BLa (13.36±3.70, 16.64±3.04 mmol.l^{-1}; t=5.27; P<0.01) mean in the 2nd set but not in the 1st set (5.76±2.90; 7.51±4.42 mmol.l^{-1}; t:-1.18; P>0.05). It was observed that the increase in BLa (5.76±2.90; 16.64±3.04 mmol.l^{-1}) of the 2nd set post-test values increased approximately three times compared to the 1st set pre-test.*

Conclusion: *The metabolic load level it creates on the athlete shows that this workout method can be used to increase anaerobic endurance and capacity.*

Keywords: *Female, anaerobic, endurance, high intensity, interval training.*

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Introduction

Different training intensities and methods are known to help improve physical fitness in athletes. Cardio-respiratory endurance is one of the main elements of physical fitness[(1)]. Interval training is one of the methods used in training loads. The characteristic of interval training is the systematic alternation of work and rest, or high and low load circuits. High Intensity Interval Training (HIIT) is a type of exercise that is getting more and more popular these days. Tabata workouts are a type of training that is a subcategory of HIIT. Tabata et al.[(2)] compared 60 minutes of continuous moderate-intensity training with 70% VO2Max consumption with 170% VO2Max HIIT. The study consisted of 8 exercises with 20 seconds of maximal loading followed by 10 seconds of active rest for a total of 4 minutes. This study showed that HIIT increased aerobic capacity at similar levels to moderate-

intensity continuous training, and also revealed that it improved anaerobic capacity by 28%. These results have led to the development of many different types of HIIT programs[2, 3]. Previous studies have emphasized the effect of different exercise protocols on women's fitness. Bianco et al.[4] revealed that Indoor Cycling Protocol may be efficient for losing weight and preventing the increased risk of cardiovascular disease in young overweight women.

In addition, it was stated that it would be appropriate to apply physical activity programs according to the Tabata protocol by grouping school students according to their physical fitness levels[5].

Many different exercise methods for physical fitness and health (Some examples are: funky, zumba, fit box, cycling activities, calisthenics based training, cross fit, suspension training, kettlebell training, total body conditioning, core training, boot camp, functional training, pilates, yoga, stretching) have been subjects of interest to people. These exercise methods are applied according to age, gender and physical activity status for both fitness and healthy life[6]. In addition to the fact that these exercises are preferred for the purpose of feeling good and protecting from various diseases, athletes use them to increase their performance. Coaches use these various methods in addition to the athletes' regular training. In performance sports, especially strength, endurance and speed motor skills are very important. So Tabata, core, plyometric etc. high-intensity training methods are included in training plans in addition to regular training.

Many studies have been conducted on the positive effects of high-intensity interval training processes on the performance of athletes[7, 8]. In sports characterized by intermittent high-intensity activities such as football and futsal, it has been reported that players have significant contributions to their performance[9, 10, 11, 12].

It is very important to know the acute physiological effects that occur during the exercises as well as the chronic effects of these training types on the improvement in the performance of the athletes. The lactate level continues to rise in parallel with the workload. Although the blood lactate threshold is accepted as 4 mmol/l, studies have shown that there is a wide individual variation in blood lactate threshold[13, 14]. Anaerobic threshold value is an important indicator of the degree of aerobic capacity. The indicator of exercise intensity, namely target heart rate, is very important in determining the training intensity in the regulation of training programs in athletes and writing an exercise prescription in a healthy life[15, 16, 17]. For athletes, training plans to be applied to improve anaerobic metabolism with intermittent high-intensity loads are very important. The most difficult part of these plans is to set the loading-recovery time intervals well. For this reason, most trainers and athletes have recently preferred the Tabata training method. The aim of this study was to reveal the heart rate and blood lactate accumulation responses and the acute effect in the loading-recovery phases of female futsal players during Tabata exercises.

Materials and methods

Participants

Twelve female futsal players (age: 20.33±0.89 yrs., height: 165.25±5.38 cm., body weight: 55.50±4.44 kg. and experience: 4.25±1.14yrs) voluntarily participated in this study. This study meets the guidelines of the Declaration of Helsinki. Subjects were fully informed about the study design, including information on the possible risks and benefits. They all signed an informed consent form to participate in the study. This study was approved by The Sports Department Review Board at Nisantasi University (ID: NU-BESYO-Md-2019/07/19) prior to data collection.

Tabata exercise protocol

The modified Tabata protocol consisted of two consecutive sets (segments), each lasting four minutes, with a one-minute recovery interval. Each set consisted of four different movements (Burpee, Jumping Lunge, Jump Squat, Mountain Climber) performed in two repetitions with a twenty-second exercise ten-second active recovery interval[2].

Measurements and data collection

Participants were measured for height (cm; Seca wall-mounted stadiometer, Seca, Birmingham, UK) and weight (kg; Tanita TBF-300A, Tanita Corporation of America, Inc., Arlington Heights, IL) in workout attire without shoes. The portable heart rate monitor (bmp; Polar RS800cx; Kempele, Finland) was used for monitoring before (HRpre-1; HRpre-2) and after (HRpost-1; HRpost-2) both sets of Tabata exercise.

The resting heart rate (HRrest) of the participants was monitored in the sitting position for 5 minutes before the tests and warming up, and the lowest heart rate was recorded. The maximal heart

rate of the participants was calculated according to the equation (HRmax=220 - age). To calculate the exercise intensity, the ratio of the participants' pre-test and post-test HR values to the maximal heart rate was calculated with the following formula (HRmax%=HR/HRmax *100).

Blood samples were taken from the finger for determination of blood lactate concentration using portable lactate test analyzer (mmol.l-1; Lactate Scout, SensLab GmbH, Germany). Blood lactate (BLa) concentration measurements were done in arterialized capillary blood before (BLa-pre) and after (BLa-post) the Tabata excercise.

Participants warmed up for ten minutes before the Tabata exercise. Before the first set, heart rate (HR. pre-1) and blood lactate (BLa.pre-1) measurements were recorded. At the end of the first set, which lasted four minutes, heart rate (HR.post-1) and blood lactate (BLa.post-1) measurements were made and recorded. At the end of the one-minute recovery interval, the same measurements were repeated immediately before and after the second set.

Data analysis

Data are expressed as and mean ± SD. The normal distribution of the data was checked using the Shapiro Wilks test. After confirming normal distribution, paired sample t-test was used to compare the difference in HR responses and BLa accumulation between the before-after of sets in Tabata exercise. Significant level was defined as $p \leq 0.05$. Effect size (Cohen's d) was calculated to determine the practical difference between variables. Effect size values of 0-0.19, 0.20-0.49, 0.50-0.79, and 0.8 and above were considered to represent trivial, small, medium, and large differences, respectively[18].

Results

A total of 12 female athletes participated in the study (age: 20.33±0.89 yrs., height: 165.25±5.38 cm., body weight: 55.50±4.44 kg.and experience: 4.25±1.14yrs). HRrest and HRmax averages of the participants, respectively; 55.00±4.31 and 199.67±0.89 bpm.

The heart rate and blood lactate responses are presented in Table 1. In the interval given between sets, it is seen that recovery occurs in terms of heart rate, but the increase in blood lactate accumulation continues. After both sets of Tabata exercise, we found that the mean heart rate increased significantly compared to the mean before the set (set-1; pre-test: 122.75±6.73; post-test: 188.33±9.71 bpm; t=-19.88; P<0.01), (set-2; pre-test: 128.08±5.89; post-test: 194.75±4.33 bpm; t=-33.31, P<0.01).

Effect size was found to be large between the pre-test and post-test mean scores of both sets (respectively; 7.85; 12.90). When we examined the level of this increase in heart rate as HRmax%, we saw how the rate of Tabata exercises before the sets (respectively; 61.48±3.42 %; 64.15±3.00 % of HRmax) increased after the sets (94.33±4.98 %; 97.54±1.98 % of HRmax). The effect size for HRmax% was large (respectively; 7.69; 13.14). The blood lactate accumulation showed an increasing trend during the Tabata workout. The difference between the first set of pre-test and post-test BLa mean scores was not significant (respectively; 5.76±2.90; 7.51±4.42 mmol.l-1; t:-1.18; P>0.05), but a significant difference was found in the second set (13.36±3.70, 16.64±3.04 mmol.l-1.; t=-5.27; P<0.01). For BLa accumulation, the effect size was found to be medium for the first set and large for the second set (respectively; 0.47; 0.97).

There was a significant difference between the HRpre-tests of both sets (t=-3.31; P<0.01), but not between the HRpost-tests (t=-2.20; P>0.05). On the other hand, there was a significant difference between BLa.pre-tests (t=-6.11; P<0.01) and BLa.post-tests (t=-6.95; P<0.01) of both sets.

Variable	Set	Pre-test (mean±sd)	t	P	Post-test (mean±sd)	t	P	t	P	ES
HR (bpm)	First	122.75±6.73	-3.31*	.007	188.33±9.71	-2.20	.050	-19.88*	.000	7.85-L
	Second	128.08±5.89			194.75±4.33			-33.31*	.000	12.90-L
HRmax %	First	61.48±3.42	-3.31*	.007	94.33±4.98	-2.21	.050	-19.86*	.000	7.69-L
	Second	64.15±3.00			97.54±1.98			-33.90*	.000	13.14-L
BLa (Mmol.L-1)	First	5.76±2.90	-6.11*	.000	7.51±4.42	-6.95*	.000	-1.18	.262	0.47-M
	Second	13.36±3.70			16.64±3.04			-5.27*	.000	0.97-L

Table 1: Comparison and effect size analysis of participants' heart rate and blood lactate responses in Tabata workouts.

HR: heart rate, HRmax%: percentage of maximal heart rate, BLa: blood lactate, pre-test: test before the sets, post-test:test after the sets, ES: effect size Cohen's D.

Discussion and conclusion

The results of this research showed that Tabata workouts created a sub-maximal and near-maximal workload on female futsal players. An increasing HR and BLa physiological responses emerged under the influence of loading. Although partially fluctuating changes were observed in the HR responses of intermittent loading, it was observed that the increase in BLa was not affected by the

short recovery intervals. The results of this research showed that Tabata workouts created a sub-maximal and maximal workload on female futsal players. An increasing HR and BLa physiological responses emerged under the influence of loading. Although partially fluctuating changes were observed in the HR responses of intermittent loading, it was observed that the BLa increase was not affected by the short recovery intervals.

Since sports such as football and futsal use mixed energy sources, training planning is quite difficult. For this reason, many studies have been conducted on the acute and chronic effects of widely used Tabata training[19]. After the first study[2], which showed that it can be used to increase aerobic and anaerobic capacity, the acute effect of requiring high metabolic demand was also revealed[20]. Besides, Viana, et al.[19] in his review study on Tabata training, reported that studies that deviated from the original protocol for various reasons produced very different and unrealistic results.

Karahan(10) reported that 8-weeks skill-based maximal intensity interval training improved female futsal players' average anaerobic power, fatigue index and VO2max (10.7%, 22.1% and 9.6% ($p<0.05$), respectively).

Nascimento et al[21] stated that repetitive sprint training lasting 2 days a week for 4-weeks improved the repetitive sprint ability (RSA) of young futsal players, especially the experimental group's "peak velocity (ES=0.71)", "speed at heart rate deflection". (ES =0.83)" and "the peak blood lactate concentration in the repeated maximal sprint test (ES=1.00)".

In studies on the acute effect of Tabata exercises performed in accordance with the original protocol, it was reported that the change in oxygen volume (VO2) of %VO2max ranged from approximately 43%[22] to 71%[23]. However, Tabata et al.[20] reported that subjects achieved values corresponding to 96.5% of the VO2max. The blood lactate and heart rate ranged from 6.4 mmol/l[23] to 16.3 mmol/l[24], approximately 149 bpm[22] to 162 bpm[23], respectively. Thus, Viana, et al.[19], despite the inconsistencies in the results of the chronic and acute effects of Tabata training, the merit of the Tabata Protocol is in its time efficiency more than in its superiority in comparison with traditional protocols.

Thus, knowing the physiological acute effect of Tabata training method, which is frequently used to develop the conditional features needed by performance athletes, is very important in terms of regulating the training load of the coaches. This study, limited to the participation of female futsal players, will provide coaches and athletes with information about this method.

These results indicate that supplemental interval training sessions can replicate the metabolic demands of the sport and suggest to futsal players and conditioning specialists that interval training designed to increase lactate levels can be effective and should be a part of their comprehensive training programs.

References

1) Helgerud, J., Hoydal, K., Wang, E., Karlsen, T., Berg, P., et al. Aerobic High-Intensity Intervals Improve VO2max More Than Moderate Training. Med Sci Sports Exerc. 2007; 39 (4): 665-71. doi: 10.1249/mss.0b013e3180304570
2) Tabata, I., Nischimura, K., Kouzaki, M., Hirai, Y., Ogita, F. et al. Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO2 max. Med Sci Sports Exerc. 1996; 28(10), 1327-1330.
3) Emberts, T., Porcari, J., Dobers-Tein, S., Steffen, J., Foster, C. Exercise ıntensity and energy expenditure of a tabata workout. J Sports Sci Med. 2013; 12, 612-613. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3772611.
4) Bianco, A., Bellafiore, M., Battaglia, G., Paoli, A., Caramazza, G., Farina, F., Palma, A. The effects of indoor cycling training in sedentary overweight women. J Sports Med Phys Fitness 2010; 50(2): 159-65. PMID: 20585293.
5) Domaradzki, J., Rokita, A., Koźlenia, D., Popowczak, M. Optimal values of body composition for the lowest risk of failure in Tabata training's effects in adolescents: A pilot study. BioMed Research International 2021; V-2021;1-7. https://doi.org/10.1155/2021/6675416.
6) Paoli,A., Bianco,A. What is fitness training? Definitions and implications: A systematic review article. Iran J Public Health 2015; 44(5): 602-14. PMID: 26284201.
7) Laursen, PB., Jenkins, DG. The scientific basis for high-intensity interval training. Sports medicine, 2002; 32(1): 53-73. 0112-1642/02/0001-0053/$22.00/0.
8) Wisløff, U., Ellingsen, Ø., Kemi, OJ. High-intensity interval training to maximize cardiac benefits of exercise training?. Exercise and sport sciences reviews, 2009; 37(3):139-146. doi: 10.1097/JES.0b013e3181aa65fc.
9) Fatemeh, B., Ramin, S., Marzieh, N. Effect of high-intensity interval training on body composition and bioenergetic indices in boys-futsal players. Физическое воспитание студентов, 2016; (5): 42-49.

10) Karahan, M. The effect of skill-based maximal intensity interval training on aerobic and anaerobic performance of female futsal players. Biol. sport, 2012; 29(3): 223-7. Doi:10.5604/20831862.1003447.
11) Castagna, C., Alvarez, JCB. Physiological demands of an intermittent futsal-oriented high-intensity test. J Strength Cond Res, 2010; 24(9): 2322-9. doi: 10.1519/JSC.0b013e3181e347b9.
12) Clemente, FM., Nikolaidis, PT. Profile of 1-month training load in male and female football and futsal players. SpringerPlus, 2016; 5(1): 1-10. Doi: 10.1186/s40064-016-2327-x.
13) Jonathan, M., Euan, A. A perspective on exercise, lactate, and the anaerobic threshold. Chest 1997; 111, 787-795.
14) Astrand PO., Rodahl K. Textbook of work physiology physiological bases of exercise. 3th ed. McGraw-Hill; 1986.
15) McArdle WD, Katch FI., Katch VL. Essentials of Exercise Physiology. 2th ed. Johnson E, Gulliver K, eds. Lippincott Williams and Wilkins. 2000; 170-205,
16) Foss ML., Keteyian SJ. Fox's Physiological Basis for Exercise and Sport. 6th ed. WCB/McGraw-Hill; 1998.
17) Mellion MB. Sports Medicine Secrets, 2th ed. Philadelphia: Hanley and Belfus Inc. 1999; 57-61.
18) Cohen, J. Statistical Power Analysis for the Behavioral Sciences. Hillsdale, NJ: Erlbaum Associates. 1988; 567
19) Viana, RB., De Lira, CAB., Naves, JPA., Coswig, VS., Del Vecchio, FB., Gentil, P. Tabata protocol: a review of its application, variations and outcomes. Clin Physiol Funct Imaging, 2019; 39(1), 1-8. Doi: 10.1111/cpf.12513.
20) Tabata, I., Irisawa, KO., Kouzaki, MO., Nishimura, KO., Ogita, FU., Miyachi, MO. Metabolic profile of high intensity intermittent exercises. Med Sci Sports Exerc. 1997; 29(3), 390-395. https://pre-hab.de/tabata/tabatastudie.pdf.
21) Nascimento, PCD., Lucas, RDD., Pupo, JD., Arins, FB., Castagna, C., Guglielmo, LGA. Effects of four weeks of repeated sprint training on physiological indices in futsal players. Revista Brasileira de Cineantropometria & Desempenho Humano, 2015; 17: 91-103. doi: http://dx.doi.org/10.5007/1980-0037.2015v17n1p91.
22) Williams, BM., Kraemer, RR. Comparison of cardiorespiratory and metabolic responses in kettlebell high-intensity interval training versus sprint interval cycling. J Strength Cond. Res. 2015; 29(12), 3317-25. doi: 10.1519/JSC.0000000000001193
23) Fortner, HA., Salgado, JM., Holmstrup, AM., Holmstrup, ME. Cardiovascular and metabolic demads of the kettlebell swing using Tabata interval versus a traditional resistance protocol. Int. J. Exerc. Sci. 2014. 7(3), 179. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4831858/.
24) Amtmann, JA., Amtmann, KA., Spath, WK. Lactate and rate of perceived exertion responses of athletes training for and competing in a mixed martial arts event. J. Strength Cond. Res. 2008; 22(2):645-7. doi: 10.1519/JSC.0b013e318166018e.

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