The effect of four-week high intensity interval training on blood oxygen saturation, body composition and some performance parameters in young male football players

O efeito do treinamento de intervalo de alta intensidade de quatro semanas na saturação de oxigênio no sangue, composição corporal e alguns parâmetros de desempenho em jogadores de futebol masculino jovens

Tahir Volkan Aslan¹
Muhammed Zahit Kahraman²

Abstract
This study was conducted to determine the effect of four weeks of high intensity interval training on blood oxygen saturation, body composition and some performance parameters in young male football players. Pre-test-post-test control group experimental method was used in the study. Twelve experimental (age: 16,33±,77 years; height: 171,50±,6,23 cm; body weight: 58,33±,5,19 kg) and 12 control (age: 16,50±,52 years; height: 168,58±,5,68 cm; body weight: 58,05±,4,60 kg) male football players aged 15-17 years, who regularly exercise and have been playing football for at least 3 years participated in the study. In the study, the experimental group performed high intensity interval training 3 days a week in addition to football training for 4 weeks. The control group only performed routine football training. In the study, height and body weight, resting heart rate, systolic and diastolic blood pressure, blood oxygen saturation, body composition, 20 m sprint test, Illinois agility test and Yo-Yo interval running test were applied as pre and post tests. The normality level of the data was determined by Shapiro-Wilk test. Independent Sample T Test for independent groups and

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Paired Sample T Test for dependent groups were used to analyse the normally distributed data. According to the findings of the study, while statistical significance was determined in blood oxygen saturation, body composition, Illinois agility test and Yo-Yo interval running parameters of the experimental group (p<0.05), no significant difference was found in 20 m sprint test (p>0.05). According to the results of the study, it can be said that 4-week high intensity interval training has positive effects on blood oxygen saturation, body composition and performance parameters in young male football players.

Keywords: HIIT. Football. Blood Oxygen Saturation. Body Composition.

Resumo
Este estudo foi realizado para determinar o efeito de quatro semanas de treinamento de intervalo de alta intensidade sobre a saturação de oxigênio no sangue, composição corporal e alguns parâmetros de desempenho em jovens jogadores de futebol do sexo masculino. No estudo foi utilizado o método experimental do grupo de controlo pré-ensaio-pós-ensaio. Doze jogadores experimentais (idade: 16,33±77 anos; altura: 171,50±6,23 cm; peso corporal: 58,33±5,19 kg) e 12 (idade: 16,50±5,52 anos; 168,58 anos; 5,68 anos; peso corporal: 5800 cm; 80,05 anos de idade; 4,60 anos) que se exercitam regularmente e jogam futebol há pelo menos 3 anos participaram do estudo. No estudo, o grupo experimental realizou treinamento de intervalo de alta intensidade 3 dias por semana, além de treinamento de futebol por 4 semanas. O grupo de controle só realizava treinamentos rotineiros de futebol. No estudo, a altura e o peso corporal, a frequência cardíaca em repouso, a pressão arterial sistólica e diastólica, a saturação de oxigênio no sangue, a composição corporal, o teste sprint de 20 m, o teste de agilidade de Illinois e o teste de execução do intervalo Yo-Yo foram aplicados como testes pré e pós. O nível de normalidade dos dados foi determinado pelo teste de Shapiro-Wilk. O Teste T de Amostra Independente para grupos independentes e o Teste T de Amostra Emparelhada para grupos dependentes foram usados para analisar os dados normalmente distribuídos. De acordo com as conclusões do estudo, embora a significância estatística tenha sido determinada nos parâmetros de saturação de oxigênio no sangue, composição corporal, teste de agilidade de Illinois e intervalo Yo-Yo do grupo experimental (p<0,05), nenhuma diferença significativa foi encontrada no teste sprint de 20 m (p>0,05). De acordo com os resultados do estudo, pode-se dizer que o treinamento com intervalo de alta intensidade de 4 semanas tem efeitos positivos na saturação de oxigênio no sangue, composição corporal e parâmetros de desempenho em jovens jogadores de futebol do sexo masculino.

Introduction

Football, one of the most popular sports in the world (Bangsbo, 1994), is played by a large number of men and women with different skill levels. Stølen et al. (2005) suggested that technical, tactical, physical, physiological and mental factors primarily affect the overall performance of football players. Furthermore, many researchers have shown that among the above-mentioned sub-factors, physical fitness has the greatest influence on the overall performance of footballers (Stølen et al., 2005; Hoff and Helgerud, 2004; Gabbett et al., 2007). In every sport activity, an exceptional level of physical fitness is required for the efficient understanding, development and application of athletic skills (Wang and Peng, 2007; Lees and Nolan, 1998; Smith, 2003).

Football is a high-intensity and intermittent sport that requires significant physical capacity. To perform at elite level, footballers must demonstrate high levels of physical capacity such as endurance, strength, speed and agility (Stølen et al., 2005). Several studies have shown that high levels of physical fitness enable footballers to reach the highest possible performance (Bolotin and Bakayev, 2017; Paillard et al., 2006; Brechue et al., 2010, Özdemir et al., 2018, Duyan et al. 2022).

Furthermore, in a football competition, footballers cover a distance of approximately 8-12 km at or near the anaerobic threshold, which is exhibited at 75% of the average maxVO2 (Santos-Silva et al., 2007; Dittrich et al., 2011). In addition, although there is no consensus on what constitutes a high-speed effort, a key component of football is high-intensity running with a threshold between 12 km/h and 24 km/h (Burgess et al., 2006; Dellal et al., 2011). Sarmento et al (2014), found that elite footballers typically run between 9 and 14 km during a 90 min match, with 22-24% of the total match distance covered at speeds greater than 15 km/h (high intensity threshold), 8-9% at speeds greater than 20 km/h (very high intensity threshold) and 2-3% at speeds greater than 25 km/h (sprint threshold). One study showed a 2% increase in total distance travelled and a 30% increase in high-intensity sprints in the modern game of football. As a result, football matches are becoming more physically demanding (Bush et al., 2014).

High intensity interval training, which is a method that contributes positively to health and performance perspectives with positive adaptation for both sedentary and athletes, has attracted a great deal of attention due to its more economical and efficient use of time.
The effect of four-week high-intensity interval training on blood oxygen saturation, body composition and some performance parameters in young male football players compared to traditional aerobic exercise prescription, as well as increasing anaerobic mechanisms, metabolic functions and physical performance together with the aerobic system (Bayati et al., 2011; Samuel et al., 2013).

Interval training is a training method performed by applying loading and rest cycles (Karabıyık, 2021). Unlike continuous exercise, the HIIT model, which includes only the total duration and intensity of loading, consists of five basic elements: high loading intensity, optimal loading duration, rest type and duration, and total exercise duration (or number of repetitions), which is realised by repeating more than one exercise series at certain intervals. After reaching the maximum heart rate with loads, the intensity of the load, the duration of the load and the rest periods between repetitions can vary according to the purpose of the training in high intensity interval training based on reloading after the heart rate drops to the desired level between repetitions (Korkmaz, 2017; Azuma and Matsumoto, 2017).

HIIT workouts are characteristically composed of passive rest or light exercises at 40 to 50% of maximum heart rate, with work periods lasting from 15 seconds to 4 minutes and approaching 80% to 95% of one's maximum heart rate, with recovery periods generally equal to or slightly longer than intense loading intervals. These training patterns with combined loading and rest periods generally consist of 6 to 10 repetition intervals. The total HIIT exercise duration varies from 10 to 40 minutes or more, proportional to the duration of the intervals performed in the work and rest periods. HIIT training applications, which consist of many training protocols such as Tabata, Peter Coe, timmon, gibala, circular training and "insanity" and can also be applied in combination with other high intensity exercise programmes, are included in the literature as a highly effective method to stimulate physiological adaptations that enable performance levels to reach better levels (Umutlu, 2019; Akgül et al., 2016; Altınkök, 2015).

While preparing training programmes in football, it is a very complex and challenging situation to include training for all the characteristics that need to be developed in the programme. The ever-increasing physical and physiological needs of football have led researchers to develop different training methods and to design training programmes that aim to develop more features in the least amount of time. In this framework, it is aimed to contribute to the literature by examining the effect of high intensity interval training on physical and physiological features on young football players.

Methodology
2.1 Participants

In the study, pre-test-post-test control group experimental method was used. The participants were 24 male footballers aged 15-17 years, exercising regularly and playing football for at least 3 years. The athletes were randomly divided into two groups as 12 Experimental (age: 16.33±7.77 years; height: 171.50±6.23 cm; body weight: 58.33±5.19 kg) and 12 Control (age: 16.50±5.52 years; height: 168.58±5.68 cm; body weight: 58.05±4.60 kg). The inclusion criteria of the football players in the study were as follows: (a) playing football for at least 3 years; (b) having no history of disability that would affect the outcome of the study; (c) participating in the study regularly and; (d) following the instructions of the researchers throughout the study. All football players were informed about the requirements and risks of the study and signed an informed consent form indicating that they voluntarily participated in the study. This study was approved by the Muş Alparslan University Scientific Research and Publication Ethics Committee with the number 2023-99020 and was conducted in accordance with the Declaration of Helsinki.

2.2 Experimental Design of the Study

The experimental group performed high intensity interval training 3 days a week in addition to football training for 4 weeks. The control group performed only routine football training (Table 1). Before starting high intensity interval training, height and body weight, resting heart rate, systolic and diastolic blood pressure, blood oxygen saturation, body composition (body weight, body fat percentage and muscle weight), 20 m sprint test, Illinois agility test and two days later Yo-Yo 1 intermittent recovery test were applied to both groups as pre-test and the same tests were repeated to both groups as post-test after 4 weeks of training (Figure 1).
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Figure 1: Experimental design
Source: Author

<table>
<thead>
<tr>
<th>Days</th>
<th>Time</th>
<th>Training content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>45 min</td>
<td>Regeneration (10 min warm-up, 10 min 5x2 game, 10 aerobic running, 10 min stretching)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>90 min</td>
<td>15 min warm-up run, 15 min 5x2 game, 15 min core strength training, 15 min pass training, 20 min double goal match, 10 min stretching</td>
</tr>
<tr>
<td>Wednesday</td>
<td>90 min</td>
<td>15 min warm-up run, 10 min 5x2 game, 15 min plyometric work, 20 min tactical work, 20 min half field game, 10 min stretching</td>
</tr>
<tr>
<td>Thursday</td>
<td>90 min</td>
<td>90 minutes double goal match</td>
</tr>
<tr>
<td>Friday</td>
<td>90 min</td>
<td>10 min warm-up run, 10 min 5x2 game, 20 min speed work, 20 min shooting practice, 20 min half field game, 10 min stretching</td>
</tr>
<tr>
<td>Saturday</td>
<td>-</td>
<td>Rest</td>
</tr>
<tr>
<td>Sunday</td>
<td>90 min</td>
<td>Match</td>
</tr>
</tbody>
</table>

Table 1: Weekly training programme of the athletes participating in the study (Gökkurt, 2019).
Source: Author
2.3 HIIT Training Protocol

At 90% of HR max, 90 seconds of running and 90 seconds of walking (rest) were performed for 7.5 minutes and this was accepted as 1 set. The study was performed over 3 sets and 2 minutes rest was given between sets (Arazi et al 2017). In these training sessions, the heart rates of all participants were monitored using Polar brand H10 (Polar Electro, Finland) model chest bands and IOS Polar Team application using a tablet. In order to determine the maximal heart rates of the football players, a preliminary Yo-Yo first level intermittent running test was performed and the maximal heart rates of the athletes were determined with the IOS Polar Team application when they finished the test.

2.4 Data Collection Tools

2.4.1 Height Measurement

The participants' height was measured with a stadiometer (SECA, Germany) with an accuracy of 0.01 metres (m).

2.4.2 Body Weight Measurement

Body weights were measured with an electronic scale (Tanita BC- 418 MA, Japan) with an accuracy of 0.1 kilogram (kg).

2.4.3 Resting Heart Rate and Systolic-Diastolic Blood Pressure Measurement

Heart rate, systolic and diastolic blood pressure of all participants in 1 minute were measured by health personnel using "OMRON M2 Basic Electronic Blood Pressure Monitor". The measurements were taken after the athlete rested in the supine position for 15 minutes.

2.4.4 Blood Oxygen Saturation Measurement (SpO₂)

Pulse oximetry determines the ratio of oxygenated haemoglobin in arterial blood. This value is called functional SpO₂ (Lingaiah et al., 2013; Gökhan, 2010). Blood oxygen saturation was measured by the healthcare personnel using a CMS50D Fingertip Pulse Oximetry.
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2.4.5 Body Composition Measurements

Body composition components such as body weight, body fat ratio and body muscle ratio of the participants were determined by bioelectrical impedance analysis method by entering the predetermined height, age and gender of the participants on the data screen of the device (Tanita BC-418 MA, Japan). After the device completed the measurements, the values read from the output were recorded. Participants were asked not to take a bath or sauna at least 24 hours before the measurements and not to consume any food at least 4 hours before the measurements. The measurements were performed between 8:00-10:00 in the morning and the participants were not exercised on the day of the measurements. The hands and heels were placed on the electrodes, taking care that the feet were not wet during the measurement. The handles connected to the electrode on the device were held by the athletes during the measurement period and the measurement was carried out.

2.4.6 20-m Sprint Test

The purpose of the test is to measure acceleration speed. The 20 m sprint measurements of the subjects were taken by warming up for 10 minutes before the test and running one by one at a distance determined as 20 m between the start and finish line on a flat ground on the running track. The athletes were warned to run the determined distance at maximal speed. At the start and end point of the 20 m running track, an electronic photocell device (Smart Speed; Fusion Sport, Australia) was placed and the athletes started the speed run from behind the start line and completed the test. This test was applied to the athletes twice and their best degrees were recorded (Özdemir, 2013).

2.4.7 Illinois Agility Test

Illinois test was applied to evaluate the agility performance of the participants. The test consists of a 40 m straight run with 180° turns every 10 m and a 20 m slalom run between cones. The test track, consisting of three cones arranged on a straight line with a width of 5 m, a length of 10 m and 3.3 m intervals in the middle section, was set up on a football field.
with artificial turf. After the test track was prepared, a two-door photocell electronic stopwatch system (Smart Speed; Fusion Sport, Australia) with an accuracy of 0.01 s was placed at the beginning and end. The test was repeated twice for each participant for the reliability of the test and the best performance value was recorded in seconds (Hopkins, 2000).

2.4.8 Yo-Yo Intermittent Recovery Test Level 1

The test is an endurance test consisting of shuttle runs in an area of 2 x 20 m, starting with a running speed of 10 km/h with a warning sound from the signalling device and at the end of each 40 m, the test protocol consists of shuttle runs at speeds gradually increasing the running speed by 0.5 km/h or 1 km/h. After each 40 m run, the athletes rest for 10 seconds in a 2x5 m recovery zone. The run is made from point "A" to point "B" and when the signal sound is heard, the athletes run to the other point again. The running speed increases according to the test protocol and if the athlete cannot catch the signal for the first time when he/she reaches point "A", he/she gets an error and if he/she cannot be at point "A" when the second signal sound is heard, the test is terminated. Each time the athlete arrives at point "A", which is the starting point, the test distance is marked and recorded on the test paper. The test is terminated when the athlete reaches the exhaustion point or misses two consecutive signals (Bangsbo et al., 2008; Krstrup et al., 2003; Svensson and Drust, 2004; Castanga et al., 2006).

2.5 Data Analysis

SPSS 22.0 package programme was used for statistical analysis of the data. Normality levels of the data were determined by Shapiro-Wilk test. Parametric tests were preferred in the analysis of normally distributed data. Independent Sample T Test for independent groups and Paired Sample T Test for dependent groups were used and significance level was accepted as 0.05 in statistical comparisons.

### Results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>( \bar{x} \pm Sd )</th>
</tr>
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<tbody>
<tr>
<td>Age (year)</td>
<td>Experimental</td>
<td>12</td>
<td>16.33±.77</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>16.50±.52</td>
</tr>
</tbody>
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Table 2: Descriptive statistics table of athletes participating in the study

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>x̄ ± Sd</th>
<th>t</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>Experimental</td>
<td>12</td>
<td>171,50±6,23</td>
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<td></td>
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<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>168,58±5,68</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Body Weight (kg)</td>
<td>Experimental</td>
<td>12</td>
<td>58,33±5,19</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>58,05±4,60</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Comparison of the Pre-Test Values of the Groups

According to Table 3, no significant difference was found between the pre-test values of resting pulse rate, systolic blood pressure, diastolic blood pressure, blood oxygen saturation, 20 m sprint, Illinois agility, Yo Yo intermittent recovery, body fat percentage, muscle weight and body weight of the athletes in the experimental and control groups (p>0.05). The fact that there was no significant difference between the baseline values of both groups (p>0.05) shows that these groups have similar characteristics.
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According to Table 4, while there was no statistically significant difference between the resting pulse, systolic and diastolic blood pressure, 20 m sprint, muscle weight and body weight post-test values of the athletes in the experimental and control groups (p>0.05), statistically significant differences were found between the groups in blood oxygen saturation, Illinois agility, Yo-Yo intermittent recovery test and body fat percentage post-test values (p<0.05).

In blood oxygen saturation values, the post-test values of the athletes in the experimental group (97.91±.90) were higher than the athletes in the control group (96.83±.93). In the Illinois agility test, the posttest values of the athletes in the experimental group (15.45±.32) were lower than those in the control group (15.85±.38). In the Yo Yo intermittent recovery test, the posttest values of the athletes in the experimental group (1956.66±183.86) were higher than those in the control group (1703.33±237.07). In body fat percentage values, the post-test values of the athletes in the experimental group (11.27±1.12) were lower than those in the control group (13.35±3.12).

Table 4: Comparison of the Post-Test Values of the Groups

<table>
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<tr>
<th>Parameters</th>
<th>Group</th>
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<th>t</th>
<th>p</th>
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</thead>
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<tr>
<td>Resting heart rate (bpm)</td>
<td>Pre-test</td>
<td>12</td>
<td>72,66±8.34</td>
<td>2,141</td>
<td>.056</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>69,41±7.77</td>
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<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>Pre-test</td>
<td>12</td>
<td>116.25±8.55</td>
<td>.862</td>
<td>.407</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>114.66±8.01</td>
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<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>Pre-test</td>
<td>12</td>
<td>74.16±5.20</td>
<td>1.366</td>
<td>.199</td>
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<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>72.33±6.70</td>
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<td></td>
</tr>
</tbody>
</table>

*sec: second, m: metres, kg: kilogram, bpm: beats per minute

Table 4: Comparison of the Post-Test Values of the Groups
Source: Author

* p<0.05

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<table>
<thead>
<tr>
<th>Parameters</th>
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<th>(\bar{x} \pm Sd)</th>
<th>t</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Blood oxygen saturation (SpO(_2))</td>
<td>Pre-test</td>
<td>12</td>
<td>97.16±1.02</td>
<td>-2.283</td>
<td>.043*</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>97.91±.90</td>
<td></td>
<td></td>
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<tr>
<td>20 m Sprint (sec)</td>
<td>Pre-test</td>
<td>12</td>
<td>3.44±10</td>
<td>1.595</td>
<td>.139</td>
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<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>3.37±10</td>
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<tr>
<td>Illinois agility (sec)</td>
<td>Pre-test</td>
<td>12</td>
<td>15.99±.37</td>
<td>6.517</td>
<td>.000*</td>
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<td></td>
<td>Post-test</td>
<td>12</td>
<td>15.45±.32</td>
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<tr>
<td>Yo-Yo IR1 (m)</td>
<td>Pre-test</td>
<td>12</td>
<td>1648.33±249.72</td>
<td>-3.862</td>
<td>.003*</td>
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<td></td>
<td>Post-test</td>
<td>12</td>
<td>1956.66±183.86</td>
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<tr>
<td>Body Fat Percentage (%)</td>
<td>Pre-test</td>
<td>12</td>
<td>13.90±1.63</td>
<td>9.613</td>
<td>.000*</td>
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<tr>
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<td>Post-test</td>
<td>12</td>
<td>11.27±1.12</td>
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<tr>
<td>Muscle weight (kg)</td>
<td>Pre-test</td>
<td>12</td>
<td>46.55±5.33</td>
<td>-3.202</td>
<td>.008</td>
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<td>Body weight (kg)</td>
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<td>Post-test</td>
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<td>56.58±5.08</td>
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</table>

*p<0.05  sec: second  m: metres  kg: kilogram  bpm: beats per minute

**Table 5: Comparison of Experimental Group Pre-Test and Post-Test Values**

Source: Author

When the pre-test - post-test measurement values of the participants are analysed in Table 5, no statistically significant difference was found between the resting pulse, systolic and diastolic blood pressure, and 20 m sprint pre-test and post-test values of the athletes in the experimental group (p>0.05), while a statistically significant difference was found between the blood oxygen saturation, Illinois agility, Yo-Yo intermittent recovery, body fat percentage, muscle weight, and body weight pre-test and post-test values (p<0.05).

Blood oxygen saturation post-test values (97.91±.90) were higher than pre-test values (97.16±1.02), Yo-Yo interval recovery post-test values (1956.66±183.86) were higher than pre-test values (1648.33±249.72), muscle weight post-test values (47.80±5.02) were higher than pre-test values (46.55±5.33). Illinois agility test posttest values (15.45±.32) were lower than pre-test values (15.99±.37), body fat percentage posttest values (11.27±1.12) were lower than pre-test values (13.90±1.63), body weight posttest values (56.58±5.08) were lower than pre-test values (58.33±5.19).
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<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
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<th>p-value</th>
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<tr>
<td><strong>Body Fat Percentage (%)</strong></td>
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<td>12</td>
<td>12</td>
<td>13,35±3,12</td>
</tr>
<tr>
<td><strong>Muscle weight (kg)</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>44,37±4,82</td>
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<td></td>
<td></td>
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<td>-2,672 .022*</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>44,84±4,94</td>
</tr>
<tr>
<td><strong>Body weight (kg)</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>58,05±4,60</td>
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<td>2,007 .070</td>
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<tr>
<td></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>57,50±4,77</td>
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</tbody>
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*p<0.05  sec: second  m: metres  kg: kilogram  bpm: beats per minute
Table 6: Comparison of Control Group Pre-Test and Post-Test Values
Source: Author

When the pre-test - post-test measurement values of the participants are analysed in Table 6, a statistically significant difference was found between the Yo-Yo intermittent recovery and muscle weight pre-test and post-test values of the athletes in the control group (p<0.05).

Yo-Yo intermittent recovery post-test values (1703,33±237,07) were higher than pre-test values (1588,33±241,27) and muscle weight post-test values (44,84±4,94) were higher than pre-test values (44,37±4,82).

Discussion

This study was conducted to determine the effect of four weeks of high intensity interval training on blood oxygen saturation, body composition and some performance parameters in young male football players.

High-intensity interval training (HIIT) is a popular form of training used among athletes to further enhance their already high levels of physical activity. However, HIIT has also aroused great interest among amateurs (Bartlett et al., 2011; Laursen, and Jenkins, 2002). The basis of HIIT is to perform repeated maximal efforts with alternating rest breaks (Billat, 2001a; Billat, 2001b). According to Kimm et al. (Kim et al.,2006), one of the main advantages of this form of training is its short duration and variety of exercises, which prevents monotonisation of the sessions. Bartlett et al. (2011) and Jung et al. (2014) suggest that HIIT training can be a more enjoyable and attractive form of training compared to moderate-intensity continuous training used for weight loss. As reported by Gibala et al. (2014) and Gillen et al. (2014), this training leads to adaptive effects similar to low-intensity endurance training, with increases in strength and anaerobic capacity. It has been confirmed that HIIT training can be an alternative to traditional endurance training to provide beneficial physiological and biochemical changes in both healthy and diseased populations (Skelly et al., 2014;Siahkouhian et al., 2013).
In our study, it was determined that the post-test averages of blood oxygen saturation of the experimental group to which high intensity interval training (HIIT) was applied improved significantly compared to the pre-test averages. There was no statistically significant difference between the pre-test and post-test averages of blood oxygen saturation in the control group without HIIT. In the comparison between the groups, it was determined that there were significant positive increases in the post-test blood oxygen saturation averages after HIIT. As a result of 4 weeks of high intensity interval training, it is seen that it positively affects the development of blood oxygen saturation. Özdal et al. (2013) reported that aerobic training may have increasing effects on the oxygen saturation (SpO₂) of both athletes and sedentary people in a study conducted in male athletes aged 12-14 years who regularly train. Mohammadyari and Saberi (2022) compared the effects of eight weeks of crossfit and high intensity interval training on some factors related to health and performance and reported that blood oxygen saturation (SpO₂) values increased significantly compared to the pre-test. Our research findings are similar to the literature reports. This may be explained as the development of respiratory muscles and respiratory system and adaptation to endurance training by increasing oxygen exchange in order to provide the necessary oxygen as a result of high intensity exercises. It can be said that the development of respiratory muscles due to aerobic exercise, increase in respiratory volume, provision of appropriate ventilation perfusion ratio, myocardial hypertrophy and cardiac output increase as a result of the intensification of blood oxygen content and exercise increases blood haemoglobin count.

In the study, no statistically significant difference was found between the pre-test and post-test values of resting pulse, systolic and diastolic blood pressure values of the athletes in the experimental and control groups. No statistically significant difference was found in the comparison of the same parameters between the groups. Mahanonda et al. (2000) investigated the effect of regular exercise on cardiovascular risk factors and found no significant difference in systolic and diastolic blood pressures, although they found that the resting heart rate of the regular exercise group was lower than the non-exercise group. However, in a study conducted by Racil et al. (2016), it was stated that HIIT exercises decreased systolic and diastolic blood pressure values, and in a study conducted by Whyte et al. (2010), it was stated that it decreased systolic blood pressure. It is thought that this difference in the studies may be due to reasons such as the diversity of the subject groups included in the studies, differences in the application time and intensity of the preferred methods.

When the body composition measurement values of our study were analysed, a statistically significant difference was found between the pre-test and post-test values of the
The effect of four-week high-intensity interval training on blood oxygen saturation, body composition and some performance parameters in young male football players.

Experimental group in all body composition parameters (body fat percentage, muscle weight and body weight), while a statistically significant difference was found only between the muscle weight pre-test and post-test values of the athletes in the control group (p<0.05). In the comparison between the groups, statistically significant differences were found between the pre-test and post-test values of all body composition parameters (body fat percentage, muscle weight and body weight) in favour of the experimental group. As a result of the four-week high intensity interval training programme, it was observed that the interventions positively affected the body composition parameters. In a study conducted on forty-five young women using a bicycle ergometer in a HIIT programme lasting for fifteen weeks, three days a week, a significant decrease in body subcutaneous fat and body weight was found (Trapp et al., 2008). In another study, Hazell et al. (2014) performed HIIT training three days a week for a total of six weeks for fifteen recreationally active women. As a result of the training, 8 per cent reduction in body fat and 3.5 per cent reduction in waist circumference occurred. In another study showing similar positive effects on forty-three overweight Chinese women, it was reported that there was a significant decrease in body fat percentage, fat mass, abdominal subcutaneous and visceral fat areas (Zhang et al., 2015). In another study, twenty women who had not trained before were applied long- or short-term HIIT, and it was reported that there was a decrease in fat mass, fat percentage, waist circumference, and skin folds after training in both training groups compared to before training (Alves et al., 2017). The findings of the study are similar to the findings in the literature.

When the performance parameters of our study were analysed, no statistically significant difference was found between the 20 m sprint pre-test and post-test values of the athletes in the experimental group, while a statistically significant difference was found between the Illinois agility, Yo-Yo intermittent recovery pre-test and post-test values. While there was no significant difference in the speed and agility values of the athletes in the control group, a statistically significant difference was found between the Yo-Yo intermittent recovery pre-test and post-test values (p<0.05). In the intergroup comparison, a statistically significant difference was found between the Yo-Yo intermittent recovery and Illinois agility posttest values of the experimental group athletes. It was observed that both high intensity interval training programme and routine football training increased aerobic endurance performance (running distance) of both experimental and control groups in Yo-Yo intermittent recovery test. HIIT is effective in improving both aerobic capacity and anaerobic capacity as it stimulates more muscle fibres, cardiovascular and respiratory system (Karp, 2000; Gillen et al., 2014; Gharah et al., 2014). Aschendorf et al. (2018) applied HIIT to...
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In conclusion, it can be said that 4-week high intensity interval training has positive effects on blood oxygen saturation, body composition and performance parameters in young male football players.

References


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Submetido em: 22.09.2023
Aceito em: 25.10.2023