International Journal of Sport Studies for Health

Journal Homepage

A Comparative Study of Intense Continuous and Intermittent Aerobic Training on Physiological Factors in Football Players

Mohammad Ali Samavati Sharif[1*], Massoud Ramezani[2], Hojjatollah Siavoshi[1]

[1] Ph.D. in Exercise Physiology, Department of Sport Sciences, Faculty of Humanities, Omran and Toseeh Higher Education Institute, Hamadan, Iran
[2] M.A. in Exercise Physiology, Department of Sport Sciences, Faculty of Humanities, Omran and Toseeh Higher Education Institute, Hamadan, Iran

*** Corresponding author email address**: ali.samavati@gmail.com

A r t i c l e I n f o

Article type:
Original Paper

How to cite this article:
Samavati Sharif, M. A., Ramezani, M., & Siavoshi, H. (2024). A Comparative Study of Intense Continuous and Intermittent Aerobic Training on Physiological Factors in Football Players. *International Journal of Sport Studies for Health*, *7*(1), 74-81.
http://dx.doi.org/10.61838/kman.intjssh.7.1.9

A B S T R A C T

Objective: Identifying new training methods to enhance athletes' physical fitness and physiological factors has become a major focus for coaches and sports specialists. Aerobic training, especially high-intensity interval training (HIIT) and intense continuous training, are recognized for their effectiveness in improving health and performance metrics. This study compares these two training methods to assess their impact on specific physiological factors in young football players from Hamadan city.

Methods and Materials: This quasi-experimental study involved 45 young football players who met specific inclusion criteria (e.g., non-smokers, no cardiovascular diseases, no recent structured exercise programs, etc.). The participants were randomly divided into three groups: an intense continuous aerobic exercise group, an intense intermittent program group, and a control group, each consisting of 15 players. The continuous aerobic group trained thrice weekly at 90-95% of their maximum heart rate, while the intermittent group performed 30 minutes of high-intensity training followed by 30 minutes of rest, also thrice weekly. Physiological factors, including maximal oxygen consumption (VO2max), heart rate, and blood pressure, were measured before and after six weeks of training.

Results: Both training methods significantly improved the physiological factors compared to the control group. However, intense continuous aerobic training showed more significant and substantial improvements. VO2max increased significantly in both experimental groups but more so in the continuous aerobic group. Similarly, both training methods resulted in significant reductions in resting heart rate and blood pressure, with more pronounced effects observed in the continuous aerobic group.

Article history:
Received 06 October 2023
Revised 04 December 2023
Accepted 18 December 2023
Published online 01 January 2024

Conclusion: This study highlights the distinct impacts of intense continuous and intermittent aerobic training on physiological factors in football players. While both methods are beneficial, intense continuous aerobic training may provide more significant enhancements, making it a potentially more effective training strategy for improving the physical fitness and performance of football players. Further research could explore the long-term effects of these training methods and their impact on other performance metrics.

Keywords: *Maximal Oxygen Consumption, VO2max, Heart Rate, Blood Pressure, Intense Continuous Aerobic Training, Intense Interval Training*

1. Introduction

Identifying innovative training methods that improve physical fitness and physiological factors in athletes has become a significant challenge, attracting the attention of coaches and sports specialists. Studies have shown that these factors can be developed through various types of training, including intense aerobic exercise (1). High-intensity interval training (HIIT), for instance, involves explosive, high-intensity, short, and intermittent activities with low-intensity recovery periods. This method is highly efficient relative to the time spent on exercise. Typically, a HIIT session lasts between 10 to 30 minutes. Despite its short duration, it can provide health benefits comparable to or even greater than moderate-intensity training (2).

Nowadays, HIIT is considered an ideal alternative to traditional aerobic exercises, which induce similar or even greater physiological, functional, and health-related changes in adults and patients (2). Compared to moderate-intensity continuous training, HIIT, despite requiring less time and overall volume, induces greater physiological stimulation (3).

HIIT is characterized by repeated bouts of high-intensity activity close to the peak oxygen uptake, followed by periods of rest or low-intensity activity (4). These sessions can last from a few seconds to several minutes, with various intervals separated by rest periods or low-intensity activity.

Evidence indicates that if the recovery time between high-intensity intervals is reduced, the glycolytic contribution for energy supply decreases, leading to increased aerobic metabolism to compensate for the energy deficit. Researchers have also confirmed the impact of various HIIT protocols on rapidly improving exercise capacity and skeletal muscle energy metabolism (5, 6).

Football is one of the most exciting and popular sports globally, not only having the highest number of participants worldwide but also encompassing the most scientific and practical discussions and gaps. Factors such as balance play a significant role in this sport (7). Compared to other team and ball sports, football has the highest number of participants, fans, and spectators (Kirkendall, 2020). Football matches involve sprinting, dribbling with quick direction changes, shooting, and throwing. Players must execute these movements quickly and accurately. To perform these movements correctly, players need optimal physical fitness and functional readiness (8).

Key performance indicators for football players include physiological factors, as football is dependent on various physiological demands (9). In this study, physiological indicators such as systolic blood pressure (the level of arterial blood pressure when the left ventricle ejects blood following each heartbeat), diastolic blood pressure (the minimum arterial blood pressure between heartbeats), and resting heart rate (the number of heartbeats per minute at rest) were measured. By understanding the physiological performance and capacity of athletes, new and better programs can be designed to ensure their success. Football players undergo numerous physiological changes due to continuous activity and running (9), impacting their resting heart rate and systolic and diastolic blood pressure. Despite the extensive range of changes football players' experience, few studies have examined the physiological indicators and physical fitness of football players. There is a practical lack of research and strategies regarding enhancing physical fitness and reducing changes in physiological indicators through exercise training. This study aims to address these research gaps and challenges by examining the effects of two types of aerobic training—intense continuous and high-intensity interval training—on these indicators, thereby contributing to the growth and development of the football industry.

2. Materials and Methods

In this quasi-experimental study, 45 young football players from the community who met the study criteria were selected. These criteria included not having cardiovascular diseases, not being smokers, not using assistive devices, having no hearing or vision impairments, no temporary balance issues on the day of the test, not being wheelchair-

dependent, not participating in any regular exercise programs or dietary regimens in the past three years, not having skeletal, thyroid, kidney, or cardiovascular diseases, not using any specific medication, having a regular sleep cycle, not taking blood pressure-lowering drugs related to inflammatory diseases, regular attendance in training sessions, and not having injuries, especially in the ankle or knee areas. After explaining the study and obtaining informed consent, the participants were randomly divided into three groups of 15: an intense continuous aerobic exercise program, a high-intensity interval training (HIIT) program, and a control group. Other characteristics of the participants are presented in Table 1. This table summarizes the general characteristics, including age, height, weight, and body mass index, of the participants in the control group, the intense continuous aerobic training group, and the high-intensity interval training group.

Table 1. General Characteristics of the Study Participants

Variable	Group	Mean	Standard Deviation	Variance	Minimum	Maximum
Age (years)	Control	23.66	2.28	5.2	19	27
	Intense Continuous Aerobic	24.8	2.54	6.457	18	28
	High-Intensity Interval	25.13	2.92	8.552	19	31
Height (meters)	Control	1.79	0.05	0.003	1.6/1	1.8
	Intense Continuous Aerobic	1.76	0.08	0.007	1.6	1.8
	High-Intensity Interval	1.79	0.05	0.003	1.6	1.8
Weight (kilograms)	Control	73.93	3.692	13.638	68	82
	Intense Continuous Aerobic	72.93	6.584	43.352	64	84
	High-Intensity Interval	74.2	4.554	20.743	61	82
Body Mass Index (kg/m²)	Control	22.98	1.339	1.793	21.04	25.5
	Intense Continuous Aerobic	23.55	1.733	3.005	19.1	25.3
	High-Intensity Interval	23.12	1.35	1.83	21.4	25.31

At the beginning of the study, the research variables for all groups, including maximal oxygen consumption (measured by the Bruce treadmill test), resting heart rate, and systolic and diastolic blood pressure, were measured. Maximal oxygen consumption refers to the highest amount of oxygen an individual can consume in one minute, which the body's oxygen delivery system must meet as the tissue's oxygen demand increases.

In this study, maximal oxygen consumption was measured using the Bruce treadmill test, one of the most common tests for assessing VO2max. This test is conducted on a treadmill and consists of seven stages. Initially, the participant walks on the treadmill, and as the speed and incline increase from stage 3 to 4, the walking transitions to brisk walking, and if the participant can continue, they start running. The activity is stopped when the participant becomes extremely fatigued and can no longer continue (10). Resting heart rate and blood pressure were measured using the Beurer BM40 blood pressure monitor, manufactured in Germany. Beurer offers various products, including the Beurer blood pressure monitor. This monitor is digital and automatic, meaning no stethoscope is needed. The Beurer BM40 can measure blood pressure and pulse rate. Heart rate and blood pressure were measured before training and immediately after the end of the study period, 18 minutes after the participant's arrival at the research test site. All research variables were measured both at the beginning and at the end of the training protocol.

Each group then performed their specific training program (intense continuous aerobic training and high-intensity interval training). The intense continuous aerobic training protocol included a four-week aerobic program with three sessions per week, consisting of fourteen ball drills conducted on a specially designed course. The cones used to design the training course were 0.3 meters in diameter and 0.15 meters in height. The training intensity was set at 90-95% of each player's maximum heart rate, measured before the training using the Bruce treadmill test.

The Bruce treadmill test protocol is used to evaluate the overall fitness of endurance athletes. Initially developed by cardiologist Robert Bruce in 1963 as a non-invasive test for assessing patients with suspected heart disease, the Bruce treadmill test is sometimes referred to as a stress test or exercise tolerance test in clinical settings. It can be used to estimate maximal oxygen uptake (VO2 max), which measures an athlete's ability to perform sustained exercise, reflecting aerobic endurance. The Bruce protocol is a maximal exercise test where the treadmill speed and incline increase every three minutes until the participant reaches exhaustion. The time spent on the treadmill is recorded as

the test score and can be used to evaluate VO2 max. During the test, heart rate, blood pressure, and perceived exertion are often recorded.

In the training execution, players dribbled around the first ten cones in a zigzag pattern, then jumped over obstacles 30 centimeters high with the ball. Afterward, they dribbled around the next cones in a zigzag pattern and moved from point A to point B (Figure 1) while controlling the ball backward and then returned to the starting point. The work periods consisted of four four-minute bouts separated by three minutes of active rest or at 70% of the maximum heart rate. The heart rate of the players was measured using heart rate monitors. This intense continuous training was performed three times a week, at the same time each day, and at the end of regular team training sessions (11).

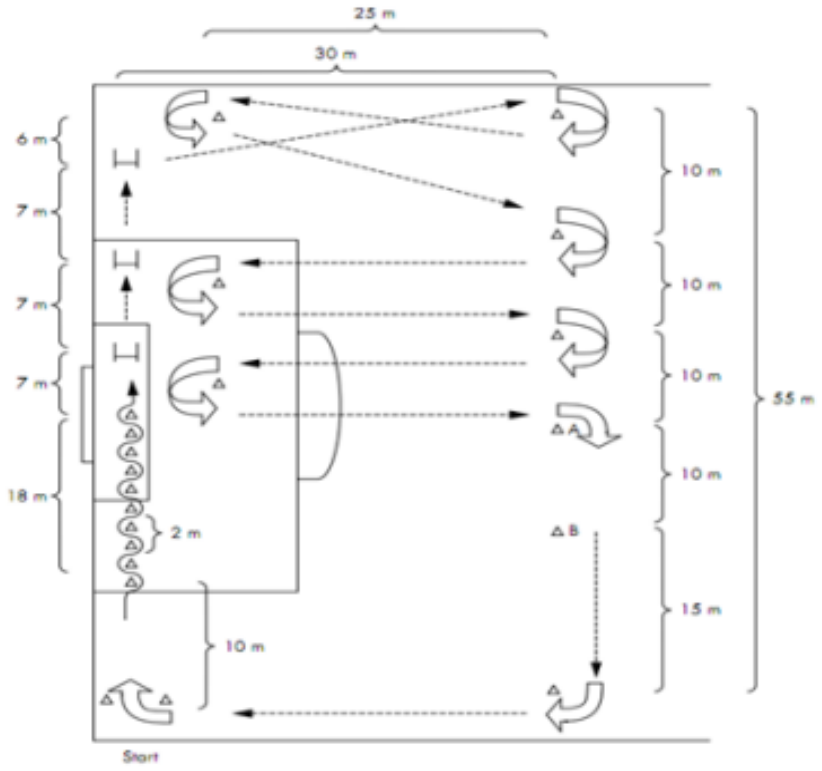

Figure 1. In the Hoff training method, each player must carry the ball through specified paths. The training area has a width of 35 meters and a length of 55 meters. The player must move backward between cones A and B while controlling the ball

The high-intensity interval training (HIIT) consisted of 30-second bouts of high-intensity exercise followed by 30 seconds of active low-intensity rest. The training protocol included 20-meter sprints with varying repetitions over six weeks. Rest intervals between sprints ranged from 20 to 30 seconds. To ensure progressive overload and effectiveness of the training, the number of short-distance sprint repetitions was set at four in the first and second weeks, five in the third and fourth weeks, and six in the fifth and sixth weeks. Each session included a 5-minute warm-up and a 5-minute cool-down. The HIIT was performed three days a week for six weeks. At the end of the study, data were collected and analyzed using descriptive statistics (mean and standard deviation) and inferential statistics. Paired t-tests were used to compare pre-test and post-test values, and independent t-tests were used to compare differences between groups. All data analysis was conducted using SPSS version 26, with a significance level set at less than 0.05.

3. Results

The means and standard deviations of the research variables (maximal oxygen consumption, heart rate, blood pressure) in the pre-test and post-test for the study groups (control, intense continuous aerobic training, high-intensity interval training) are presented in Table 2.

Table 2. Means and Standard Deviations of Research Variables in Study Groups

Variable	Group	Condition	Mean	Standard Deviation	Variance	Minimum	Maximum	Change (%)
Maximum oxygen consumption (mL/Kg.min-1)	Control	Pre-test	41.4	0.71	0.5	40.3	43.2	0.02%
		Post-test	41.4	0.71	0.5	40.3	43.1	
	Intense Continuous Aerobic	Pre-test	41.5	0.37	0.14	40.8	42.1	5.5%
		Post-test	43.9	0.8	0.64	42.75	45.1	
	High-Intensity Interval	Pre-test	41.5	0.35	0.12	40.8	42.1	3.54%
		Post-test	43.1	0.45	0.12	42.9	43.7	
Blood pressureheart rate (beats per (mmHg)minute)	Control	Pre-test	73.6	7.3	54.4	62	86	0.54%
		Post-test	74	7.6	5914	63	88	
	Intense Continuous Aerobic	Pre-test	73.6	6.9	48.6	64	84	-11.97%
		Post-test	65.7	6.6	43.7	58	75	
	High-Intensity Interval	Pre-test	73.6	5.6	31.5	65	84	-1.24%
		Post-test	70.6	5.7	33.2	61	80	
	Control	Pre-test	11.6	5.4	29.3	100	120	0.3%
		Post-test	11	4.2	18.1	105	120	
	Intense Continuous Aerobic	Pre-test	11.1	4.8	23.2	102	120	-6.79%
		Post-test	10.9	3.6	15.6	98	113	
	High-Intensity Interval	Pre-test	11.4	2.8	8.2	109	117	-3.43%
		Post-test	10.7	2.4	6.06	104	114	

The results of statistical analyses and findings of this research indicated that the maximum oxygen consumption (VO2 max) significantly increased in both experimental groups compared to the pre-test, while there was no significant difference in the control group compared to the pre-test. Furthermore, the results of inter-group comparisons showed that continuous intense aerobic exercise led to a more significant increase in VO2 max compared to intense interval training. Heart rate results also demonstrated that both exercise regimens caused a significant reduction in resting heart rate compared to the control group and the pre-test. However, continuous intense aerobic exercise resulted in a greater and more significant reduction in resting heart rate compared to intense interval training. Additionally, blood pressure in both exercise groups showed a significant decrease compared to the pre-test and the control group, with continuous intense aerobic exercise resulting in a greater and more significant decrease in blood pressure compared to intense interval training (Table 3).

Table 3. The results of the dependent t-test of Changes Inflammatory and Oxidative Stress Markers and weight

Variable	Group	Pretest	posttest	Change (%)	t	p
VO2max	Intense Continuous Aerobic	41.52±0.37	0.802±43.9	5.5%	-13.26	0.001
	High-Intensity Interval	41.57±.03	0.457 ± 10.41 0.802±43.9	3.54%	-11.5	0.001
	t	3.49		-	-	-
	p	0.002				
heart rate (beats per minute)	Intense Continuous Aerobic	73.6±6.9	6.616±65.73	-11.97%	23.4	0.001
	High-Intensity Interval	73.6±5.6	70.66±5.7	-4.24%	9.7	0.001
	t	-2.177		-	-	-
	p	0.038				
Blood pressure (mmHg)	Intense Continuous Aerobic	113.1±4.87	3.954±105.9	-6.79%	12.2	0.001
	High-Intensity Interval	112.46±2.87	2.463 ± 108.73	-3.43%	9.4	0.001
	t	-2.23		-	-	-
	p	0.029				

4. Discussion and Conclusion

The results of this study showed that both continuous intense aerobic exercise and intense interval training improve physiological indices, with the improvement being greater due to continuous intense aerobic exercise. These results align with the findings of some researchers and contrast with others (12, 13). The reason for this conclusion is that continuous intense aerobic exercise can engage large muscle groups in the body. Engaging muscle groups affects the efficiency of the body's systems. Since the body's systems contain muscles, any intense aerobic activity tends to be continuous and rhythmic in nature, engaging the body's muscles. According to the definition by Pourmand et al. (2020), this type of activity relies on aerobic metabolism, extracting energy in the form of adenosine triphosphate (ATP) from amino acids, carbohydrates, and fatty acids (14). Increasing metabolism and muscle engagement can impact the body's internal state. As metabolism and energy consumption rise in the body, carbohydrates, fatty acids, and other components are consumed, which not only enhances the efficiency of the body's systems but also ensures overall health. Influencing physiological indices can improve physiological readiness. Since these aerobic exercises utilize fat as fuel, excess body fat is burned as energy, reducing body weight. With continued exercise, the heart and vascular and respiratory systems become more efficient in response to physical activities (15).

This type of intense muscular exercise, with rhythmic and repetitive movements, can engage the muscles and bodily systems, enhancing the efficiency of physiological indices by influencing fat extraction and increasing metabolism (5). Given its high intensity, this type of training increases oxygen intake and reduces body fat. Therefore, it can be concluded that high-intensity exercises improve cardiovascular health, fat burning, and overall bodily function, enhancing physiological indices.

Aerobic exercises can prevent excessive fat accumulation in the body by increasing metabolism, thus ensuring the efficiency of bodily systems and physiological indices. Erb et al.'s (2024) study showed that both continuous and interval aerobic training protocols significantly increase blood pressure, heart rate, and pulse pressure (16). This aligns with the first subsidiary hypothesis of this study, suggesting that continuous intense aerobic exercise increases heart volume, blood flow, and the number of retinal vessels in the body. These exercises increase breathing rate and oxygen consumption by body tissues, thus reducing fat levels. They can also affect mood by influencing hormones in the body. Active muscle groups engaged in this type of exercise rely on aerobic metabolism, extracting energy in the form of ATP from amino acids, carbohydrates, and fatty acids (14). Consequently, continuous intense aerobic exercise increases muscle mitochondria and reduces body fat, which improves cardiovascular health. Thus, it can be said that this type of exercise positively affects certain physiological indices. Given the research conducted in this area and the information provided, it can be concluded that continuous intense aerobic exercise significantly impacts some physiological indices in young football players in Hamedan.

Intense interval training includes periods of very high-intensity exercise with active rest intervals of very low intensity (17). This type of training can enhance muscle efficiency in a controlled time frame, impacting bodily systems and improving internal conditions. Intense interval training is an efficient approach to improving aerobic and anaerobic capacities. It has been shown to increase both oxidative and glycolytic enzymes. Implementing the HIIT protocol for 4 to 6 weeks improves high-intensity exercise performance, muscle buffering capacity, fat oxidation, and aerobic capacity(18).

Based on this research, it can be concluded that intense interval training can engage more muscles within a short time frame, ensuring cardiovascular improvement and central bodily health. Since the cardiovascular and nervous and digestive systems are considered in physiological indices, this type of training can impact certain physiological indices such as the heart and central bodily systems. Aligning the study's results with the third subsidiary hypothesis indicates that intense interval training can rapidly engage a wide range of muscles, increasing muscle function and metabolism. HIIT is a broad term for exercises involving short periods of intense exercise with recovery and rest periods(10). These exercises can burn a lot of calories in a short time and increase oxygen consumption. The accumulated metabolic rate and increased metabolism can enhance the body's efficiency. HIIT can help individuals burn fat, increasing oxygen consumption and reducing fat, improving the efficiency of bodily systems like the cardiovascular system and certain physiological indices (19).

Research in this area shows that HIIT is an effective alternative to traditional aerobic training, inducing similar or greater physiological, functional, and health-related changes

in adults and patients (2, 20). Based on the research and provided information, it can be concluded that intense interval training significantly impacts certain physiological indices in young football players in Hamedan.

Both continuous intense aerobic and intense interval training stimulate various physiological systems in the body. In continuous intense aerobic training, the heart is constantly stimulated, striving to send more blood to the muscles, increasing blood flow and heart volume. Oxygen consumption in body tissues also rises. Continuous aerobic training impacts the body's fitness due to its prolonged nature. This continuous impact can improve physical fitness. When athletes engage in aerobic training, they consume more oxygen and increase their metabolism. Since these exercises are continuous, muscle function is also continuously impacted, leading to more sustained effects on bodily systems. In intense interval training, muscles are intensely stimulated, working under heavy loads for short periods. This increases ATP production and muscle strength and endurance. Intense aerobic training enhances muscle endurance, while continuous aerobic training enhances heart efficiency and heart rate.

Given that the body's systems are impacted by this aerobic training, and the heart is a muscle itself, physiological indices are affected by this type of training. Therefore, there is a significant difference between the effects of continuous intense aerobic and intense interval training on certain physiological indices in young football players in Hamedan. Continuous intense aerobic training constantly stimulates the heart, increasing heart rate and the effort to send more blood to the muscles. This effort requires more oxygen to ensure blood purification in the body, allowing the heart to function. In contrast, intense interval training intensely stimulates muscles, working under heavy loads for short periods. This increases ATP production and muscle strength and endurance. Intense interval training increases breathing rate and oxygen consumption by body tissues, improving physical fitness. Given the different impacts and performance of these exercises on the body, physiological indices like certain bodily systems and physical fitness are affected differently. Therefore, it can be said that there is a significant difference between the effects of continuous intense aerobic and intense interval training on certain physiological indices and physical fitness, as they are measured and analyzed differently. In continuous intense aerobic training, blood pressure and heart rate remain consistently high, strengthening the cardiovascular system. In intense interval training, exercise intensity changes periodically, significantly improving certain physiological indices like muscle strength and endurance, growth hormone levels, and blood oxygen levels (4). Thus, this study concludes that continuous intense aerobic training may have more significant benefits on the physiological indices examined in this study compared to intense interval training. However, further research is needed for precise conclusions. The study also had limitations, such as a limited geographic area in Hamedan, preventing generalization of the findings to other populations, and the lack of control over certain confounding variables like participants' diet and psychological status.

Acknowledgements

We would like to express our gratitude to all individuals helped us to do the project.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

M.A.S.S., the corresponding author, conceptualized the study, designed the research methodology, and supervised the overall project implementation. He also played a central role in drafting and revising the manuscript. M.R. was responsible for conducting the training sessions, assisting in the recruitment of participants, and contributing to the data collection process. H.S. supported the physiological measurements, helped with data analysis, and contributed to the literature review. All authors participated in discussing the findings, critically reviewed the manuscript for important intellectual content, and approved the final version for publication.

Data Availability Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Ethical Considerations

Informed consent was obtained from all individual participants included in the study.

Funding

There was no funding/support.

References

1. Sanz-Matesanz M, Martínez-Aranda LM, Gea-García GM. Effects of a Physical Training Program on Cognitive and Physical Performance and Health-Related Variables in Professional esports Players: A Pilot Study. Applied Sciences. 2024;14(7):2845. [DOI]
2. de Oliveira AF, Fidalgo ASF, Farinatti P, Monteiro W. Effects of high-intensity interval and continuous moderate aerobic training on fitness and health markers of older adults: systematic review and meta-analysis. Archives of Gerontology and Geriatrics. 2024:105451. [PMID: 38718488] [DOI]
3. Buzdagli Y, Ozan M, Baygutalp N, Oget F, Karayigit R, Yuce N, et al. The effect of high-intensity intermittent and moderate-intensity continuous exercises on neurobiological markers and cognitive performance. BMC Sports Science, Medicine and Rehabilitation. 2024;16(1):39. [PMID: 38326816] [PMCID: PMC10848527] [DOI]
4. Kayhan RF, Bayrakdaroğlu S, Ceylan Hİ, Eken Ö, Bayrakdaroğlu Y, Badicu G, et al. Effects of different rest intervals in high intensity interval training programs on VO2max, body composition, and isokinetic strength and power. Journal of Men's Health. 2024;20(5):1-11. [DOI]
5. Ruíz-Uribe M, Enríquez-Schmidt J, Monrroy-Uarac M, Mautner-Molina C, Kalazich-Rosales M, Muñoz M, et al. Moderate-Intensity Constant and High-Intensity Interval Training Confer Differential Metabolic Benefits in Skeletal Muscle, White Adipose Tissue, and Liver of Candidates to Undergo Bariatric Surgery. Journal of Clinical Medicine. 2024;13(11):3273. [DOI]
6. Chalari E, Jones HS, Hadjicharalambous M, Fogarty MC. The Impact of High-Intensity Interval Exercise Including Acceleration/Deceleration Patterns on Redox Status of Healthy Male Adults. Applied Sciences. 2024;14(6):2655. [DOI]
7. Peco J. THE COMMERCIAL ASPECT OF FOOTBALL. ISSN 1512–875X (print) ISSN 2233–0852 (online).38.
8. Lee Y-S, Lee D, Ahn NY. SAQ training on sprint, change-of-direction speed, and agility in U-20 female football players. Plos one. 2024;19(3):e0299204. [PMID: 38478514] [PMCID: PMC10936847] [DOI]
9. Yousefian F, Zafar A, Fransson D, Mohr M, Brito J, Travassos B. Characterizing the most demanding passages of kinematic and mechanical activity in elite football: a multifactorial approach. Biology of Sport. 2024;41(4):41-50. [DOI]
10. Hemati Nafar M, Kordi MR, Chubineh S, Chubineh S. The Effect of Six-weeks High Intensity Interval Training (HIIT) on Fibrinolytic Factors (t-PA, PAI-1& t-PA/PAI-1) in Sedentary Young men. Journal of Sport Biosciences. 2013;5(3):77-89. [DOI]
11. Somphong KR, Siswantoyo ES. The Effects of Speed-Based High-Intensity Interval Training on The Physical Fitness of Elite Female Football Referees: A Pilot Study.
12. Poon ETC, Li HY, Gibala MJ, Wong SHS, Ho RST. High-intensity interval training and cardiorespiratory fitness in adults: An umbrella review of systematic reviews and meta-analyses. Scandinavian Journal of Medicine & Science in Sports. 2024;34(5):e14652. [PMID: 38760916] [DOI]
13. Gaia JWP, Schuch FB, Ferreira RW, Souza EdL, Ferreira VMS, Pires DA. Effects of high-intensity interval training on depressive and anxiety symptoms in healthy individuals: A systematic review and meta-analysis of randomized clinical trials. Scandinavian Journal of Medicine & Science in Sports. 2024;34(4):e14618. [PMID: 38566446] [DOI]
14. Pourmand F, Ziaolhagh S, Molzemi S. Morphological changes in lung tissue following the uptake of silver nanoparticles produced by biosynthesis in trained male Wistar rats. Cell and Tissue Journal. 2021;11(4):262-74. [DOI]
15. Fernández-Sánchez J, Trujillo-Colmena D, Rodríguez-Castaño A, Lavín-Pérez AM, Del Coso J, Casado A, et al. Effect of Acute Caffeine Intake on Fat Oxidation Rate during Fed-State Exercise: A Systematic Review and Meta-Analysis. Nutrients. 2024;16(2):207. [PMID: 38257100] [PMCID: PMC10819049] [DOI]
16. Erb EK. The Effects Of High-Intensity Interval Training At Normobaric Hypoxia On Measures Of Performance, Hemodynamics, Autonomic Modulation, And Executive Function: Kent State University; 2024.
17. Trapp EG, Chisholm DJ, Freund J, Boutcher SH. The effects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. International journal of obesity (2005). 2008;32(4):684-91. [PMID: 18197184] [DOI]
18. Lin W, Su H, Lan X, Ni Q, Wang X, Cui K, et al. Effects of high-intensity interval training (HIIT) and maximum fat oxidation intensity training (MFOIT) on body composition, inflammation in overweight and obese adults. Science & Sports. 2024. [PMID: 38786989] [PMCID: PMC11125445] [DOI]
19. Bennett GG, Wolin KY, Puleo EM, Mâsse LC, Atienza AA. Awareness of national physical activity recommendations for health promotion among US adults. Medicine and science in sports and exercise. 2009;41(10):1849. [PMID: 19727030] [PMCID: PMC4286240] [DOI]
20. Cadenas-Sanchez C, Fernandez-Rodriguez R, Martinez-Vizcaino V, de los Reyes Gonzalez N, Lavie CJ, Galan-Mercant A, et al. A systematic review and cluster analysis approach of 103 studies of high-intensity interval training on cardiorespiratory fitness. European Journal of Preventive Cardiology. 2024;31(4):400-11. [PMID: 37738464] [DOI]