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Effect of six weeks of CrossFit training on blood lipid profile and atherogenic index of plasma in young healthy men: A pilot study

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Abstract

Study aim: The aim of our study was to determine whether six weeks of CrossFit training, a popular form of high-intensity training, improves the atherogenic index of plasma and blood lipid profile indicators in young healthy men.

Material and methods: Twenty-nine young, normolipidemic men (age 23.3 ± 2.4 years, height 181 ± 6.2 cm, BMI 24.4 ± 1.7) participated in a six-week CrossFit program. Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), autoantibodies against oxidized LDL (oLAB), and triglycerides (TG) were determined before and after completion of 6 weeks of CrossFit training, before, 3 minutes, and 60 minutes after the VO_2max cycling test to exhaustion. Based on lipids, the atherogenic index of plasma (AIP) and the ratios TC/HDL-C, LDL-C/HDL-C, and TG/HDL-C were calculated.

Results: A statistically significant main effect was found for the measures TG and HDL-C for the predictor variable TIME ($p = 0.04$ and $p = 0.02$, respectively). No significant main effect was found for the predictor variable TRIAL or the TRIAL × TIME interaction.

Conclusions: The statistically significant changes observed after cycling to exhaustion confirm that intense physical exercise affects lipid metabolism. Six weeks of CrossFit training had no effect on the statistically significant changes in plasma lipid profile and AIP in young healthy men.

Key words: High-density lipoprotein cholesterol – Low-density lipoprotein cholesterol – Triglycerides – Autoantibodies against oxidized LDL – High-intensity training

Introduction

A multitude of investigations have underscored the profound influence of the intensity and duration of physical activity on lipidomic changes and the importance of consistent moderate-intensity physical activity as a central component within non-pharmacological paradigms to reduce cardiovascular disease risk [7,21]. Extensive research confirms the effectiveness of low – to moderate-intensity exercise in improving blood lipid profiles and reducing the plasma atherogenic index [18, 31], whereas there is little evidence for analogous effects of high-intensity exercise programs. However, the studies that suggest that high-intensity physical activity can affect lipid profile are usually based on an experimental design with participants who are obese or have impaired lipid metabolism [15, 32]. Although high-intensity training may improve aerobic capacity more effectively than moderate, long-term aerobic training [6, 9], the available evidence suggests that high-intensity training has very little effect on lipid profile change, especially in young, healthy individuals [10]. A noteworthy form of training that involves high-intensity physical activity is CrossFit. Developed by Greg Glassman, it includes high-intensity functional movements with reduced rests in order to develop strength and endurance, with a combination of cardiovascular, weightlifting and gymnastics-type exercises [17]. Glassman's basic idea is that CrossFit is constantly varied, high-intensity, functional movement [11]. The concept of constant changes

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in CrossFit training makes it difficult to describe a typical CrossFit regime, and this raises concerns about data from experiments with CrossFit, particularly with regard to possible replication of the experiment. The truth is that each CrossFit coach creates and modulates their own CrossFit training, following only Glassman's instructions and ideas.

Cholesterol is a lipid from the group of steroids. In the blood, cholesterol is transported in the form of protein-lipid complexes called lipoproteins. Laboratory methods (ultracentrifugation or electrophoretic separation) can be used to isolate various fractions of serum lipoproteins, such as chylomicrons, very-low-density lipoproteins (VLDL), low-density lipoproteins (LDL) and high-density lipoproteins (HDL). Total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triacylglycerols (TG) are used to assess the blood lipid profile. The level of total cholesterol depends mainly on the level of LDL and the relationship between plasma TC levels, and the incidence of coronary heart disease is well documented [1].

LDL are very sensitive and oxidative processes initiated by ROS (reactive oxygen species), known to be produced in large quantities during intense physical exercise. Oxidatively modified lipoprotein particles (oxLDL) are strongly atherogenic and immunogenic, as produced by the immune system [27].

Increased levels of low-density lipoproteins in blood have been shown to be associated with activated platelets, polymorphonuclear leukocytes, macrophages, and vascular endothelial cells. Under the influence of enzymes, free radicals, and angiotensin released by these cells, low-density lipoprotein particles are modified in various ways and transformed into molecules with potent proatherogenic properties [34]. Many epidemiological studies have shown that a higher concentration of LDL cholesterol (LDL-C) and a lower concentration of high-density lipoprotein cholesterol (HDL-C) are associated with a higher risk of coronary heart disease and promote the development of atherosclerosis. The protective effects of HDL-C lipoproteins on the cardiovascular system include antioxidant, anti-inflammatory, and anticoagulant effects [19, 25]. In addition, one of the main functions of high-density lipoproteins is to remove unesterified cholesterol from sites where it has accumulated and transport it to the liver in a process called reverse cholesterol transport [36], which reduces the formation of new atherosclerotic plaques, and in the case of existing plaques, increases their stability and reduces the risk of rupture [37]. Triglycerides are the basic form of lipid storage in adipose tissue, muscle cells, and plasma lipoproteins, and their high blood levels increase the atherogenicity of LDL cholesterol [26]. Currently, coefficients calculated on the basis of concentration determinations of individual lipids, i.e., TC/HDL-C, LDL/HDL-C, and TG/HDL-C, are considered more useful for assessing the risk of atherosclerotic cardiovascular disease. They have a higher predictive value than the individual lipid profile parameters alone [13, 29]. Moreover, a useful indicator for the assessment of coronary heart disease risk is the atherogenic index of plasma (AIP) [4].

The aim of our study was to investigate the effects of six weeks of CrossFit training with a detailed training routine on the blood lipid profile and atherogenic index of plasma (AIP) before, 3 minutes after and 60 minutes after a VO_{2max} cycling test to exhaustion in young healthy men. We hypothesized that this intervention would lead to significant changes in the blood lipid profile and AIP values across these time points.

Material and methods

Study participants

Twenty-nine healthy young men aged 18 to 29 years (age 23.3 ± 2.4 years, height 181 ± 6.2 cm, BMI 24.4 ± 1.7) were included in the experiment. All participants were students of the Department of Physical Education at the Opole University of Technology and had at least 6 months of CrossFit training experience.

Inclusion criteria: Men. Age 18-30 years. Absence of medical contraindications. Students of the Department of Physical Education at the Opole University of Technology. Absence of injuries and contusions that could interfere with the exercises used in CrossFit training. Consent to participate in the study and statement of compliance with the guidelines. Normolipidemic – normal blood cholesterol levels were defined, according to the Journal of the American College of Cardiology, 2018 [24], as follows: total cholesterol less than 200 mg/dL (the lower the better); HDL cholesterol ideally 60 mg/dL or higher, but 40 or higher is acceptable; LDL cholesterol less than 100 mg/dL; triglycerides less than 149 (ideal < 100 mg/dL).

Exclusion criteria: Presence of medical contraindications. Presence of injuries and contusions that could interfere with CrossFit exercises. History of cardiovascular or related diseases. Uncontrolled high blood pressure. Respiratory disease that can be aggravated by high-intensity exercise. Recent major surgery or medical procedures. Taking medication that may impair physical performance or cardiovascular function. Simultaneous participation in other high-intensity exercise programs. Lack of consent to participate in the study or non-compliance with the guidelines.

CrossFit program

The CrossFit program was based on the CrossFit Training Guide on a five-day-on, two-day-off pattern. Each training session began with a 10-minute individual warm-

up. The training sessions were composed of three different modalities: monostructural metabolic conditioning, gymnastics, and weightlifting. During each training session, one, two or three modalities were trained. To avoid injury and overtraining, all participants were informed about the possibility of adapting (scaling) the training load to their own abilities. The CrossFit workouts are shown in Table 1.

Experiment design

Venous blood samples were collected, before starting and after completing the six-weeks CrossFit program (TRIAL variable) (before; 3 minutes after exercise; and 60 minutes after the VO_{2max} cycling test to exhaustion (TIME variable)), in order to estimate concentrations of TC, HDL-C, LDL-C, TG and oLAB. The performance tests were conducted in the Human Functional Research Laboratory in the Academy of Physical Education in Katowice. The CrossFit training program was performed in the sports facilities of the Faculty of Physical Education and Physiotherapy of the Opole University of Technology. Biochemical determinations were performed in the biochemical laboratory at the Academy of Physical Education in Katowice, which is responsible for compliance with the requirements of PN-ENISO9001:2009 (certificate No. PW-18011-15). Blood samples were taken from the basilic vein in tubes containing heparin before the six-weeks of CrossFit training. The samples were collected before, 3 min, and 60 min after the VO_{2max} cycling test to exhaustion. The total volume of blood collected from an individual in each of the two repeated studies was approximately 2 ml.

Biochemical analysis: Fasting blood samples were taken at the baseline and after the intervention between 8:00 and 10:00 a.m., also after an overnight fast. Blood serum was separated in the usual manner and stored frozen at –80°C until analysis. The concentrations of serum total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) were measured using enzymatic assays and commercially available diagnostic kits (Randox UK, Cat. No. CH 200, CH 203, TR 1697, and GL 2623, respectively). The intra – and inter-assay coefficients of variation (CV) were 1.98–4.28% for TC, 1.10–4.01% for HDL-C, and 2.69–4.57% for TG. The concentrations of low-density lipoprotein cholesterol (LDL-C) were calculated from TC, HDL-C, and TG as per Friedewald's formula [8].

The risk for vascular diseases in both groups was estimated based on the lipid ratios (TC/HDL-C, LDL-C/HDL-C, TG/HDL-C) and the atherogenic index of plasma (AIP) (AIP = $\log_{10}$ [TG/HDL-C], where TG and HDL-C are expressed as molar concentrations) [4].

oLAB concentration was measured by commercial enzyme immunoassay (oLAB ELISA, cat. No. BI-20032, Biomedica GmbH, Austria). The intra- and inter-assay CV were ≤ 8% CV and ≤ 4%.

Procedure of test to exhaustion

The exercise test was performed twice on the Sport Excalibur bicycle ergometer on the lower limbs, i.e., before and after the six-week CrossFit training program. The load test was characterized by a gradual increase in intensity. The initial load was 40 W and was increased by another 40 W every 3 minutes until the subject's maximum capacity was reached. During the test, heart rate (HR) was recorded using a Polar S725X heart rate monitor. A MetaLyzer 3B-R2 gas analyzer was used to measure oxygen uptake. The exercise tests were performed in the morning and the subjects were fasting.

Ethics approval and informed consent

All participants in the study signed an informed consent form. The study was approved by the Bioethics Committee of the Jerzy Kukuczka Academy of Physical Education, Katowice, Poland (No. 4/2013*)* and conducted according to the guidelines for research involving human subjects described in the Declaration of Helsinki. All tests were performed in the physiological and biochemical laboratory of the Jerzy Kukuczka Academy of Physical Education, Katowice, Poland.

Statistical analysis

Statistical analysis was performed to evaluate the effects of TRIAL and TIME on the variables studied using a two-by-three factorial ANOVA. This analysis was chosen to examine the interaction between the different experimental conditions and time points. In addition, an independent samples t-test was performed to analyze the changes in the atherogenic index of plasma (AIP). To perform these analyses, the collected data were processed using StatsCloud software, a statistical analysis tool. In addition, the effect size ($\eta^2 = 0.15$) was calculated for the 29 participants included in the study. This calculation was performed with a power of 80% and a significance level of 0.05 using MorePower 6.0. However, it is important to note that the authors acknowledge the limitations of the sample size, so caution should be exercised when interpreting the results of the effect size analyses. Further studies with larger samples are needed to confirm the observed effects.

Results

The alterations in the lipid profile throughout the study period are summarized in Table 2. Significant variations were observed in triglycerides (TG), high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C) and total cholesterol (TC) levels across different time points,

Table 1. CrossFit program according to Sadowska-Krępa et al. [35]

	Week 1
1st day (M)	5 rounds for time: run 400 m/rest 1 min/ 5 km run
2nd day (G,W)	21-15-9 reps for time: thrusters 42.5 kg/pull ups
3rd day (M,G,W)	for time: 50 push-ups/ 50 sit ups/ 50 deadlifts (60 kg)/ 50 wall ball shots (10 kg)/ 50 box jump
4th day (M,G)	20 minute AMRAP (as many rounds as possible), run 400 m/ max reps pull ups
5th day (W)	muscle clean (5 x 1 rep)/ power clean (5 x 3 reps)/ clean (5 x 5 reps)
6 and 7th day	Off
	Week 2
1st day (G)	skill and progression: muscle up
2nd day (M,W)	4 rounds for time: 50 kcal row/30 front squat (40 kg)
3rd day (M,G,W)	13 min AMRAP: 40 double unders/20 toes to bar/10 over head squat (40 kg)
4th day (G, W)	8 min AMRAP/1 min. rest/8 min AMRAP: 5 m rope climb/6 snatch (40 kg)
5th day (M)	3 rounds for time: 50 steps over head lunges (15 kg)/200 run
6 and 7th day	Off
	Week 3
1st day (W)	muscle snatch (5 x 1 rep)/power snatch (5 x 3 reps)/snatch (5 x 5 reps)
2nd day (M,G)	10 rounds for time: 30 double unders/6 hand stand push ups
3rd day (M,G,W)	3 rounds (1 min each exercise): wall ball shots (10 kg)/sumo deadlift high pull (35 kg)/box jump (60 cm)/push press (35 kg)/row (max. calories)/1 min rest
4th day (M,W)	1 km run/front squat 6-6-4-4-2-2-1-1 reps
5th day (G)	10 rounds for time: 3 weighted pull ups (15 kg)/5 strict pull ups/7 kipping pull ups
6 and 7th day	Off
	Week 4
1st day (M)	5 rounds for time: 1 km run/rest 2 min
2nd day (G,W)	skill and progression: strict ring muscle ups
3rd day (M,G,W)	for time: 1 km row/50 thrusters (30 kg)/30 pull up
4th day (M,G)	for time: 100 pull ups/100 push-ups/100 sit ups/100 squats
5th day (W)	skill and progression: medicine ball clean
6 and 7th day	Off
	Week 5
1st day (G)	skill and progression: hand stand
2nd day (M,W)	5 rounds for time: 400 m run/15 over head squats (40 kg)
3rd day (M,G,W)	for time: 50 box jumps (60 cm)/50 push-ups/50 kettlebell swings/50 walking lunges/50 knees to elbows/50 push press (20 kg)/50 back extension/50 wall ball shots/50 burpees/50 double unders
4th day (G, W)	skill and progression: Turkish get up
5th day (M)	1000 burpees
6 and 7th day	Off
	Week 6
1st day (W)	for time: snatch (60 kg) 30 reps
2nd day (M,G)	5 min AMRAP: 15 double unders/5 strict pull ups
3rd day (M,G,W)	20 min AMRAP: 5 hand stand push-ups/10 pistol squats/15 pull ups
4th day (M,W)	5 rounds for time: 5 deadlifts (120 kg)/10 burpees/1 min rest
5th day (G)	skill and progression: bar muscle ups
6 and 7th day	Off

M – metabolic conditioning, G – gymnastics, W – weightlifting,

Table 2. Changes in the lipid profile, oLAB and AIP at different time points

Trial	Time	TG [mg/dl]	HDL-C [mg/dl]	LDL-C [mg/dl]	TC [mg/dl]	oLAB [mU/ml]	AIP
Trial 1	Before	85.11 ± 35.59	57.45 ± 12.61	76.56 ± 17.71	154.84 ± 27.72	1022 ± 697,23	0.04 ± 0.25
	3 min	85.05 ± 33.10	61.66 ± 12.88	81.53 ± 21.19	164.19 ± 30.22	1023.32 ± 652.05	0.02 ± 0.24
	60 min	69.95 ± 26.61	57.49 ± 12.51	76.85 ± 25.64	151.78 ± 32.19	968.90 ± 592.12	–0.03 ± 0.23
Trial 2	Before	78.84 ± 33.16	58.98 ± 9.76	76.67 ± 23.89	158.38 ± 33.52	925.90 ± 547.77	0.00 ± 0.22
	3 min	85.85 ± 41.02	65.98 ± 11.43	79.39 ± 24.95	169.12 ± 33.19	955.75 ± 566.91	–0.02 ± 0.23
	60 min	69.81 ± 33.93	59.77 ± 11.29	74.89 ± 22.58	154.75 ± 31.22	927.25 ± 591.30	–0.07 ± 0.24

TG – triglycerides; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; TC – total cholesterol, oLAB – autoantibodies against oxidized LDL, AIP – atherogenic index of plasma. Values are given as mean ± standard deviation (SD).

suggesting possible effects on lipid metabolism due to exercise-induced stress. A statistically significant main effect was found for TG concerning the predictor variable TIME ($F(2.17) = 3.32$, $p = 0.04$, $\eta_p^2 = 0.04$), and also for HDL-C ($F(2.17) = 4.08$, $p = 0.02$, $\eta_p^2 = 0.05$). Post-hoc analyses revealed significant temporal effects on TG levels 3 and 60 min after exhaustion ($p = 0.04$) and on HDL levels both before exercise and 3 min after exercise ($p = 0.03$) as well as 3 and 60 min after exercise ($p = 0.05$). No significant main effect was found for the predictor variable TRIAL or the TRIAL × TIME interaction (Table 3). Further post-hoc investigations revealed no significant effects for LDL-C, TC, AIP, oLAB, TC/HDL, LDL-C/HDL-C and TG/HDL-C (Table 4). Comparisons between the pre – and post-training groups revealed higher values for AIP in the pre-training group ($M = 0.052$, $SD = 0.25$) than in the post-training group ($M = 0.003$, $SD = 0.23$). However, a t-test for independent samples (assuming unequal variances) showed that this difference was not statistically significant ($t(55.63) = 0.76$, $p = 0.4481$, 95% CI [–0.078, 0.175], Cohen's $d = 0.2$. The effect size shows a 55.64% probability that the values before the exercise exceed the values after the exercise (Table 5).

Discussion

The main finding of the study was that the only statistically significant effects were found for triacylglycerols and high-density lipoproteins before and after the test to exhaustion. The changes observed after the VO_2max cycling to exhaustion test confirm that intense physical training affects lipid metabolism in the short term. There were no statistically significant changes in TC, HDL-C, LDL-C, TG, oLAB, lipid ratios, and AIP before and after six weeks of CrossFit training. These results suggest that six weeks of CrossFit training had no effect on the statistically significant changes in plasma lipid profile and atherogenic index of plasma in young healthy men with normal lipid profiles. It is now known that better predictors

Table 3. Effects of TRIAL and TIME on the variables studied, a two-by-three factorial ANOVA

	Factors	f	p	η_p^2
TG [mg/dl]	TRIAL	0.13	0.7185	<0.01
	TIME	3.32	0.0385	0.04
	TRIAL × TIME	0.18	0.8326	<0.01
HDL-C [mg/dl]	TRIAL	2.30	0.1312	0.01
	TIME	4.08	0.0188	0.05
	TRIAL × TIME	0.22	0.8040	<0.01
LDL-C [mg/dl]	TRIAL	0.15	0.7007	<0.01
	TIME	0.68	0.5103	<0.01
	TRIAL × TIME	0.04	0.9576	<0.01
TC [mg/dl]	TRIAL	0.64	0.4237	<0.01
	TIME	2.86	0.0603	0.03
	TRIAL × TIME	0.02	0.9851	<0.01
AIP	TRIAL	1.24	0.2833	<0.01
	TIME	1.29	0.2343	0.02
	TRIAL × TIME	0.01	0.9952	<0.01
oLAB [mU/ml]	TRIAL	0.55	0.4584	<0.01
	TIME	0.07	0.9337	<0.01
	TRIAL × TIME	0.03	0.9706	<0.01
TC/HDL-C	TRIAL	0.61	0.4363	<0.01
	TIME	0.03	0.9738	<0.01
	TRIAL × TIME	0.06	0.9390	<0.01
LDL/HDL-C	TRIAL	1.62	0.2018	<0.01
	TIME	0.08	0.9257	<0.01
	TRIAL × TIME	0.15	0.8599	<0.01
TG/HDL-C	TRIAL	2.42	0.1214	0.01
	TIME	1.08	0.3437	0.01
	TRIAL × TIME	0.07	0.9273	< 0.01

TRIAL – before and after completing the six-weeks CrossFit program; TIME before, 3 and 60 minutes after VO_{2max} cycling test to exhaustion. TG – triglycerides; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; TC – total cholesterol; oLAB – autoantibodies against oxidized LDL; AIP – atherogenic index of plasma.

Table 4. Post-hoc analysis

	Pre-CrossFit	Post-CrossFit	Mean difference	P
TG [mg/dl]	before	3 min	3.48	0.8480
	before	60 min	12.1	0.1398
	3 min	60 min	15.58	0.0399
HDL-C [mg/dl]	before	3 min	5.61	0.0304
	before	60 min	0.42	0.9805
	3 min	60 min	5.2	0.0494
LDL-C [mg/dl]	before	3 min	3.85	0.6366
	before	60 min	0.74	0.9831
	3 min	60 min	4.59	0.5259
TC [mg/dl]	before	3 min	10.04	0.1999
	before	60 min	3.35	0.8344
	3 min	60 min	13.39	0.0591
AIP	before	3 min	0.03	0.8679
	before	60 min	0.07	0.2202
	3 min	60 min	0.04	0.4778
oLAB [mU/ml]	before	3 min	15.15	0.9902
	before	60 min	26.32	0.9707
	3 min	60 min	41.46	0.9289
TC/HDL-C	before	3 min	0.04	0.9842
	before	60 min	0.05	0.9738
	3 min	60 min	0.01	0.9986
LDL/HDL-C	before	3 min	0.04	0.9355
	before	60 min	0.01	0.9999
	3 min	60 min	0.03	0.9410
TG/HDL-C	before	3 min	0.05	0.9285
	before	60 min	0.21	0.3366
	3 min	60 min	0.16	0.5490

TG – triglycerides; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; TC – total cholesterol; oLAB – autoantibodies against oxidized LDL; AIP – atherogenic index of plasma.

Table 5. AIP before and after 6 weeks of CrossFit training

	Descriptive statistics		Confidence interval		Test statistics			Effect size
Group (n = 29)	Mean	SD	Lower CI	Upper CI	d_f	t	p	Cohen d_s
Before	0.052	0.25	–0.08	0.17	55.63	0.764	0.4481	0.201
After	0.003	0.23						

for assessing coronary heart disease risk are plasma lipid ratios and the atherogenic index. Although the study participants were initially in the low-risk group for cardiovascular disease, six weeks of CrossFit training additionally contributed to a statistically insignificant reduction in AIP. Our results suggest that six weeks of CrossFit training may lead to a modest improvement in the atherogenic index of plasma.

Regular physical activity has been reported to have a positive effect on lipid profile changes and reduce the

risk of cardiovascular disease [12], and numerous studies have confirmed the beneficial effects of physical activity on blood lipid metabolism [2, 5]. Traditional recommendations for health-enhancing exercise range from 30 to 60 minutes of physical activity performed approximately five times per week or strength training performed twice per week [16]. The guidelines for physical activity required to improve health, although widely known, are too general and do not include recommendations for high-intensity exercise, which has recently become popular. Moreover, the effect of exercise on lipid profile correlates more strongly with duration of physical activity and exercise intensity than with exercise minutes per week [16], and it has been shown that the intensity and duration of physical activity have a crucial effect on metabolism. High-intensity physical activity can improve aerobic capacity more effectively than moderate, long-term aerobic training [6]. There is also evidence that high-intensity interval training can improve cardiovascular function by reducing the likelihood of stroke [14], lowering systolic [33] and diastolic [24] blood pressure, and improving vascular endothelial function [23]. The study by Lamina and Okoye [22] showed an increase in HDL-C concentration in individuals after high-intensity training, and Currie et al. [2] and Koubaa et al. [20] found an increase in HDL-C concentration in the moderate-intensity exercise group and only a slight decrease in total cholesterol. On the other hand, high-intensity exercise appears to have very little effect on lipid profile change, especially in young, healthy individuals, whereas low – and moderate-intensity physical activity is a proven means of improving lipid metabolism. Therefore, it is necessary to understand the effects of popular forms of high-intensity physical training on lipids.

CrossFit is one of the fastest growing forms of high-intensity training [30]. This strength and conditioning program is designed to optimize physical competence in ten fitness areas: cardiovascular or respiratory endurance, stamina, strength, flexibility, power, speed, coordination, agility, balance, and accuracy [11]. Considering that a combination of aerobic endurance and strength exercises is essential for CrossFit workouts, this form of multimodal training must lead to metabolic adaptation [28], and the improvement of mitochondrial enzyme activity and insulin sensitivity should have an impact on the lipid profile and body composition [3, 35]. However, in the 2023 meta-analysis by Moscatelli [30] no significant effect of CrossFit training on these parameters was found. On the other hand, the number of studies with a high level of evidence examining the effects of CrossFit on health is small, and it is extremely difficult to determine the exact benefits of CrossFit without detailed analyses of training regimens. Although the authors found no significant changes in young normolipidemic men, it should be noted that further studies in young men with dyslipidemia and obese subjects are needed to confirm the lack of effect of CrossFit training on blood lipid profile.

Study limitations

One limitation of this study was the relatively small sample size, which could limit the generalizability of the results to larger populations. Other limitations were the lack of a control group and the short duration of the intervention – the six-week study duration may not have been sufficient to observe significant changes in lipid profiles, especially in healthy individuals with normal lipid levels at baseline.

Conclusions

The study concludes that six weeks of CrossFit training in young healthy men with normal lipid profiles did not lead to statistically significant changes in plasma lipid profile, lipid ratios or the atherogenic index in plasma. However, a slight improvement in the plasma atherogenic index was observed. These results suggest that CrossFit could serve as a preventive strategy against cardiovascular disease, especially when integrated into a sustainable lifestyle intervention. Further investigation of the underlying mechanisms and long-term effects of CrossFit on lipid metabolism could facilitate the development of tailored interventions and individualized exercise plans in both clinical and societal contexts.

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