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Effect of High Intensity Interval Training on Heart Function and Effort Capacity in Athlete Children

Sporcu Çocuklarda Yoğun Aralıklı Yüklenmelerin Kalp Fonksiyonları ve Efor Kapasiteleri Üzerine Etkisi

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EFFECT OF HIGH INTENSITY INTERVAL TRAINING ON HEART FUNCTIONS AND EFFORT CAPACITIES OF CHILD ATHLETES

ABSTRACT

The purpose of this study was to determine the effect of intense interval training on heart functions and effort capacities of child athletes. Adolescent (n: 19) footballers who play in different football clubs, whose age average is 16.8±1.2 year and also whose ages vary between 15 and 18 year participated in this study. The footballers were given a pyramidal load training with the maximal running distances of 250 meters (m) -400 m-650 m-950 m with 60% -70% -80% load intensity for 8 weeks, 3 days a week, 1 hour per day. Participator athletes were assessed by electrocardiography (ECG), echocardiography, and effort test before and after the exercises. Paired sample t-test was utilized to comparatively evaluate the pretest and posttest results in statistical analyses. Left ventricular mass (LV mass), left ventricular mass index (LV mass index), V6 derivation R wave are significantly different in the posttest ($p<0.05$). There is a statistically significant difference in heart rate and diastolic blood pressure values at rest ($p<0.05$). Duration of exercises significantly increased in the effort test (respectively 17.2+2.9; 19.6+2 minutes; $p<0.001$). There also was observed a significant difference in metabolic equality values (MET) (respectively 20.4+3.1; 22.2+2.5; $p<0.01$). There was found a significant difference in heart functions and effort capacity in child athletes at the end of intense interval training. Performance was enhanced even with 1 hour of training for 3 days a week.

Keywords: *Heart, Intensive Interval Training, Left Ventricular Mass Index.*

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SPORCU ÇOCUKLARDA YOĞUN ARALIKLI YÜKLENMELERİN KALP FONKSİYONLARI VE EFOR KAPASİTELERİ ÜZERİNE ETKİSİ

ÖZ:

Çalışmanın amacı sporcu çocuklarda yoğun aralıklı yüklenmelerin kalp fonksiyonları ve efor kapasitesi üzerine etkisini belirlemektir. Çeşitli futbol kulüplerinde oynayan, yaş ortalamaları 16.8±1,2 yıl olup yaşları 15-18 yıl arasında değişen 19 adölesan futbolcu çalışmaya dahil edildi. Futbolculara 8 hafta, haftanın 3 günü günde 1 saat olacak şekilde yüklenme antrenmanı 250 metre(m)-400 m-650 m-950 m koşu mesafelerinin maksimalleri ile %60-%70-%80 yüklenme şiddeti ile piramidal olarak yaptırıldı. Antrenmanlara katılan sporcular egzersiz öncesi ve sonrası elektrokardiyografi (EKG), ekokardiyografi ve efor testi ile değerlendirildi.

İstatistiksel analizlerde ön test ve son test sonuçlarının karşılaştırmalı olarak değerlendirilmesinde bağımlı örneklem t testi kullanıldı. Sol ventriküler kitle (LV mass), sol ventriküler kitle indexi (LV mass index), V6 derivasyonu R dalgası, son testte anlamlı farklı bulundu (p<0,05). İstirahatteki kalp hızı ve diyastolik kan basıncı değerlerinde istatistiksel olarak anlamlı farklılık vardı. (p<0,05). Efor testinde ise egzersiz süresi son testte anlamlı olarak artmış bulundu (sırasıyla 17.2+2.9, 19.6+2 dakika; p<0,001). Metabolik eşitlik (MET) değerlerinde de son testte anlamlı farklılık saptandı. (Sırasıyla 20,4+3,1; 22,2+2.5; p<0,01). Sporcu çocuklarda yoğun aralıklı antrenmanlar sonucunda kalp fonksiyonları ve efor kapasitesinde anlamlı farklılık bulunmuş olup haftada 3 gün, günde 1 saatlik antrenmanlarla bile performansı arttırdığı gösterilmiştir.

Anahtar Kelimeler: *Yoğun Aralıklı Yüklenme, Sol Ventrikül Kitle İndeksi, Kalp.*

INTRODUCTION

Sports activities are systematic works as well as important for physical development and basic skills. Training is all of the exercises which provide functional and morphological changes in an organism and are applied in specific periods to increase the athlete's form. It also is the sum of changes arising from adapting to the training and repeating the exercises systematically. Physical training is only beneficial as long as it forces the body to adapt to high loads. There will occur no adaptation if the training is insufficient to create any change in the body (Bompa, 2003). Ceylan et al. (2016) stated that the trainings and the sports year were effective.

Training that is performed to improve physical development and basic skills are classified as high-intensity short duration and low-intensity long duration based on training intensity. Interval training that includes high-intensity low duration exercises from these training models accelerates metabolism more than other types of training; training intensity increases and decreases in this model and it also is directly associated with heart rate control and applied by changing work and rest or high and low load circuit (ACSM., 1980). Kumak et al. (2021), internal and external load responses may cause different heart rates. It is stated that there is a correlation between RPE and maximum HR, average HR and workload (Bozdoğan et al., 2016). It can be mentioned that the interval resistance method can be used to reorganize aerobic and anaerobic capacity; namely, heart enlargement and carbohydrate metabolism. Since this method is not a routinized training program, the sporter is not bored during exercises; he swiftly burns fat; his metabolism works fast after exercises; his resistance and condition increase at the same time. This method has positive impacts on sedentary such as increasing muscle mass and strengthening the heart and also the parameters such as health and performance when it is regularly applied (Günay et al., 2000; Baydil 2005; Nakaahara et al., 2014). Kirişci et al., (2020) when comparison of physiological outputs of different maximum aerobic speed determination tests, they found differences in blood lactate, Maxvo2 and maximum aerobic tests.

It is known that regularly performed proper training is beneficial for athletes or sedentaries in terms of heart health. Training provides enlargement in veins to the heart; helps the heart nourish better. Training also decreases the amount of LDL, often referred to as "bad" cholesterol causing vascular occlusion; increases high-density lipoprotein (HDL) to protect vessels. Again, training is effective on obesity; beneficial to regulate the blood sugar for diabetic patients, and it also reduces the blood pressure in patients with high blood pressure (Marwa et al., 2018).

It is accepted that high-intensity interval training (HIIT) provides important advantages in many parameters such as VO2max, recovery time, running distance and increase in repeated sprint capacity (Köse & Atlı, 2020). This study aimed to determine the effect of the high-intensity interval training model on cardiac parameters (ECO, EKG) and effort capacity in adolescent football players.

İt is thought that HIIT is a viable method for the development of some performance parameters of football players at different levels in less time.

METHODS

19 male licensed football players voluntarily participated in this study (age average is 16.83±1.29 years, training age is 3.3±1.5 years, bodyweight is 66.07±8.84 kg). Height measurements were made with a pharmaceutical-type height measuring device with bare feet and only shorts on them. Body weights were recorded with a sensitivity of 100 gr. using the Felix brand FL598 digital glass weighing machine. Moreover, athletes performed an intensive interval training program for 1 hour a day, 3 days a week, and totally for 8 weeks. Training intensity was specified as 220 based on the age formula; training intensity was specified based on the pulse that was measured within 10-15 seconds after the end of each repetition. ECG, Echocardiography, and Effort tests were applied for child athletes before training and also after 8-weeks of training; their pretest and posttest measurement values were recorded.

Participants signed an informed consent form after KÜ GOKAEK 2017/53 numbered ethics committee approval was received from Kocaeli University Human Researches Ethics Committee. This study has been supported by Kocaeli University Scientific Research Unit (SRU).

Data Collection

Training Method

Intensive Interval Training Method

Intense: 80-90%

Rest Between Sets: 2-4 minutes productive rest

1st Day

4*2 minutes (intensity 80-90%, rest between sets 4 minutes productive rest, training after sets was performed after 120 pulses)

2nd Day

6*120 meters (intensity 80-90% rest between sets 4 minutes productive rest; training after sets was performed after 120 pulses)

3rd Day

12*40 meters (5 minutes rest between sets, intensity 80-90% 30 seconds within a set every 40 meters, training after sets was performed after 120 pulses).

- 4*40 meters 1st set (40 meter-40 meter- 40 meter- 40 meter)
- 4*40 meters 2nd set (40 meter-40 meter- 40 meter- 40 meter)
- 4*40 meters 3rd set (40 meter-40 meter- 40 meter- 40 meter)

Electrocardiography

12-channel electrocardiography recordings of the athletes were obtained using the Cardiofax M-ECG 1350K (Nikon Kohden Corporation, Japan) device. QRS axis, QRS (ms), QTC (ms), PR (ms), V1, V2, V3, V4, V5, V6 derivations, ST-T wave variability parameters were measured; V6 derivation R wavelength was taken into account. Athletes' resting pulse was measured by electrocardiography device; all the ECG records were evaluated as single-blind by the same pediatric cardiologist without mentioning the names of participators.

Effort test

Symptom-limited maximal exercise test in Norav 1200 brand effort instrument Bruce protocol integrated with computer and ECG system was applied to athletes in effort test unit in the cardiology polyclinic. Blood pressure, during the effort test, was automatically measured 6 times with the electronic blood pressure meter on the left arm effort test device in a sitting position after 5 minutes of rest and every 3 minutes at stage 1 (2.7 km/h, 10% elevation), stage 2 (4 km/h, 12% elevation), stage 3 (5.4 km/h, 14% elevation) and also the 3rd and 5th minutes of the recovery phase. Moreover, heart rate and double product (heart rate x systolic blood pressure) were automatically measured with the ECG system on the device. Effort test was accepted as maximal when it is reached 85% of the target heart rate that is computed based on a 220-age formula; effort test was accepted as submaximal when it is reached 70%-85% of the target heart rate. However, the participators continued to run to the point where they were exhausted and the test was terminated when they were exhausted. The last stage that the participators could complete was accepted as peak exercise. The formula (Running Speed 26.8, Horizontal Component (HC)= Speed 0.1, Vertical Component (VC)= Speed 1.8Slope, Oxygen Consumption ($VO_{2)}$= HC+VC+3,5 ml/kg/min, Metabolic Threshold Value (MET)= VO_2/3,5) that machine automatically determines to measure the metabolic threshold value was utilized. Measuring systolic blood pressure above 214 mmHg during exercise was evaluated as excessive blood pressure response in line with the information obtained from the 2002 update of the exercise stress test manual published by the American College of Cardiology / American Heart Association (ACC / AHA) in 1997.

Analysis of Data

‟SPSS for Windows Version 22.00 program" evaluated data; significance level was accepted as $p<0.05$ by using paired sample t-test in comparatively evaluating pretest and posttest results.

RESULTS

Table 1. Athletes' age and training age, mean, standard deviation, highest and lowest values

Participants	Min	Max	Mean	sd
Age (year)	14.6	18.8	16.8	1.2
Training age (year)	2.2	6.5	3.3	1.5

As is seen in Table 1, athletes' age average is 16.8±1.2 years; their training age was measured as 3.3±1.5 years.

Table 2. Weight (kg), ef (%), resting pulse (min), lv mass (gr), lv mass index-(gr/m²), v6 r(mm), systolic blood pressure (mmhg) and diastolic blood pressure (mmhg) mean, standard deviation and p values of athletes

Participants	Pretest Mean± sd	Posttest Mean± sd	p
Weight(kg)	66.07±8.84	65.76±8.58	0.250
Resting Heart Rate(min)	70.36±11.52	64.89±10.12	0.450
Left Ventricular Mass(gr)	171.76±30.71	192.68±40.66	0.001
Left Ventricular Mass Index (gr/ m²)	38.01±7.38	42.50±8.46	0.001
Ejection Fraction (EF) (%)	65.68±4.37	67.21±4.44	0.285
V6 derivation R (mm)	11.84±2.91	13.26±3.52	0.001
Systolic Blood Pressure mmHg	114.47±14.38	111.05±12.20	0.590
Diastolic Blood Pressure mmHg	69.47±10.54	59.47±5.88	<0.001

As is seen in Table 2, it is observed when pretest, posttest Weight(kg), EF (%), and Systolic Blood Pressure measurement values are compared that there is a significant difference ($p>0.05$). On the other hand, there is seen a significant difference at $p<0.05$ level when Resting Pulse(min), LV Mass(gr), LV Mass Index(gr/m²), V6 R(mm), and Diastolic Blood Pressure (mmHg) measurement values are compared (Table 2).

Table 3. Pretest and posttest significance levels belong to athletes who participated in effort test

Participants	Pretest Mean± sd	Posttest Mean± sd	p
Maximum (KAH)	187.89±7.28	187.78±6.45	0.953
1st min Recovery (KAH)	146.89±15.74	142.00±13.92	0.295
2nd min Regeneration (KAH)	125.11±14.11	124.95±11.65	0.862
3rd min Regeneration (KAH)	114.79±11.80	113.53±9.46	0.619
Duration of Exercise (min)	17.26±2.92	19.68±2.02	0.001
Metabolic Threshold Value (MET)	20.45±3.16	22.22±2.56	0.011

As is seen in Table 3, there is no significant difference in pretest-posttest maximum pulse rate with 1st min, 2nd min, and 3rd min regeneration pulse rate (PR) measurement values ($p>0.05$); on the other hand, there is a statistically significant difference in pretest-posttest exercise time (min) measurement values and metabolic threshold value (MET) measurements ($p<0.05$) (Table 3).

DISCUSSION

This study scrutinized the effect of high-intensity interval training lasting 3 days a week for 8 weeks on heart functions and effort capacities of child athletes whose age average is 15-18 years. There is significant difference in Resting Pulse (min), Diastolic blood pressure, LV mass gr., LV mass index (g/m²), Duration of Exercises (min), Metabolic Threshold Value (MET), V6 R mm values. On the other hand, there is no significant difference in Body Weight (gr.), Maximum (KAH), 1st regeneration (KAH), 2nd regeneration (KAH), 3rd regeneration (KAH), Systolic Blood Pressure mmHg, and EF % rates.

High-intensity training brings along new and positive gains for sedentaries and sporters in terms of positive adaptation, health, and performance. It is emphasized in several studies that endurance training is effective on body composition; moreover, endurance training decreases body weight, body fat percentage, body mass index as well as causes increases in body density and fat-free mass. In addition to all these, endurance training is pretty effective on both team sports and individual sports; with reference to clinical studies, it prevents many cases and events related to chronic diseases and has beneficial effects on the quality of life of patients (Patlar et al. 2003; Gökdemir et al. 2007; Revan et al.2008; Trapp et al. 2008).

Yüksel et al. (2007) conducted continuous running and interval running training 3 days a week for 8 weeks. They mentioned that there is no significant difference in body weight values of the interval training group; however, there is a significant difference in body weight values of the group who performed continuous running. Similarly, Berger et al., (2006) organized continuous and high-intensity interval training for 3-4 days a week for 6 weeks; they did not find a significant difference in athletes' body weight. According to their findings, participators' bodyweight decreases while weight loss due to training is insignificant. Interval training does not cause huge changes in terms of body weight while it brings along decreases in body fat ratio at the same time (Serkan et al., 2008, Cardenosa et al., 2016).

Matsuo et al., (2014) conducted interval training for sedentary adults for 3 days a week lasting 8 weeks; for findings, resting pulse significantly decreases. Hatle et al., (2014) organized high-intensity training for 21 university students and mentioned that students' heart rate significantly decreases. Currie et al., (2013) conducted a study for 8 coronary artery patients dividing them into two as the control and training group. They highlighted that the resting pulse of the group who performed 12-weeks high-intensity interval training significantly decreased. This paper reveals that child athletes' resting pulse rate decreases after 8-weeks of training; there also is a significant difference in resting pulse levels. It can be thought that this related decrease might be seen based on the increase in heartbeat volume.

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Moreover, just as adults, high-intensity interval training decreases resting pulse rate and it also has advantages not only for healthy individuals but also the patients (Mohr et al. 2014, Huang et al. 2014).

There might be seen a significant increase in heart measurements of people who are continuously exposed to stress compared to sedentaries. This situation that especially occurs in endurance sporters by ventricular wall thickening and enlargement of the ventricular cavity is known as cardiac hypertrophy (Cantwell and Doller 2000; Hazar and Koç 2003). Regarding literature, Matsuo et al. (2014) applied high-intensity interval training for 3 days a week lasting 8 weeks in total for healthy sedentary males. According to their results, this training method increases LV mass and left ventricular mass indexes (LV mass index g/m^2) while EF% (Beat Fraction) ratio decreases. Nakahara et al. (2014) organized 1 session per week for 8 weeks of intense interval training for 14 healthy men. For findings, participators' LV indexes significantly increased after the training; EF% ratio also increased but it was insignificant. Esfandiari et al., (2013) made research with the participation of 16 males who have not performed training before. They mentioned at the end of the 12-weeks interval training program that participators' LV mass and LV mass indexes increased; moreover, there also was seen an insignificant increase in participators' EF% ratios.

Sharf et al. (2015) organized 3-days and 16-weeks intense interval training for 42 males who have not performed exercises before. According to their study results, LV mass index increased after training while the increase that occurred in EF% ratios after exercises were insignificant. This paper reveals that high-intensity interval training increases the left ventricular mass (LV mass g) of athletes as well as left ventricular mass index, which is an indicator of left ventricular hypertrophy. Moreover, we also observed an insignificant increase in the EF% ratio that is an indicator of how much of the blood that comes to the heart is pumped at each heartbeat and how well the heart contracts with each heartbeat. It is seen when the results are analyzed that modified interval training affects left ventricular hypertrophy, which is defined as cardiac morphological adaptation in athletes, increase in cardiorespiratory functions during exercise and exercise performance.

Changes in V5-V6 derivations from Echocardiographic (ECG) findings based on training are accepted as the presence of cardiac hypertrophy in athletes. Hazar and Koç (2003) conducted a study and highlighted that there was an increase in wrestlers' V5-V6 derivation and R values; left ventricular hypertrophy was ween in wrestlers based on pretty high left ventricular electrical force. Similarly, Sevimli and Koçyiğit (2009) made research with the participation of 76 children who performed endurance training for 60 minutes, 3 days a week for 8 weeks. According to their findings, child athletes have a significant difference in V6 derivation and wavelength compared to children who do not play sports. ECG measurements and

Rwavelength in V6 derivations of sporters were recorded in our study; it was also found that Rwavelength grew longer after exercises. In conclusion, it is thought that intense interval training causes increases in left ventricular muscle mass in child athletes.

Regarding sources, systolic blood pressure increases by the decrease in peripheral resistance during aerobic exercises; this increase is rooted in the increase in heart rate volume. Systolic blood pressure increases during static exercises as well; however, its mechanism is different from aerobic exercises. Systolic blood pressure and peripheral resistance increase are responsible for such exercises. Systolic blood pressure decreases a little or does not change during resistance exercises (Baydil, 2005). Diastolic blood pressure may decrease a little or remain stable by the decrease in peripheral resistance during aerobic exercises while it (diastolic blood pressure) increases in static exercises. Again, diastolic blood pressure may increase or decrease a little or does not change during resistance exercises (Hauser,2003)

Buchan et al., (2012) organized high-intensity training for a total of 7 weeks, 3 days a week for 41 Scottish adolescents. For their findings, participators' systolic and diastolic blood pressure decreased after exercises while there was no significant difference. Kouba et al., (2013) researched 29 obese adolescents and mentioned that intense interval training caused a decrease in systolic and diastolic blood pressures of obese adolescents. Lawal and Kankanala (2010) surveyed Nigerian adolescents and expressed that intense interval training for 3 days a week for 6 weeks in total caused an insignificant decrease in systolic and diastolic blood pressure. Tjonna et al., (2013) organized intense interval training for 3 days a week for 10 weeks for 28 healthy men who have not performed exercises before. According to their findings, systolic and diastolic blood pressure decreased after exercises and there was a significant difference in diastolic blood pressure drop. This paper, too, reveals that the systolic and diastolic blood pressure of sporters decreases after training, and only the decrease in diastolic blood pressure was found to be significant. In other words, this finding shows that related training methods have an effect that decreases systolic and diastolic blood pressure of child athletes.

ECG and Echocardiographic measurements of child athletes were recorded before and after training; they were applied effort tests to see the effects of training. Moreover, their heart rate variability, heart rate regenerations, exercise duration, and MET capacity values were also measured. There was found no difference in effort test maximum heart rate and effort test 1 minute, 2 minutes, and 3 minutes recovery heart rate of sporters. However, a significant difference was observed in effort test duration and metabolic threshold values. Much as there were no significant changes in the maximum heart rate of sporters, increases in metabolic threshold value level can be accepted as an indicator of increases in effort capacities.

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Finally, it can be pointed out that intense interval training for 3 days a week for 8 weeks increases cardiac parameters in child athletes; again, this training method improves the values such as heart rate in effort test, duration of exercise, heart rate recovery level and MET level. The high-intensity interval training technique is accepted as one of the most effective training methods that developed the cardiovascular system, metabolic functions, and thus physical performance of athletes.

SUGGESTIONS

We found significant difference in Resting Pulse (min), Diastolic blood pressure, LV mass gr, LV mass index (g/m²), Exercise Time (min), Metabolic Threshold Value (MET), V6 R mm values of child athletes.

There was not any significant difference in Body Weight, Maximum (HR), 1st min Recovery (HR), 2nd min Recovery (HR), 3rd min Recovery (HR), Systolic Blood Pressure mmHg, and EF% ratios.

- The positive effect of this training method on cardiac functions of 15-18 years old athletes positively contributes to the sportive success of sporters who will compete in individual and team sports.
- Determination of effects of intense interval training on heart, circulatory and respiratory parameters of athletes in different sports branches can bring along advantages for coaches and sporters in terms of sport-specific training methods.
- Implementation of intensive interval training with determined load intensity may create positive results for patients with hypertension and regulating systolic and diastolic blood pressure.
- Based on the data obtained from athletes and healthy individuals, it may be recommended to prescribe intensive intermittent exercise to obese individuals to obtain positive results in the targeted treatment process.

Yazar Katkı Oranları:

Çalışmanın Tasarlanması (Design of Study) : SDK (% 50), DD (% 50)

Veri Toplanması (Data Acquisition) : SDK (%40), ÖK (30), OT (30)

Veri Analizi (Data Analysis) : DSK (% 70), DD (% 40)

Makalenin Yazımı (Writing up) : DD (% 100)

Makale Gönderimi ve Revizyonu (Submission and Revision) : DD (% 100)

REFERENCES

A.C.S.M (Amerikan Collage Of Sports Medicine). (1990). The recommended quantity and quality of exercise for developing and maintaining cardionespiratory and muscular fitness in healthy adults. Medical Science Sports Exercise, 4 (3), 22-265.

Baydil, B. (2005). The Effect of Interval Training Program Applied at High Altitude on Some Physiology Parameters of Sedentary Men at High School Level. Kastamonu Journal, 13(1), 299–310.

Berger, N., Tolfrey, K., Williams, A. (2006). Influence of Continuous and Interval Training.

Bompa, T. O. (2003). Periodization Training Theory and Method (2nd Edition). Dumat Offset, Ankara.

Bozdoğan, T. K., Kızılet, A., Çağlayan, A., Erdem, K., Demirel, N. (2016). Farklı lig düzeylerindeki müsabakalarda görev yapan üst klasman hakemlerinin fizyolojik açıdan değerlendirilmesi. Spor ve Performans Araştırmaları Dergisi, 7(2), 97-102.

Buchan,S.,& Young, J.(2012). The effects of a novel high intensity exercise intervention onestablished markers of cardiovascular disease and health in Scottish adolescent youth. Journal of Public Health Research, 1(2), 155.

Camacho-Cardenosa, M., Camacho-Cardenosa, A., Brazo-Sayovera, J., Marcos-Serano, M., Timon, R., & Olcina, G. (2016). Effects of High Intensity Interval Training on Fat Mass Parameters in Adolescents. Revista Espanola de Salud Publica, 90, 1-9.

Cantwell, D., &Allen, L. (2000). ECG variations in college athletes. The Physician and Sports Medicine, 27(9), 68-74.

Ceylan, L., Demirkan, E., & Küçük, H. (2016). Examination of sprint duration and repeated sprint level of soccer players in different age group. International Journal of Science Culture and Sport, 4, 188-199.

Currie, D. (2013). Heart rate recovery and heart rate variability are unchanged in patients with coronary artery disease following 12 weeks of high-intensity interval and moderate-intensity endurance exercise training. Applied Physiology Nutrition and Metabolism, 38(6), 644-650.

Esfandiari, S., Zion,S., &Jack, M.(2014). Short-term high-intensity interval and continuous moderate-intensity training improve maximal aerobic power and diastolic filling during exercise. European Journal of Applied Physiology, 114(2), 331-343.

Gökdemir, K., Koç, H., & Yüksel, O. (2007). The Effect of Aerobic Training Program on Some Respiratory and Circulation Parameters and Body Fat Ratio of University Students. SDÜ Exercises, 1(1), 145-149.

Günay, M., Tamer, K., Cicioğlu, İ., & Çevik, C. (2000). The Effect of Two Different Types of Interval Training Programs on Some Physiological Parameters, Ege University Journal of Sports Medicine, 35(4), 143.

Hatle, H., Støbakk, P., Mølmen, H., Bronstad, E., Tjonna, A.E., Steinshamn, S., Wisloff, U., İngu, C. (2014). Effect of 24 sessions of high-intensity aerobic interval training carried out at either high or moderate frequency, a randomized trial. PLoS One, 9(2), e88375.

Hazer, S., &Koç, H. (2003). Investigation of Heart Structure and Functions of Wrestlers at the Level of Turkish Wrestling National Team by Electrocardiography Method. Gazi Journal of Physical Education And Sports Sciences, 1; 3-14.

Huang, S.(2014). Modified high-intensity interval training increases peak cardiac power output in patients with heart failure. European Journal of Applied Physiology, 114(9), 1853-1862.

Khammassi, M., Ouerghi, N., Hadj-Taieb, S., Feki M., Thivel, D., & Bouassida,A. .(2018) İmpact of a 12-week high-intensity interval training without caloric restriction on body composition and lipid profile in sedentary healthy overweight/obese youth. Journal Exercise Rehabilitation, 14(1),118-125

Kirişci., Kızılet, A., & Bozdoğan, T. (2020). Comparison of Physiological Outputs of Different Maximum Aerobic Speed Determination Tests. Progress in Nutrition, 22;3. e2020036.

Koç H., Tamer, K., & Çoksevim, B. (2007). The Effect of Continuous and Interval Running Programs on Plasma Urea and Creatine Levels. Journal of Health Sciences, 16 (1), 17–22.

Koubaa, A., Trabelsi, H., Masmoudi, L., Sahnoun, Z., Zeghal, K.M., Hakım, A., Koubâa, A. (2013). Effect of Intermittent and continuous training on body composition cardio-respiratory fitness and lipid profile in obese adolescents. IOSR-JPBS, 3(2), 31-37.

Köse, B., & Atlı, A. (2020). Genç Futbolcularda Yüksek Şiddetli İnterval Antrenmanın Çeviklik Sürat ve Aerobik Performans Üzerine Etkisinin İncelenmesi. Türkiye Spor Bilimleri Dergisi, 4(1),61-68.

Kumak, A., Kizilet, A., & Bozdoğan, T. (2021). Exploration of the effect of small sided games on the technical skills, internal and external loads of main and joker players. Progress in Nutrition, 23(2).

Lawal, B., & Venkatseswarul, K. (2010). Effects of intermittent and continuous training on the blood pressure of Nigerian adolescents and children. British Journal of Sports Medicine, 44(1), 28-28.

Matsuo, T., Saotome, K., &Seino, S. (2014). Low-volume, high-intensity, aerobic interval exercise for sedentary adults: VO2max, cardiac mass, and heart rate recovery. European Journal of Applied Physiology, 114(9), 1963-1972.

Mohr, M. (2014). High-intensity intermittent swimming improves cardiovascular health status for women with mild hypertension. BioMed Research International, 2014; 5(2), 1-9.

Nakahara, H., Shin-ya, U., Tadayoshi M (2015). Low-frequency severe-intensity interval training improves cardiorespiratory functions. Medicine and Science in Sports and Exercise, 47(4), 789-798.

Patlar, S., Sanioğlu, A., Kaplan, T., & Polat,Y. (2003). The Effect of Continuous Run Method and Play Form Method on Endurance Parameters of Football Players. SU Journal of Physical Education and Sports Science, 5(1), 10–17.

Revan, S., Balcı, Ş., Pepe, & Aydaoğmuş, M. (2008). Effects of continuous and internal running training on body composition and aerobic capacity. Spormeter Journal of Physical Education and Sport Sciences, 6(4), 193-197.

Scharf, M., Schmid, A., Kemmler, W., von Stengel, S., May, M. S., Wuest, W., Lell, M. M. (2015). Myocardial adaptation to high-intensity (interval) training in previously untrained men with a longitudinal cardiovascular magnetic resonance imaging study (Running Study and Heart Trial). Circulation: Cardiovascular Imaging, 8(4), e002566.

Serkan, H., Koç, H. (2003). Investigation of Heart Structure and Functions of Wrestlers at the Level of Turkish Wrestling National Team by Electrocardiography Method. Gazi Journal of Physical Education and Sports Sciences, 1; 3-14

Sevimli, D., Fuat, K. (2009). Effects of aerobic exercise on cardiopulmonary system in children. TAF Preventive Medicine Bulletin, 8(2), 125-130.

Tjønna, A., Leinan, I., &Bartnes ,A.(2013). Low-and high-volume of intensive endurance training significantly improves maximal oxygen uptake after 10-weeks of training in healthy men. PloS one, 8(5), e65382.

Trapp, E., Chisholm, D., Freund, J., & Boutcher, S.H. (2008). The Effects of High– Intensity Intermittent Exercise Training on Fat Loss and Fasting Insulin Levels of Young Women. International Journal of Obesity, 32(4), 684–691.

Yüksel, O., Koç, H., Özdilek, Ç., &Gökdemir, K. (2007). The effect of continuous and interval training programs on aerobic and anaerobic power of university students. Jounal of Health Sciences, 16(3),133–139.