

Effect of high-intensity interval training on body composition and bioenergetic indices in boys - futsal players

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Abstract:

Background: High-intensity interval trainings (HIIT) can result in the best improvement of body fitness among athletes in the shortest possible time. The impact of HIIT on bioenergetic factors of futsal players has not been studied extensively. The objective of the present study was to investigate the effect of 3-week HIIT on body composition indices, maximum aerobic power, and maximum anaerobic power, anaerobic power among boys - futsal players. **Material:** 30 boys - futsal players (mean±SD age, 13.49±1.03 years; BMI, 20.95±1.78 kg/m²) participated in the study voluntarily. They were randomly assigned to experimental (n=15) and control (n=15) groups. HIIT lasted for three weeks, three sessions a week for 12-36 minutes on treadmill. Weight, body mass index (BMI), waist to hip ratio (WHR), thickness of body fat, maximal aerobic power, and maximum anaerobic power were recorded before intervention and 48 hours after the final training session. Aerobic power was measured with 20-m shuttle run, and maximum anaerobic power was measured with RAST test. Paired sample t-test was used to determine pretest-posttest differences, and independent t-test was used to determine between-group differences. The significance level was set to P < 0.05. **Results:** Significant differences were found in weight, BMI, thickness of body fat, maximum aerobic power and maximum anaerobic power in experimental group (P = 0.001) before and after training intervention, but the change in WHR was not significant (P < 0.05). No significant differences were observed in selected body composition between experimental and control groups, but they exhibited significant differences in maximum aerobic power and maximum anaerobic power (P = 0.001). **Conclusion:** According to the results, HIIT can be an effective training program for improving the performance of bioenergetic indices of futsal players. Also, it is recommended to study the effect of similar trainings with longer durations on other indices in other sports in future studies.

Keywords:

interval trainings, body mass index, anaerobic power, futsal.

Фатемех Балбаси, Рамин Шабани, Марзиех Назари. Влияние интервальной тренировки высокой интенсивности на состав тела и биоэнергетические показатели у подростков – футзалистов. **Цель:** Интенсивные интервальные тренировки могут привести к улучшению пропорциональности и гармоничности развития тела среди спортсменов в кратчайшие сроки. Влияние такой тренировки на биоэнергетические факторы футзалистов не изучена. Цель настоящего исследования состояла в том, чтобы исследовать влияние 3-недельной интенсивной интервальной тренировки на показатели состава тела, максимальной аэробной и анаэробной мощности среди подростков – футзалистов. **Материал:** 30 подростков - футзалистов (средний возраст 13,49±1,03 лет, индекс массы тела 20,95 ± 1,78 кг/м²) приняли участие в исследовании на добровольной основе. Они были случайным образом распределены в экспериментальную (n = 15) и контрольную (n = 15) групп. Тренировки продолжались в течение трех недель по три раза в неделю в течение 12-36 минутного упражнения на беговой дорожке. Вес, индекс массы тела, индекс отношения размера талии к бедру, толщина жировых отложений, максимальная аэробная и анаэробная мощность были зарегистрированы до тренировки и через 48 часов после последней тренировки. Аэробные мощность была измерена в 20-м челночном беге, а максимальная анаэробная мощность была измерена с помощью теста RAST. Был использован t-тест для парной выборки для определения предтестовых-посттестовых различий и независимый t-тест для определения различий между группами. Уровень значимости был установлен p<0,05. **Результаты:** были обнаружены значительные различия в весе, индексе массы тела, толщине жировых отложений, максимальной аэробной и анаэробной мощности в опытной группе (p=0,001) до и после эксперимента. Но изменения соотношения размеров талии к бедру не были статистически значимым (p<0,05). Никаких существенных различий не было обнаружено и в выбранной композиции тела между экспериментальной и контрольной групп. Наблюдались значительные различия в максимальной аэробной и анаэробной мощности (p=0,001). **Выводы:** Согласно результатам, интенсивная интервальная тренировка может быть эффективной в повышению биоэнергетических показателей футзалистов. Кроме того, в будущих исследованиях рекомендуется изучить влияние подобных более длительных тренировок по другим показателям в других видах спорта.

интервальные тренировки, индекс массы тела, анаэробная мощность, мини-футбол.

Фатемех Балбаси, Рамин Шабани, Марзиех Назари. Влияние интервальной тренировки высокой интенсивности на состав тела и биоэнергетические показатели у подростков - футзалистов. **Мета:** Интенсивные интервальные тренировки могут привести до улучшения пропорциональности и гармоничности развития тела среди спортсменов в наикоротші терміни. Влияние такого тренування на біоенергетичні фактори футзалістів не вивчена. Мета цього дослідження полягала в тому, щоб дослідити вплив 3-тижневого інтенсивного інтервального тренування на показники складу тіла, максимальної аеробної та анаеробної потужності серед підлітків - футзалістів. **Матеріал:** 30 підлітків - футзалістів (середній вік 13,49 ± 1,03 років, індекс маси тіла 20,95 ± 1,78 кг / м²) взяли участь в дослідженні на добровільній основі. Вони були випадковим чином розподілені в експериментальну (n = 15) і контрольну (n = 15) групи. Тренування тривали протягом трьох тижнів по три рази на тиждень протягом 12-36 хвилинних вправ на біговій доріжці. Вага, індекс маси тіла, індекс відношення розміру талії до стегна, товщина жирових відкладень, максимальна аеробна і анаеробна потужність були зареєстровані до тренування і через 48 годин після останнього тренування. Аеробні потужність була виміряна в 20-м човниковому бігу, а максимальна анаеробна потужність була виміряна за допомогою тесту RAST. Було використано t-тест для парної вибірки для визначення передтестових-посттестових відмінностей і незалежний t-тест для визначення відмінностей між групами. Рівень значущості був встановлений p<0,05. **Результати:** були виявлені значні відмінності у вазі, індексі маси тіла, товщині жирових відкладень, максимальної аеробної і анаеробної потужності в дослідній групі (p=0,001) до і після експерименту. Але зміни співвідношення розмірів талії до стегна були статистично значущим (p<0,05). Ніяких істотних відмінностей не було виявлено і в обраній композиції тіла між експериментальною і контрольною групами. Спостерігалися значні відмінності в максимальній аеробній і анаеробній потужності (p=0,001). **Висновки:** Згідно з результатами, інтенсивне інтервальне тренування може бути ефективним у підвищенні біоенергетичних показників футзалістів. Крім того, в майбутніх дослідженнях рекомендується вивчити вплив подібних більш тривалих тренувань за іншими показниками в інших видах спорту.

інтервальні тренування, індекс маси тіла, анаеробна потужність, міні-футбол.

Introduction

Most sports need performance of short-time, quick activities with the maximum power efficiency. So, coaches and sport specialists have been always seeking new trainings to improve athletes' aerobic and anaerobic power

in the shortest possible time [1]. High-intensity interval trainings (HIIT) are new interval methods interested by athletes, coaches, and researchers in recent years. Though there is no comprehensive definition of HIIT, it generally refers to repetitions of short-time interval exercises with full intensity or intensities close to what results in maximal

oxygen uptake. Depending on training intensity, an HIIT effort may last for several seconds to several minutes in which the intervals are separated with a cool-down period of a few minutes or low-intensity activity [2].

Futsal is a high-intensity athletic activity. The fact that professional futsal players should perform repeated, rapid activities in smaller field with shorter rest than soccer players shows that aerobic and anaerobic power are necessary in futsal [3].

Maximum aerobic power (VO_{2max}) is a common way to measure aerobic performance. It shows the maximum possible oxygen that human body can intake in one minute, and it is closely related to body endurance and aerobic activity and depends on the performance of skeleton, muscular, and cardiovascular systems [4]. In addition, maximum anaerobic power (P_{max}) is the ability of all muscles to produce more force with high speed in sprint activities for a very short time [5]. Given the strong correlation of health with fat level, the evaluation of body composition (especially body fat percent) is an important component of physical fitness [6].

Doğramacı et al. (2006) estimated that futsal players reached 75% of maximum heart rate and 90% of maximum oxygen intake in high-intensity, competitive games [7]. Many studies have specified HIIT advantages as improving athletic capacity and the factors related to endurance performance including muscle oxidative capacity and VO_{2max} [8, 9, 10, 11]. In addition to improving aerobic power due to the rest periods between activities, these trainings increase speed or the ability of maintaining speed in long-time intervals [12]. Also, post-HIIT adaptations show that these adaptations improve skeleton muscle glycogen at rest and maximize glycolytic and oxidative enzymes, and also, it is reported that maximum oxygen intake does not change after HIIT programs [13].

There are disagreements about the impact of HIIT training on body composition and bioenergy level, so that whilst some studies report the reduction of body composition such as weight, BMI, fat percent, and waist circumference [14, 15], others report no significant improvement [11, 16]. On the other hand, significant improvements are reported in aerobic and anaerobic power by some studies [9, 10, 11], whereas others did not observe any influences [16, 17]. High-quality, low-volume trainings are, in essence, used to find a training program with the appropriate intensity, duration, and repetition which can result in rapid and concurrent improvement of aerobic and anaerobic power. Therefore, since few studies have been reported on the effect of HIIT training on the improvement of aerobic and anaerobic performance among futsal players [18, 19] and yet they have yielded inconsistent results, and given the possible usefulness of HIIT training and the importance of bioenergetic indices in futsal, the present study was aimed at examining the effect of HIIT training on body composition and bioenergetic indices.

Material and Methods

Participants

Thirty boys - futsal players (mean±SD age, 13.49±1.03

years; BMI, 20.95±1.78 kg/m²) playing in futsal club of Roodbar city in Guilan Province, Iran volunteered to participate in this study. They were randomly assigned to experimental (n = 15) and control (n = 15) groups. The conditions for participation were player's consent, no illness record, and training experience of at least six months to two years, and the conditions for the exclusion of subjects included injury so severe that he could not keep training, and absence for two consecutive or three non-consecutive sessions.

The research was approved by Human Studies Review Committee at Islamic Azad University, Rasht Research Design.

One week before the fulfillment of the protocol, the volunteers were briefed to get familiarized with high-intensity interval training. The day after getting their consent, their height, weight, thickness of body fat, BMI, WHR, VO_{2max} , and P_{max} were measured. The tests were administered one week before and 48 hours after the last training session. The height was measured with a ruler with the precision of 1 mm. The subjects were weighed with a scale (made by Beurer Co., Germany) with the precision of 0.1 kg, in which they were asked to go on scale without shoes and with the least clothes. The height was recorded in centimeter and the weight in kilogram. The waist circumference was measured at the point midway between the lowest rib and the iliac crest in standing position. To measure thickness of body fat, the thickness of subcutaneous fat layer was measured with a caliper (SAEHAN, South Korea) on abdomen, chest and thigh [20]. Then, the recordings were used to estimate Total thickness of body fat by Jackson and Pollock's formula. Body mass index (BMI) was measured in kg m⁻² by

$$BMI = \text{weight (kg)} / \text{height (m)}^2$$

To ensure the reliability and validity of the measurements, they were all carried out in a single day. Aerobic power was measured with 20-m shuttle run test and anaerobic power was measured with RAST test. In shuttle run test, the subjects were asked to run a 20-m course periodically with uniform increase in pace. The test was designed in 21 levels (each level with its own number of shuttles). The subjects departed from the start line covering the course between two consecutive obstacles to reach the next pace [21]. In RAST test, a 30-m course was selected with plenty of empty space in either side. The subjects were asked to warm up for at least seven minutes. At the outset, they were weighed. Then, they started running. They should rest for 10 seconds at the end of the course. Immediately afterwards, they should run back. The subjects should run the course six times with their highest speed [22].

Trainings protocol

The trainings lasted for 10 sessions, three sessions a week. The subjects were completely trained one week before the research, and they run on a treadmill for one session as a test. The training sessions included warm-up (15 minutes), main training phase, and cool-down for

experimental group. HIIT group warmed up in general and specific manner (including jogging, stretching, sit-up with medicine-ball, skipping rope, push-up, and workout with ball), and cool-down phase included jogging, resting, and stretching for recovery. In the main phase of the training, the subjects run on treadmill on the basis of VO_{2peak} . Rest time was 1:3 and training duration was 12-18 minutes in the first week, 25 minutes in the second week, and 36 minutes in the third week.

The trend of the trainings is presented in Table 1.

Statistical analysis

Data were descriptively analyzed by mean, standard deviation. After Kolmogorov-Smirnov Test and given the normal distribution of data, paired sample t-test was used to determine pretest-posttest differences, and independent t-test was used to estimate between-group differences. All statistical analyses were carried out with SPSS (Ver. 22)

Software Package. The significance level was set to less than 0.05.

Results

Table 2 presents some anthropometric descriptive of the subjects including age, height, weight, total thickness of body fat, BMI, and WHR (Table 2).

As is evident in Table 3, HIIT significantly affected weight, BMI, and thickness of body fat of subjects in experimental group ($P < 0.05$). However, no effect was observed on WHR ($P > 0.05$). Control group showed significant change just in thickness of body fat between pre-test and post-test ($P < 0.05$) and other variables did not change significantly ($P > 0.05$). On the other hand, HIIT resulted in significant change in VO_{2max} and P_{max} of experimental group between pre-test and post-test ($P < 0.05$, Table 3).

According to Table 4, there was no significant

Table1. High intensity interval training program

session	Rest Time Second	Activity Time Second	Replete		Speed Treadmill	Total Time	
1	90	30	2	8	7.5	7	12
2	90	30	3	8	7.5	7	18
3	90	30	3	8	7.5	7	18
4	135	45	3	9	8.5	8	25
5	135	45	3	9	8.5	8	25
6	135	45	3	9	8.5	8	25
7	135	45	3	10	9.5	9	25
8	135	45	3	10	9.5	9	25
9	135	45	4	10	9.5	9	36
10	135	45	4	10	9.5	9	36

Table2. Baseline characteristics of study participants (mean± SD)

variable	Control mean± SD	Experimental mean± SD
Age (year)	1.06±13.53	1.18±13.46
Height(m)	4.97±149.00	3.61±159.27
Weight(kg)	3.06±45.86	4.04±47.87
Thickness of body fat(mm)	1.00±17.17	1.51±15.15
BMI(kg/m ²)	1.15±20.66	2.14±21.24
WHR	0.02±0.85	0.01±0.86

BMI: body mass index; WHR: waist to hip ratio

Table 3. Effects of HIIT training according paired t-tests (n=30)

	Group	Before	After	t	p
Weight(kg)	Control	3.06±45.86	2.87±45.72	1.16	0.2
	Experimental	4.4±47.87	3.96±47.56	3.2	*0.005
BMI(kg/m ²)	Control	1.15±20.66	1.11±20.60	1.1	0.2
	Experimental	2.14±21.24	2.13±21.11	3.31	*0.005
WHR	Control	0.02±0.85	0.01±0.86	0.1	0.89
	Experimental	0.0±0.86	0.00±0.86	0.1	0.8
Thickness of body fat(mm)	Control	1.0±17.17	0.8±16.62	5.9	*0.000
	Experimental	1.51±15.15	1.38±14.62	7.4	*0.000
Vo _{2max}	Control	5.09±41.01	5.10±41.17	0.7	0.4
	Experimental	4.84±42.30	5.33±47.94	10.18	*0.000
P _{max}	Control	40.72±42.58	36.97±41.88	3.1	*0.007
	Experimental	47.87±47.15	55.01±54.91	14.13	*0.000

p≤0.05

Table 4. In depended t-test between groups (n=30)

	Group	Mean± Difference	t	DF	p
Weight(kg)	Control	0.48±0.14	0.9-	28	0.3
	Experimental	0.34±0.29			
BMI(kg/m ²)	Control	0.22±0.06	0.9-	28	0.3
	Experimental	0.14±0.12			
WHR	Control	0.003±0.002-	1.09-	28	0.2
	Experimental	0.2±0.05			
Thickness of body fat(mm)	Control	0.35±0.54	0.3	28	0.7
	Experimental	0.26±0.51			
Vo2max (ml/kg/min)	Control	0.78±0.16	5.4-	28	0.001*
	Experimental	2.14±5.64			
Pmax	Control	10.64±8.70-	13.7-	28	0.001*
	Experimental	18.02±65.76			

p≤0.05

difference in BMI between control and experimental groups ($P > 0.05$). But, there was significant difference in VO_{2max} and P_{max} between control and experimental groups ($P < 0.05$). In other words, HIIT improved VO_{2max} and P_{max} in experimental group as compared to control group.

Discussion

It was revealed that three weeks of HIIT of boys could improve bioenergetic indices including aerobic and anaerobic power in both groups. Body composition including weight, BMI, and to measure thickness of body fat, the thickness of subcutaneous fat layer was measured with a caliper (SAEHAN, South Korea) on abdomen, chest and thigh showed reduction only in experimental group.

There are inconsistencies in the results of studies about the effect of HIIT on body composition variations. Some studies show no change [27,28] whilst others report significant changes [14, 24, 11].

According to Trapp et al. (2008), 15-week HIIT intervention had more effect on body composition than steady-state exercise training [11]. Gremeaux et al. (2012) observed a significant improvement in body composition after a long period of HIIT, too [14]. The study was conducted on overweight people posed exposed to a long-time intervention (9 full months) including nutritional counseling, HIIT and resistance training. Post-intervention results indicated significant decreases in all anthropometric indices except muscle mass which showed no significant difference with baseline. They concluded that a combination of HIIT and resistance training with nutritional control can be an optimized way for maintaining muscle mass during fat loss. Another study revealed that two-week HIIT intervention resulted in significant loss of body composition and WHR [15]. However, it should be considered that the participants were

obese, sedentary men, which may be a factor affecting the results of this study. Tremblay et al. (1994) found that long-time HIIT decreased subcutaneous significantly in both young men and women. They compared HIIT with steady-state exercise training and found that although total energy cost was lower (about half) in HIIT than in steady-state training, just HIIT changed body composition [23].

Trapp et al. (2008) examined normal-weight men and women and observed that 15-week HIIT intervention resulted in favorable changes in body composition. They compared interval training with steady-state training and control (no training). Total body mass and fat mass was significantly lower in HIIT group than in other two groups. They, also, stated that the trend of fat loss from legs was desirable in HIIT group. HIIT resulted in significant loss of central abdominal fat as compared to steady-state group. HIIT group showed significantly higher lean body mass. The changes in other lean tissues were not significant [11]. Also, shing et al. (2013) reported significant loss of body fat percentage after 4-week HIIT, whilst the subjects had good body shape. So, it is possible to have body composition change even after a short period of these trainings. They compared interval training with traditional resistance training and observed that interval training changed body composition significantly. Gender plays an important role in body composition so that the results of tests differ for men and women, so they should not be compared. The other aspects which should be considered in body composition studies include age and heritage because they both considerably influence body composition. For example, adipose tissue percentage depends on heritage and also, on exercise and nutrition [24].

Long-time exercise trainings usually impact body composition indices considerably. Most studies on HIIT

show that the longer the exercise trainings are, the more effective they are on body composition indices. In fact, the inconsistencies in the results of the studies are likely to be associated with the differences in training durations and subjects. In the present study, since a short-time (3-week) HIIT intervention was administered, it did not significantly affect body composition indices [11, 23].

A significant difference was found in VO₂max and Pmax between control and experimental groups in the present study. In general, VO₂max is known as the best indicator of cardiovascular endurance and aerobic fitness. Whilst continuous training and other long-time trainings are widely used for improving VO₂max and almost all athletes in most sports use them, recent studies show that the effects of HIIT on the improvement of aerobic power is similar to that of long-time trainings. It may be associated with high intensity of HIIT and the intervals between training sets. VO₂max is reportedly increased by 5-14% after HIIT. The present study showed a similar increase (11.8%) in VO₂max in experimental group (intervened with HIIT) as compared to control.

The results of the present study are in agreement with most previous studies. In this sense, Laursen et al. (2005) reported the increased VO₂max among cyclists by 4-week HIIT intervention. They suggested that peripheral adaptations are more responsible for performance improvement than central adaptations. A mechanism for increasing aerobic power is the increased activity of oxidative enzymes as reported in some studies [25]. In a study on the effect of interval training at 95% and 100% of the velocity at VO₂max on aerobic physiological indices and running performance, Denadai et al. (2010) found that post-training VO₂max did not change in two groups and that VO₂max performance was significantly increased in the group of 100% of VO₂max [26]. Also, castagna et al. (2010) studied the physiological aspects of futsal-oriented HIIT and reported that aerobic velocity and threshold, maximum velocity, and VO₂max were significantly related to training program [19]. Astorino et al. (2012) examined the impact of HIIT on cardiovascular performance, VO₂max, and muscular power and observed a significant improvement in VO₂max as compared to baseline [27]. In a study on the effect of skill-based maximal intensity interval training on aerobic and anaerobic performance of female futsal players, Karahan (2012) reported that mean aerobic power and VO₂max of experimental group were improved by 10.7, 22.1 and 9.6%, respectively. It implied that skill-based HIIT influenced aerobic and anaerobic performance of female futsal players significantly [18].

On the contrary, some studies show that VO₂max is not affected by HIIT. For example, Laursen et al. (2002)

and Burgomaster et al. (2005) reported that 2-week HIIT did not increase VO₂max significantly [29, 30]. The difference in results may be associated with the difference in subjects (trained and not-trained) as well as the difference in training program duration. Experiments have shown that HIIT improves blood pumping by heart. This finding may explain why VO₂max is increased by HIIT as observed in some studies. Also, following the trainings, aerobic phosphorylation rate is increased. This adaptation may be brought about by the increase in the number and activity of oxidative enzymes in muscles which can be a likely mechanism for VO₂max improvement. Interestingly, most studies on the impact of HIIT on physiological factors that affect aerobic capacity show good adaptations in spite of lower intensity of their interval training programs.

One another finding of the present study was the 13.8% improvement of anaerobic power in experimental group, whereas it showed a 2% decrease in control group. Other studies confirm these findings. Although most studies report the increase in anaerobic capacity following HIIT, the reported range of the increase varies. For example, Tabata et al. (1996) reported a 28% increase in anaerobic capacity after 6-week HIIT intervention [9]. One reason for inconsistent responses can be the duration of training program. Also, the effect of pre-training anaerobic fitness and the size of its response to training program can be another reason for the observed inconsistency. The improvement of aerobic capacity can be related to such factors as the increased concentration of phosphocreatine in muscles and its reproduction rate duration recovery, the activity of anaerobic enzymes, activation of motor unit, and the increase in buffer capacity of muscles. Low number of participants and the lack of nutritional control can be mentioned as the limitations of the study.

In conclusion, the present study examined the effect of 3-week HIIT intervention on body composition and bioenergetic indices of boy futsal players. It was found that HIIT increased aerobic and anaerobic powers significantly as compared to control. It seems that HIIT with the studied intensity and duration can be an effective training program for improving body composition and bioenergetic variables among boys. It is recommended to study the effect of similar trainings with longer durations on other indices in other sports in future studies.

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Conflict of interest

The authors declare that there is no conflict of interest

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