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# The Effect of Continuous Aerobic and High-Intensity Interval Training on Some Physical Fitness Factors in Young Football Players

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

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A B S T R A C T

**Objective**: The purpose of this study was to investigate the effect of continuous aerobic and high-intensity interval training on some physical fitness factors in young football players.
**Methods and Materials**: For this purpose, 45 young football players from Hamadan were randomly selected and divided into three groups of 15: the continuous high-intensity aerobic training group (three sessions per week, at 90-95% of maximum heart rate), the high-intensity interval training group (three days per week, 30 minutes of high-intensity training, 30 minutes of rest), and the control group. At the beginning and after the completion of the 6-week training protocol, factors such as sprint speed test, 4x9 shuttle run agility test, and explosive leg power test were measured. The collected data were then analyzed using covariance analysis (ANCOVA) with pre-test values as the covariate and pairwise comparisons using Bonferroni post hoc test in SPSS version 26, with a significance level of less than 0.05.
**Findings**: The results showed significant differences in all physical fitness factors among all groups compared to the control group and among the groups themselves.
**Conclusion**: The results of this study suggest that both continuous high-intensity aerobic training and high-intensity interval training likely lead to significant improvements in physical fitness factors, with continuous aerobic training potentially resulting in greater improvements. However, further research is needed for more precise examination.

***Keywords:*** *Speed, agility, power, long jump, shuttle run, football.*

## 1. Introduction

From the perspective of exercise science, football is an intermittent activity that includes multiple motor skills such as running, kicking, jumping, and tackling. Performance in football depends on various physical (anthropometric), physiological, technical, and tactical factors (1); among these, factors such as balance play an important role (2). A football player covers a distance of approximately 10 to 13 kilometers in each match, most of which involves walking and low-intensity activity. Interspersed within low-intensity activities are high-

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intensity activities requiring acceleration, direction changes, jumping, tackling, and specific football technical skills (3). The presence of maximum intensity activities not only constitutes the most exciting moments in football but also the most decisive ones (4, 5).

One of the most important indicators of general health and quality of life is having a suitable physical condition and high physical fitness. Physical fitness is the ability to effectively perform physical and educational tasks and other activities in a way that leaves physical reserves for emergency situations (6). The World Health Organization defines physical fitness as the ability to perform muscular work satisfactorily, which means that a person possesses a level of cardiorespiratory and muscular fitness, speed, and agility, among other attributes, to perform their duties optimally. Despite the many definitions of physical fitness, it can be described as the beneficial effects of sports activities that increase the body's efficiency and ability to perform physical activities, evidenced by the absence of fatigue and rapid return to the initial state after heavy activity. Physical fitness is explained by eight factors, including body composition, strength, flexibility, endurance, speed, balance, coordination, and agility (4).

Given the competitive nature of professional sports, psychological characteristics significantly impact the physical fitness and success of skilled athletes. With increased physical fitness, athletes' self-confidence rises, helping them overcome emotional states such as anxiety and stress (7). Physical fitness is assessed by eight factors: body composition, strength, flexibility, endurance, speed, balance, coordination, and agility (4). The ultimate goal of using physical performance tests or more advanced and applicable laboratory tests is to obtain information that can be used to improve an athlete's performance in competitions. For example, the information obtained from a suitable measurement can be used for individual training planning or demonstrating the effects of a specific training program (8, 9). Football players' physical fitness index includes basic skills such as stepping, balance, precision, and shooting power. Stepping is one of the most common activities individuals perform in daily life to minimize fatigue and ensure safety to prevent falls and related injuries (3, 7). Nonetheless, the important point is that physical fitness cannot be stored and requires continuous training (10).

Therefore, the purpose of this study is to examine the impact of high-intensity interval training and continuous aerobic training on some physical fitness factors in young football players to determine which of these two types of training has a greater effect on improving the physical fitness factors of football players.

## 2. Methods and Materials

In this quasi-experimental study, 45 young football players from Hamadan were randomly selected and divided into three groups of 15: the continuous high-intensity aerobic training group (three sessions per week, at 90-95% of maximum heart rate), the high-intensity interval training group (three days per week, 30 minutes of high-intensity training, 30 minutes of rest), and the control group. The criteria for selecting participants included not having cardiovascular diseases, not being smokers, not using assistive devices, not having hearing or visual impairments, not having temporary balance issues on the test day, not being wheelchair-dependent, not participating in any regular exercise program or diet over the past three years, not having skeletal, thyroid, kidney, and cardiovascular diseases, not using specific medications, having a regular sleep cycle, and not taking blood pressure-lowering medications related to inflammatory diseases. Additionally, a written informed consent and a physical activity readiness questionnaire were obtained from all participants.

At the beginning and after the completion of the 6-week training protocol, sprint speed test, 4x9 shuttle run agility test, and explosive leg power test were measured. The sprint speed test measures the overall body movement, with higher scores for shorter completion times. The 4x9 shuttle run agility test assesses the subject's agility, where the participant stands behind the start line. At the "ready" signal, they start moving, pick up the first block after 9 meters, return to the start line, and place the block behind the line. They then immediately repeat the process with the second block. The stopwatch starts at the "go" signal and stops when the participant's chest crosses the finish line after two complete shuttle runs. The explosive leg power test measures the horizontal displacement ability of football players, where participants stand behind the start line and jump forward with a knee bend and forward lean, repeating the action twice (11).

Each group then performed their specific training program (continuous high-intensity aerobic training and high-intensity interval training). The continuous high-intensity aerobic training protocol included a four-week aerobic program with three sessions per week, consisting of fourteen periods of ball movement in a specially designed course. The cones used to design the course were 0.3 meters

in diameter and 0.15 meters in height. The training intensity was 90-95% of the maximum heart rate of each player, measured on a treadmill using the Bruce test before starting the training. The Bruce treadmill protocol, used to assess the overall fitness of endurance athletes, was initially designed by cardiologist Robert Bruce in 1963 as a non-invasive test for evaluating patients with suspected heart disease. In a clinical setting, the Bruce treadmill test is sometimes referred to as a stress or exercise tolerance test. It can estimate maximum oxygen uptake (VO2 max), a measure of an athlete's ability to perform sustained exercise, related to aerobic endurance. The Bruce protocol is a maximal exercise test where the athlete works to complete fatigue as treadmill speed and incline increase every three minutes. The total time on the treadmill is the test score, which can estimate maximum oxygen consumption. Heart rate, blood pressure, and perceived exertion are often collected during the test. The training method involved players dribbling the first 10 cones in a zigzag pattern, jumping over 30 cm high hurdles, and then moving the next set of cones in a zigzag pattern, moving backward from point A to point B while controlling the ball, then returning to the starting point. The work activity periods included four four-minute sessions separated by three-minute active rest periods at 70% of maximum heart rate. Players' heart rates were measured using heart rate monitors. This continuous high-intensity training was conducted three times a week at the end of the team's training sessions, at the same time each day (12).

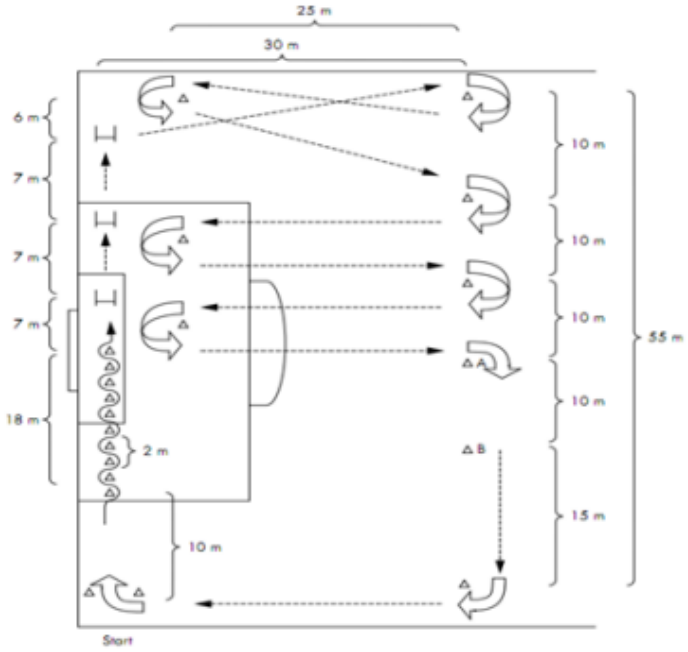


**Figure 1.** Huff training method, in which each player must carry the ball along designated paths; the training area is 35 meters wide and 55 meters long, with players moving backward between cones A and B.

High-intensity interval training included high-intensity exercise intervals lasting 30 seconds and low-intensity active rest intervals lasting 30 seconds. The training protocol involved 20-meter sprints with varying repetitions from the first to the sixth week, with rest intervals of 20-30 seconds between sprints. To adhere to the principle of overload and training effectiveness, the number of short-term sprints was set at 4 repetitions for the first and second weeks, 5 repetitions for the third and fourth weeks, and 6 repetitions for the fifth and sixth weeks. Each session included 5 minutes for warm-up and 5 minutes for cool-down. High-intensity interval training was conducted three times a week for six weeks.

Finally, the collected data were analyzed using mean and standard deviation as descriptive statistics, and for inferential statistics and hypothesis testing, the data were analyzed using covariance analysis (ANCOVA) and pairwise comparisons with Bonferroni post hoc test in SPSS version 26, with a significance level of less than 0.05.

## 3. Findings and Results

Table 1 presents the means and standard deviations of the research variables and physical fitness factors of the participants, separated by groups and at two time points: pre-test and post-test (Table 1).

**Table 1.** Descriptive Statistics of Research Variables and Physical Fitness Factors

| Variable | Group | Time | Mean | Standard Deviation | Variance | Minimum | Maximum | Change (%) |
|---|---|---|---|---|---|---|---|---|
| Speed | Control | Pre-test | 5.6 | 0.227 | 0.052 | 5.28 | 6.06 | -0.17 |
| | | Post-test | 5.59 | 0.217 | 0.047 | 5.3 | 6.04 | |
| | Continuous Aerobic | Pre-test | 5.52 | 0.266 | 0.071 | 5.19 | 6.15 | -6.97 |
| | | Post-test | 5.16 | 0.261 | 0.068 | 4.85 | 5.85 | |
| | High-Intensity Interval | Pre-test | 5.58 | 0.238 | 0.057 | 5.25 | 6.11 | -3.58 |
| | | Post-test | 5.38 | 0.272 | 0.074 | 5.05 | 6.0 | |
| Agility | Control | Pre-test | 9.51 | 0.285 | 0.081 | 8.88 | 9.84 | -0.1 |
| | | Post-test | 9.5 | 0.281 | 0.079 | 8.85 | 9.82 | |
| | Continuous Aerobic | Pre-test | 9.51 | 0.174 | 0.031 | 9.25 | 9.86 | -4.16 |
| | | Post-test | 9.13 | 0.103 | 0.011 | 9.02 | 9.39 | |
| | High-Intensity Interval | Pre-test | 9.5 | 0.232 | 0.054 | 8.96 | 9.85 | -2.1 |
| | | Post-test | 9.3 | 0.231 | 0.054 | 8.8 | 9.7 | |
| Explosive Leg Power | Control | Pre-test | 264.33 | 4.952 | 24.525 | 249.89 | 269.5 | 0.011 |
| | | Post-test | 264.36 | 4.959 | 24.596 | 249.86 | 269.52 | |
| | Continuous Aerobic | Pre-test | 261.2 | 0.561 | 0.315 | 259.98 | 262.02 | 2.66 |
| | | Post-test | 268.34 | 1.07 | 1.146 | 266.24 | 269.92 | |
| | High-Intensity Interval | Pre-test | 263.12 | 1.041 | 1.074 | 261.3 | 264.5 | 1.53 |
| | | Post-test | 267.22 | 0.884 | 0.782 | 265.97 | 269.53 | |

Results from the analysis of covariance (ANCOVA), with pre-test values as covariates, indicated significant differences across all variables of physical fitness factors among all groups compared to the control group. Specifically, for sprint speed, there was a significant main effect of the group, $F(2, 41) = 40.37$, $p < 0.001$, $\eta^2 = 0.562$. For agility, the group effect was also significant, $F(2, 41) = 48.53$, $p < 0.001$, $\eta^2 = 0.703$. Similarly, for explosive leg power, the group effect was significant, $F(2, 41) = 50.04$, $p < 0.001$, $\eta^2 = 0.710$ (Table 2).

**Table 2.** Analysis of Covariance (ANCOVA) Results

| Source | SS | df | MS | F | p | Effect Size ($\eta^2$) |
|---|---|---|---|---|---|---|
| Speed | | | | | | |
| Pre-test (Covariate) | 2.345 | 1 | 2.345 | 124.23 | <0.001 | 0.741 |
| Group | 1.524 | 2 | 0.762 | 40.37 | <0.001 | 0.562 |
| Error | 0.834 | 41 | 0.020 | | | |
| Total | 4.703 | 44 | | | | |
| Agility | | | | | | |
| Pre-test (Covariate) | 3.021 | 1 | 3.021 | 148.29 | <0.001 | 0.783 |
| Group | 1.978 | 2 | 0.989 | 48.53 | <0.001 | 0.703 |
| Error | 0.836 | 41 | 0.020 | | | |
| Total | 5.835 | 44 | | | | |
| Explosive Leg Power | | | | | | |
| Pre-test (Covariate) | 2.157 | 1 | 2.157 | 111.59 | <0.001 | 0.731 |
| Group | 1.934 | 2 | 0.967 | 50.04 | <0.001 | 0.710 |
| Error | 0.792 | 41 | 0.019 | | | |
| Total | 4.883 | 44 | | | | |

The Bonferroni post hoc comparisons revealed that both the continuous aerobic training group and the high-intensity interval training group significantly outperformed the control group and each other in all measured physical fitness factors (Table 3).

**Table 3.** Pairwise Comparisons with Bonferroni Test

| Variable | Group (I) | Group (J) | Mean Difference (I-J) | Std. Error | Significance | Lower Bound (95% CI) | Upper Bound (95% CI) |
|---|---|---|---|---|---|---|---|
| Sprint Speed | Control | Continuous Aerobic | 0.355 | 0.018 | <0.001 | 0.309 | 0.401 |
| | | High-Intensity Interval | 0.191 | 0.018 | <0.001 | 0.145 | 0.237 |
| | Continuous Aerobic | Control | -0.355 | 0.018 | <0.001 | -0.401 | -0.309 |
| | | High-Intensity Interval | -0.164 | 0.018 | <0.001 | -0.210 | -0.118 |
| | High-Intensity Interval | Control | -0.191 | 0.018 | <0.001 | -0.237 | -0.145 |
| | | Continuous Aerobic | 0.164 | 0.018 | <0.001 | 0.118 | 0.210 |
| Agility | Control | Continuous Aerobic | 0.371 | 0.026 | <0.001 | 0.307 | 0.436 |
| | | High-Intensity Interval | 0.190 | 0.026 | <0.001 | 0.125 | 0.254 |
| | Continuous Aerobic | Control | -0.371 | 0.026 | <0.001 | -0.436 | -0.307 |
| | | High-Intensity Interval | -0.181 | 0.026 | <0.001 | -0.246 | -0.117 |
| | High-Intensity Interval | Control | -0.190 | 0.026 | <0.001 | -0.254 | -0.125 |
| | | Continuous Aerobic | 0.181 | 0.026 | <0.001 | 0.117 | 0.246 |
| Explosive Leg Power | Control | Continuous Aerobic | -7.067 | 0.272 | <0.001 | -7.747 | -6.387 |
| | | High-Intensity Interval | -4.061 | 0.252 | <0.001 | -4.691 | -3.432 |
| | Continuous Aerobic | Control | 7.067 | 0.272 | <0.001 | 6.387 | 7.747 |
| | | High-Intensity Interval | 3.005 | 0.258 | <0.001 | 2.362 | 3.648 |
| | High-Intensity Interval | Control | 4.061 | 0.252 | <0.001 | 3.432 | 4.691 |
| | | Continuous Aerobic | -3.005 | 0.258 | <0.001 | -3.648 | -2.362 |

## 4. Discussion and Conclusion

The results of this study indicated that both continuous high-intensity aerobic training and high-intensity interval training lead to significant improvements in physical fitness factors, with continuous aerobic training showing greater improvements. This finding aligns with the results of prior studies (2, 3, 7, 8, 11-14). One reason for this conclusion may be that physical fitness encompasses the ability to perform daily activities with strength, alertness, without undue fatigue, with ample energy, and to enjoy leisure activities and face unforeseen emergencies (6).

High-intensity aerobic exercises engage large muscle groups due to the high intensity of the activity, providing energy through increased metabolism and fat burning. Continuous high-intensity aerobic training can improve factors such as strength, coordination, and agility. This type of exercise continuously relies on metabolism and, when practiced in groups, can enhance individuals' happiness and prevent depression. These exercises can increase the secretion of endorphins, which are hormones that induce happiness in the brain, thus leading to greater joy and enjoyment (4, 5).

The alignment of physical fitness concepts with enjoying leisure activities suggests that mental presence is enhanced in this sport, preventing depression and improving the individual's mood after exercise, thereby enhancing physical fitness. Another beneficial effect of these exercises is increasing individuals' endurance, resulting in less fatigue during daily tasks and greater physical strength and well-being due to optimal weight loss (9). The emergence of joy and pleasure indicates that such exercises effectively enhance physical fitness. Additionally, continuous high-intensity aerobic exercises, by increasing metabolism and

reducing fat, can prevent weight gain and improve individuals' readiness for activity and sports. Bakinde's (2022) findings showed that aerobic exercise affects muscular strength, agility, body balance, and the speed of athletes at Ilorin University. Based on the findings, this study recommends that Ilorin University athletes participate in explosive strength training with coaches' assistance to improve their muscular strength (9).

The alignment of the current study's results with the second partial hypothesis indicates that continuous high-intensity aerobic training increases breathing rate and oxygen consumption by body tissues. Additionally, these exercises enhance the production of happiness-inducing hormones, improving the individual's mood and mental state. These effects lead to improved physical and mental fitness. Continuous high-intensity aerobic training also increases ATP production, improving muscle strength and endurance, thus enhancing athletes' physical fitness (11, 13). Therefore, based on the conducted research, it can be concluded that continuous high-intensity aerobic training has a significant effect on the physical fitness of young football players in Hamadan.

Furthermore, high-intensity interval training is performed at very high intensities during active rest intervals. This type of training can quickly increase the body's metabolism and oxygen consumption, thereby improving endurance and flexibility. A prominent feature of these exercises is their short duration (1). Performing high-intensity interval training increases the activity of both aerobic and anaerobic enzymes. It has been shown that high-intensity interval training increases neural and muscular conduction speed. Improved neural and muscular conduction can enhance body fitness and efficiency. Additionally, high-intensity interval training can affect physical fitness factors such as speed, strength, and agility. Aschendorf et al. (2019) examined the effect of high-intensity interval basketball training on aerobic performance and physical capacities, showing significant improvements in the intermittent recovery test performance in the training group, with no improvements found in the control group. Positive effects in the training group were evident in sprint and agility tests, with and without the ball. Sprint and agility performance significantly decreased in the control group (13).

Given the alignment of the current study with the fourth partial hypothesis and considering that physical fitness factors include muscular strength, muscular endurance, cardiorespiratory endurance, flexibility, and body composition, it can be said that high-intensity interval training can influence the body's skill strengths and agility, facilitating physical fitness. It increases muscle strength and endurance, enhancing the athlete's physical fitness. When used in group settings, these exercises can reduce depression and integrate individuals into social groups, leading to enjoyment of leisure time (5). Given the impact of these exercises on endurance and flexibility, it can be concluded that high-intensity interval training significantly affects the physical fitness of young football players in Hamadan.

The difference between continuous high-intensity aerobic and high-intensity interval training on physical fitness is due to the different stimulation of the body. Continuous high-intensity aerobic training is a sustained exercise that can significantly impact individuals' physical fitness factors over a long period. Endurance and flexibility factors are affected by continuous aerobic training. As these factors increase in the body continuously, physical fitness also improves. Physical fitness is the ability to perform daily activities with strength, alertness, without undue fatigue, with ample energy, and to enjoy leisure activities and face unforeseen emergencies (6). When continuous aerobic exercise is done in groups, it integrates individuals into social settings, preventing depression and positively influencing their inner joy. The secretion of happiness-inducing hormones can also enhance their physical fitness and well-being. Therefore, continuous aerobic exercises increase endurance, positively affecting physical fitness.

Moghadam Naghavi et al. (2016) showed that explosive power significantly increased in the supplement and training + supplement groups, but no significant difference was observed in the training alone and control groups. No significant differences were observed in resting systolic and diastolic blood pressure and perceived exertion (Borg) among the groups. Thus, after six weeks of high-intensity interval training with ginseng supplementation, the explosive power of the trained individuals increased. The study shows that high-intensity interval training can increase neural and muscular conduction speed. Given that physical fitness factors such as power, agility, speed, strength, and flexibility are affected by high-intensity interval training, neural and muscular systems can improve, and the individual's morale for exercising can also increase. These types of exercises can increase the intensity of training for individuals, thus improving their physical fitness with high-intensity interval training experiences (15).

Considering the discussed points and the different effects of these two types of training, it can be concluded that there is a significant difference between the impact of continuous

high-intensity aerobic training and high-intensity interval training on the physical fitness of young football players in Hamadan.

In conclusion, this study suggests that both continuous high-intensity aerobic training and high-intensity interval training can lead to significant improvements in physical fitness factors, with potentially greater improvements resulting from continuous aerobic training. However, more research and further investigations are needed for a better understanding.

## Authors' Contributions

M.A.S.S., the corresponding author, conceptualized the study, designed the research methodology, and supervised the implementation of the training protocols. He also led the drafting and revising of 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 physical fitness 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.

## Declaration

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

## Transparency Statement

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

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## Declaration of Interest

The authors report no conflict of interest.

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## Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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