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► **To cite this version:**

Omar Alsharab, Raoua Triki, Nidhal Jebabli, Jihen Khalfoun, Hassane Zouhal, et al.. Effects of a CrossFit Training Program on Body Composition and Hematological Parameters in Young Soccer Players. *Advances in Social Sciences Research Journal*, 2024, 11 (3), pp.283-294. 10.14738/as-srj.113.16543 . hal-04530623

HAL Id: hal-04530623

<https://hal.science/hal-04530623>

Submitted on 24 May 2024

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Effects of a CrossFit Training Program on Body Composition and Hematological Parameters in Young Soccer Players

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ABSTRACT

The study aimed to identify the effects of CrossFit training on body composition and hematological parameters in young soccer players. Forty soccer players voluntarily took part in this study, they were divided randomly into two equal groups: Experimental group (N=20) underwent a 12 weeks of CrossFit training program, and the control group (N=20) underwent 12 weeks of traditional training. Body

composition and hematological parameters were measured before and after the experiment among both groups. As results, a significant time x group interaction effect was observed for body mass index ($p=0.99$; $ES=0.45$), body fat percentage ($p=0.19$; $ES=0.36$), and muscle mass ($p=0.16$; $ES=0.57$), which indicate a positively significant change of body mass index and body fat percentage, muscle mass ($p<0.05$). While a significant group x time effect was reported for body fat mass ($p=0.04$, $ES=0.43$) and basal metabolic rate ($p=0.005$, $ES=0.55$), with favor for experimental group compared to control group. Additionally results showed a statistically significant group x time effect for Hemoglobin ($p=0.001$; $ES=0.24$) Red blood cells ($p=0.04$, $ES=0.56$) and Hematocrit ($p=0.007$; $ES=0.36$) with favor for EG in comparison with CG group, an increasing was presents for all previous parameters respectively among experimental group ($p<0.001$). However, no statistically significant effect of group x time was indicated for platelets ($p=0.16$; $ES=0.58$), significant increasing was reported for both groups. CrossFit exercise program can be recommended as an effective program in enhancing and adjusting the vital indicators of young soccer players and improve performance.

Keywords: 12 weeks of training, High intensity training, body composition, blood markers

INTRODUCTION

Soccer game is a field sport that requires a higher physiological adaptation demand to provide the best physical performance, thus, understanding the physiological scales of Soccer players helps to develop Soccer-specific skills and improve performance [45]. Trainers and practitioners can greatly benefit from the development of new exercise program interventions aimed at enhancing physiological measures of aerobic fitness and associated aerobic performance results [8].

In recent years the CrossFit training system which is a high intensity training exercise has gained great popularity and has been increasingly practiced [10-20]. CrossFit sport combines weightlifting, gymnastic skills, and cardiovascular exercises [33-34]. which are prepared with different types of exercises, a large number of diverse movements, various expressions of an ever-changing physique, especially strength and endurance [22-21].

With the introduction of functional exercises as the main component [20]. the CrossFit method has therefore been promoted as a very exotic sport [4-23] and a new kind of aerobics aimed to improve physiological parameters of athletes [20].

Among the physiological characteristics is the body composition, which refers to the fatty and non-fatty components of the human body [24]. which play an important interest to athletic performance especially in sports that require alternating aerobic and anaerobic metabolism [27-30].

In fact, soccer game is an intermittent high-intensity sport combined aerobic and anaerobic abilities [18-25]. therefore, coaches and practitioners aware of the evolution of the players body composition throughout the season to adjust training programs, prevent injuries and improve athletic performance [9].

[46] Söyler and Kayantaş reported a significant reducing of body weight and fat mass among 20 soccer players underwent a mix of HIIT and CrossFit training program during the preparatory period. While Radzimiński et al. [40] noted that professional soccer players with low fat content and higher levels of aerobic capacity are able to cover longer distances in sprinting and high-speed running distance (HSR) during official matches.

Hematological parameters are also important to enhance aerobic performance, the stability of blood condition indicators is an important factor in achieving the highest performance and athletic output [36-3]. A regular blood test can also determine the requirements imposed on physiological systems and possible decreases in performance and physical ability of soccer players [36].

In fact, some blood measurements are regularly related to the endurance of athletes, and there are various biochemical and hematological parameters that have an important role in the responses of athletes to training [43]. such as hemoglobin (HBG), hematocrit (HCT), red blood cells (RBC), iron status and ferritin concentration (ferritin), as these hematological parameters affect aerobic capacity, which is fundamental for the technical and tactical development of soccer players, and they change throughout the season [6]. The cardiovascular system must therefore ensure the supply of substrate to the working muscles [32].

However, there is little scientific data on the effect of CrossFit training on physiological adaptation in soccer game, based on previous literature [46] we hypothesis that adding a CrossFit training strategy during soccer sessions improves body composition and physiological parameters, so through this study we tried to identify the effectiveness of the CrossFit training on body composition variables and blood characteristics in young soccer players.

MATERIALS AND METHODS

Participants

40 young soccer players were recruited from two teams affiliated to the Palestinian Soccer Federation and divided randomly into two groups: Experimental group (EG) N=20 (age=17.42±0.66, height=172.90±5.17, body mass= 62.86±5.48, BMI= 21.17±1.27) underwent a 12 weeks of CrossFit training program, and the control group N=20 (CG) (age=17.48±0.70, height= 174.30±5.62, body mass= 63.85±5.48, BMI= 21.44±1.24) underwent 12 weeks of traditional training (Table 1).

None of the participants reported neuromuscular disorders or specific musculoskeletal injuries, Goalkeepers were excluded because of the difference in physical and skill requirements inside the stadium, participants were asked to stop any type of physical exercise other than those provided in the study.

Before giving their written informed consent, participants and their parents were fully informed about the purpose, possible risks and procedures of the study. Participant was required to obtain an official medical permit from the government body of the Ministry of health as an indicator of positive health status and the possibility of participating in the training program. All actions were carried out in accordance with the Helsinki Declaration of 2013.

Table 1: Participant's characteristics (means \pm SD) (n=40).

Variables	GE (n=20)	GC (n=20)
Age (year)	17.42 \pm 0.66	17.48 \pm 0.70
Height (m)	1.72 \pm 0.51	1.74 \pm 0.56
Body mass (kg)	62.86 \pm 5.48	63.85 \pm 5.53
BMI (kg/m ²)	21.17 \pm 1.27	21.44 \pm 1.24

Experimental Design

This study started in July 2021 and ended in October 2021 (12 weeks of training) with two test sessions (pre-and post-training test) occurs during the preparation period and before the competition period to control external factors and integrate them with the training system.

The two groups underwent 12 weeks of training programs with 3 sessions/week (Sunday, Tuesday, Thursday), 60 min/session. Each session started with 10 minutes of technical instructions, followed by (10 minutes) of dynamic warm-up for, consisting of low intensity running, stretching exercises and Swedish exercises specific to the training session. A (10 to 20 minutes) technical exercises, followed by a (10 to 20 minutes) daily workout and, finally, calming exercises with stretching (5-10 minutes). During the 20 min of daily workout The GE group program training involved an additional CrossFit-based pilot program during each training session, however, In the GC group underwent the regular routine training program without adjustment.

Anthropometric measurements and blood analyses were evaluated before and after the intervention among both groups in the laboratory by a specialist doctor, between 8:00 and 10:00 am, under the same conditions, order, and arrangement.

CrossFit Protocol

The CrossFit exercises included aerobic exercises (M) (e.g., running and jumping rope), Gymnastics (W) (e.g., Pull-ups, Push-ups, Squat, Box Jump) and weightlifting (W) (e.g., Wallball, Deadlift, Press). Repetition, distance, and recovery time recovery and exercises performed in the AMRAP style in varying time ranges from 10 to 25 minutes. Through the training program, emphasis was placed on strengthening the muscles of the body considered the most used in the game of soccer, such as the muscles of the back, abdomen, chest, thighs, in addition to the muscles of the arms and hands, which have a great role in achieving balance for the player while running and jumping.

Anthropometric Measurements

All participants were measured for the selected body mass and body composition variables using bioelectric impedance (BC-418, Tanita, Tokyo, Japan). The measurements were taken in the morning, 3 hours after waking up and in a fasting state. The device was calibrated to calculate the weight of clothing (0.2 kg) and data related to age, gender and height were entered. After that, the participants were placed on the scales in a stand position with their bare feet and hands on the marked area. The device analyzes the body composition based on differences in the ability to act with electric current by body tissues (different resistance) due to different water content. The variables measured were body mass (BM; kg), body mass index (BMI; Kg/m²), body fat percentage (BFP; %), fat mass (FM; kg), muscle mass (MM; kg) and basal metabolic rate (BMR; Kcal/Day). [1-31].

Blood Tests

For hematological parameters blood samples were taken by an official doctor specializing in medical analyzes, 15 ml of venous blood was collected in the morning between 08:00 - 10:00 after fasting overnight and at least 12 hours without exercise and 48 hours without high-intensity training program. Participants had been sitting for 30 minutes before blood collection. Blood samples were taken via the brachial medium vein in vacuum tubes (Vacuette, Greiner bioOne, France) without anticoagulants and with (EDTA) after centrifugation at 2500 (rpm) for 10 (minutes), serum was stored at -70 degrees Celsius to determine the hematological parameters: (hemoglobin (Hgb M/mm³), red blood cells (RBC g/dl), hematocrit (HCT%), and platelets (plt10³/μL) [42].

Statistical Analysis

Data were expressed as mean values and standard deviations (SD). SPSS 25.00 data analysis package was used for all statistical tests. The normality of data distribution was confirmed using the Kolmogorov-Smirnov test. A Two-way ANOVA test was used to compare all parameters measured before and after the intervention (T1 vs. T2) and between the two groups (GE vs. GC). In case of significant group-by-time interactions, post hoc tests were computed using Bonferroni adjustments to identify group-specific changes over time.

Effect sizes (ES) were calculated using ANOVA output by converting partial eta-squared η_p^2 to Cohen's d values. In addition, within-group ES were computed using the following equation: $ES = (\text{mean post} - \text{mean pre}) / SD$. ES were classified according to Hopkins et al. (2009). ES were considered trivial (<0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2, 0) and very large (2.0-4.0). The percentage of variation (%) of all variables was also calculated to establish changes between pre-and post-tests using the following formula:

$$\left(\frac{\text{final value} - \text{initial value}}{\text{initial value}} \right) \times 100$$

A statistical significance for all analyses was set at $p < 0.05$.

RESULTS

All participants completed the study with a 100% adherence to the procedures. No injuries were observed or reported during the experimental period. The data of body composition measurements are presented in Table 2 for both groups at T1 and T2.

Analysis of the Data (Table 2) indicated no significant time x group effect between both groups for body mass index ($p=0.99$; $ES=0.45$), body fat percentage ($p=0.19$; $ES=0.36$), and muscle mass ($p=0.16$; $ES=0.57$). Analysis indicated a statistically significant modification among both EG and CG, a decreasing of body mass index and body fat percentage $p<0.05$ and a significant increase of muscle mass $p<0.05$. While a significant group x time effect was reported for body fat mass ($p=0.04$, $ES=0.43$) and basal metabolic rate ($p=0.005$, $ES=0.55$), with favor for EG in comparison with CG.

Table 2: Changes in body composition (mean \pm SD) before and after 12 weeks of training programs among the two groups (n=40).

Variables	GE (n=20)			GC (n=20)			p values (ES)		
	T1	T2	(%)	T1	T2	(%)	Time	Group	Group x time
Body Mass Index (Kg/m ²)	21.57 \pm 1.28	21.17 \pm 1.27***	-1,90%	21.58 \pm 1.23	21.44 \pm 1.24*	-0,70%	0.001 (0.48)	0.3 (0.57)	0.99 (0.45)
Body Fat (%)	13.78 \pm 2.18	12.76 \pm 1.91***	-7,40%	13.70 \pm 2.00	13.58 \pm 2.02*	-0,88%	0.001 (0.42)	0.06 (0.37)	0.19 (0.36)
Fat Mass (Kg)	8.15 \pm 2.15	7.64 \pm 1.98***	-6,26%	8.96 \pm 1.71	8.84 \pm 1.73*	-1,34%	0.001 (0.52)	0.003 (0.21)	0.04 (0.43)
Muscle Mass (Kg)	51.20 \pm 4.98	53.03 \pm 4.96***	3,57%	50.85 \pm 4.02	50.99 \pm 4.14*	0,28%	0.001 (0.43)	0.07 (0.38)	0.16 (0.57)
Basal Metabolic Rate (Kcal/Day)	1675.22 \pm 103.37	1821.09 \pm 119.08**	8,71%	1701.64 \pm 108.50	1714.06 \pm 107.35*	0,73%	0.001 (0.53)	0.04 (0.32)	0.005 (0.55)

GE: Experimental group; GC: control group; *: p< 0.05 (pre-post test); **: p< 0.01 (pre-post test); ***: p< 0.001 (pre-post test).

Table 3 presented the hematological parameters variation between the two groups at T1 and T2. Results indicated a statistically significant group x time effect for Hemoglobin (p=0.001; ES=0.24) Red blood cells (p=0.04, ES=0.56) and Hematocrit (p=0.007; ES=0.36) with favor for EG in comparison with CG group, an increasing was presents for all previous parameters respectively among experimental group with p<0.001. However, no statistically significant effect of group x time was indicated for platelets (p=0.16; ES=0.58), significant increasing was reported for both groups.

Table 3: Hematological parameters (mean \pm SD) before and after 12 weeks of training programs among the two groups (n=40).

Variables	GE (n=20)			GC (n=20)			P value (ES)		
	T1	T2	(%)	T1	T2	(%)	Time	Group	Group x time
Hemoglobin (M/mm ³)	14.36 \pm 0.73	15.24 \pm 0.51***	6,13%	14.60 \pm 0.64	14.64 \pm 0.64***	0,97%	0.001 (0.74)	0.002 (0.35)	0.001 (0.24)
Red Blood Cells (g/dl)	5.20 \pm 0.32	5.54 \pm 0.34***	6,54%	5.23 \pm 0.45	5.28 \pm 0.44***	0,96%	0.001 (0.37)	0.04 (0.67)	0.045 (0.56)
Hematocrit (%)	44.92 \pm 1.70	47.41 \pm 1.86***	5,54%	45.28 \pm 1.90	45.69 \pm 1.90***	0,91%	0.001 (0.62)	0.02 (0.36)	0.007 (0.36)
Platelet (103/ μ l)	260.45 \pm 49.15	287.20 \pm 50.86***	10,27%	262.60 \pm 49.27	264.75 \pm 47.63***	0,82%	0.001 (0.43)	0.08 (0.39)	0.166 (0.58)

GE: Experimental group; GC: control group; *: p< 0.05 (pre-post test); **: p< 0.01 (pre-post test); ***: p< 0.001 (pre-post test).

DISCUSSION

The main objective of this pilot study was to investigate the effects of a regular 12-week CrossFit training program on body composition and hematological parameters in young soccer players. We assumed that adding a CrossFit training program would improve body composition by reducing body fat percentage, fat mass, and increasing muscle mass and basal metabolic rate at rest. We also assumed that GE would increase the values of blood markers: hemoglobin (Hgb), red blood cells (RBC), hematocrit (HCT) and platelets (PLT) in young soccer players.

Findings in this study confirmed these hypotheses, CrossFit experimental group provided significantly better results than the control group in some measurements of body components

and hematological parameters after the intervention period. Intergroup comparisons showed that measurements among experimental group were significantly improved in comparison with the control group in terms of measurements of fat mass, hemoglobin (HGB), red blood cells (RBC), hematocrit (HCT) and metabolic rate (BMR), with no significant differences in BMI, body fat percentage, muscle mass and platelets (PLT) between the experimental and control group.

The Effect of CrossFit Training on Body Composition Measurements

In the current study, the results related to the body composition of the participants indicated a statistically significant improvement on all variables, as the results showed a decrease in body mass index (difference -1,90%), a decrease in body fat percentage (difference -7,40%), a decrease in fat mass (difference -6,26%), an increase in muscle mass (difference 3,57%), an increase in metabolic rate (difference 8,71%). Looking at the literature from the same specialty, the results of the current study are consistent with the study of Söyler & Kayantaş [46], after 10 weeks of Cross fit and HIIT training for soccer players, it was determined that there were significant differences in body composition, the percentage of body fat BFP decreased (11.6- %), however, the BMI values were not statistically significant. While contradictory results were presented by Adlof et al [2] who found that after 8 weeks of CrossFit training, the average body fat percentage increased with no significant changes were found in total body mass or lean body mass, indicating that the CrossFit training program did not result in positive changes in body composition in female soccer players. As for studies on other disciplines, the results of the current study were consistent with the study of Choi et al [11] found that 14 weeks of supervised CrossFit exercises are effective in modifying body composition: body mass index ($P = 0.002$), muscle mass ($P = 0.007$), Basal Metabolic Rate ($P = 0.010$), in a sample of Korean university students, except for the percentage of body fat, which was statistically non-functional and contradicts the current study. Kićanović et al [26] reported that 12-week of CrossFit training program applied to healthy active males decrease significantly adipose tissue in comparison with traditional training. Same results were presented in recent studies conducted CrossFit training among sedentary and recreational subjects [5-13-14-17-36-37-38]. According to the results of our study, although the CrossFit training program was not applied in combination with the diet, the positive changes due to the decrease in the percentage of fat and the increase in muscle mass can be explained by the response and reactive result of the body resulting from intensive and comprehensive exercise regimes, the regular training period that lasted 12 weeks in addition to the use of strength and resistance training through body mass or iron weights. Also, the increase in muscle mass resulting from resistance training in various forms within the CrossFit program may increase the metabolism at rest. As indicated Yüksel et al [37] that strength training modifies body composition while enhancing muscle resistance. As confirmed by Meyer et al that CrossFit increases muscle and reduces lean body mass, through proper training and increased intensity [35].

The Effect of CrossFit Training on Hematological Parameters

As far as we know, the current study is the first to investigate whether CrossFit training for 12 weeks has positive effects on blood parameters in young soccer players, so we will try to explain the results and comment on them from some theories in related studies. In the study of Choi et al [11] noted that twice a week of 14 weeks of supervised CrossFit exercises are ineffective in modifying blood profiles in a sample of Korean university students. These results contradict the current study, which revealed the presence of statistically significant changes in blood markers in young soccer players. These changes can be explained by regular exercise, the combination

of aerobic and weight training, as well as the different repetitions and intensity of exercises within the CrossFit training program. Where Komka et al explains [28] that physical exertion causes many physiological changes in the body. As pointed out Clemente et al that sports training may lead to a variety of biomarkers in soccer players [12].

In the study of Silva et al [44] after applying 6 weeks of the prescribed soccer training program, the results showed a significant increase in the number of erythrocytes, hemoglobin, and hematocrit. As revealed by a study [12] Clemente et al that intensive training in the preseason leads to significant increases in PLT platelets (difference 6.42; $p = 0.006$; $d = 0.36$). While no significant differences were found in the hemoglobin and red blood cell variant. As for the study [42] Saidi et al on elite soccer players, after a six-week period of the season interspersed with soccer training and games (busy period) a significant decrease in the number of erythrocytes ($p < 0.002$, $ES = 0.5$), hemoglobin concentration Hb ($p < 0.018$, $ES = 0.8$) and the percentage of hematocrit Ht ($P < 0.001$, $ES = 0.6$) was found. And in the study Anđelković et al [3] which aimed to monitor the hematological and biochemical behavior of elite soccer players during half a competitive season, the results indicated a decrease in hemoglobin and hematocrit levels, while the RBC erythrocyte count and platelet count did not change. In the study Belviranlı et al [7] aimed at determining the effects of high-intensity acute interval training on blood parameters in sedentary adults aged 18-24 years. The results showed a 12% increase in hematocrit, a 5.3% increase in hemoglobin, and an 8% increase in the number of red blood cells. The number of platelets increased significantly immediately after acute HIIT and their values began to return to rest levels 3 hours after exercise, and completely returned to rest levels 6 hours after exercise. The study of Durkalec-Michalski et al showed that 4-week of keto diet (KD) and CrossFit training have a statistically effect on blood markers among females practicing Cross fit [15-16].

Limitation

The current study has several limitations that require discussion. There were not many participants and therefore the sample size is limited. The diet of the players was not monitored, or any dietary supplements were taken throughout the program, despite the correlation between nutrition, blood parameters and body components. The current study is also, to our knowledge, the first to provide data on the bio responsiveness of blood parameters after 12 weeks of regular CrossFit training in young soccer players. The results discussed here should therefore be treated as preliminary data for further research in a similar systematic pattern that would involve different groups of athletes in other sports, to examine the effects of regular CrossFit workouts on blood markers and body components.

CONCLUSIONS

The data show that 12 weeks of CrossFit training in the soccer program were effective and achieved clear developments in modifying body composition by increasing muscle mass and decreasing the percentage of fat mass among young soccer players, and also contributed to enhancing blood parameters by increasing the percentage of hemoglobin Hb, the number of red blood cells RBC, hematocrit HCT, and platelets PLT, accordingly, the CrossFit exercise program can be recommended as an effective program in enhancing and adjusting the vital indicators of young soccer players.

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