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Original Article

Effects of a Tabata Exercise on Lipid Profile and Body Composition Indices in Overweight Boys

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Abstract

Introduction: The implementation of exercise programs has been shown to enhance metabolic health in adolescents; however, research regarding their effectiveness within university environments remains scarce.
Objective: This study sought to examine the impact of Tabata exercise on the lipid profile and body composition among overweight male adolescents.
Methods: A total of 30 overweight boys took part in this study on a voluntary basis. Participants were randomly divided into two groups engaging in Tabata exercises (n=30) and a control group (n=30). Measurements of anthropometric variables, body composition, and lipid profile indicators were conducted at both the commencement and conclusion of the exercise program. The Tabata exercise regimen was carried out over a period of eight weeks, with sessions occurring three times per week. Data analysis was performed using a covariance statistical test, with a significance threshold set at less than 0.05%.
Results: A notable reduction in body mass index (BMI) and body fat percentage, along with an increase in muscle mass, was recorded in the Tabata exercise group when compared to the control group (P<0.05). Regarding lipid profile parameters, the Tabata exercise group exhibited a significant decline in total cholesterol and low-density lipoprotein levels, as well as a significant rise in high-density lipoprotein levels compared to the control group (P=0.001). However, the alterations in blood triglyceride levels did not reach statistical significance between the groups (P=0.050).
Conclusion: The implementation of Tabata training has been shown to be beneficial in enhancing body composition and lipid profiles among overweight adolescent males; therefore, it is advisable to incorporate Tabata interval workouts into their exercise regimen.

Keywords: Tabata Exercise, Overweight, Lipid Profile, Adolescents

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1. Introduction

In recent years, the issues of overweight and obesity have become significant global health challenges, with their rates rising sharply across the globe. These conditions are defined by an excessive buildup of body fat in adipose tissue, which can result in detrimental health consequences (1,2). Numerous studies have recognized overweight and obesity as contributing factors to chronic and potentially fatal diseases, such as diabetes, various forms of cancer, cardiovascular disorders, and hypertension. The escalating rates of these conditions, along with the associated mortality and complications, pose a serious threat to public health in numerous nations. Furthermore, they impose detrimental health effects and financial strains on individuals and society as a whole (3-5). A significant issue associated with the obesity epidemic is its effect on children and adolescents. According to the World Health Organization, the prevalence of overweight and obesity in individuals aged 5 to 19 years increased dramatically from 4% in 1975 to 18% in 2016 (6,7). In Iran, the rise in obesity among this age group can be attributed to unhealthy eating patterns and insufficient physical activity, with some individuals being entirely inactive (8). Recent research indicates that the obesity prevalence within this demographic in Iran varies between 7% and 16% (9).

The incidence of childhood obesity is associated with an increased likelihood of chronic diseases in adulthood, as research has demonstrated a relationship between higher body fat levels and lipid profile indicators (10,11). In particular, the metabolic irregularities linked to obesity result in elevated concentrations of free fatty acids due to insulin resistance, along with increased triglycerides, total cholesterol, and low-density lipoproteins, while levels of high-density lipoproteins are reduced. It is plausible that the accumulation of free fatty acids in the liver, resulting from obesity, plays a role in the excessive production of very low-density lipoprotein (VLDL) and subsequent liver dysfunction, as well as disruptions in reverse cholesterol transport (12). Lipid profile indicators generally include triglycerides, total cholesterol, and both high-density and low-density lipoproteins, which are classified as plasma-soluble lipoproteins. Broadly, lipoproteins can be divided into various categories, such as VLDL, low-density

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lipoprotein (LDL), and high-density lipoprotein (HDL). Sustained changes in these lipid parameters due to overweight and obesity are significant factors contributing to the onset of chronic metabolic and cardiovascular diseases over time (13,14).

Recent research has identified a range of strategies to combat obesity, including modifications to diet, consistent physical activity, behavioral therapy, and pharmacological treatments. Notably, sports interventions have demonstrated effectiveness in facilitating weight management, promoting weight loss, maintaining weight after loss, and mitigating obesity. Engaging in sports is strongly advocated as a means of achieving a therapeutic lifestyle change, given the extensive health benefits associated with such activities. It has been observed that participation in sports can positively influence lipid profiles. When participating in exercise, it is essential to take into account both the intensity and duration of the activity to optimize health benefits (15). Low-intensity exercises performed over longer durations tend to utilize fat as a primary energy source, whereas high-intensity workouts predominantly draw on carbohydrates. Evidence suggests that traditional low- to moderate-intensity exercise is more effective in modifying lipid profiles than high-intensity workouts (16,17). A distinct form of interval training, referred to as Tabata, was established in 1996 and consists of short intervals of high-intensity exercise lasting 20 seconds, interspersed with brief recovery periods of 10 seconds, all within a 30-minute framework (18). This innovative training regimen, which utilizes functional movements or bodyweight exercises, has been found to significantly improve physical fitness, as well as aerobic and anaerobic capacity, and body composition (19). Empirical studies have highlighted the beneficial impacts of Tabata training on physical fitness levels, reduction in body fat, and improvements in cardiometabolic health indicators (20,21). Consequently, researchers advocate for the incorporation of Tabata exercises as a means to enhance overall physical fitness and health outcomes (19-21). The precise characteristics of the program, including the types of exercises, their duration, and the optimal volume necessary to achieve the desired outcomes in inactive adolescents, remain ambiguous. Nonetheless, evidence suggests that short-duration intermittent exercises can lead to beneficial physical results and improvements in body composition. The atherogenic responses and associated pathogenic risk factors linked to Tabata training in overweight adolescents are not thoroughly understood. Therefore, the implementation of this training method across different age demographics, along with a detailed understanding of the metabolic and atherogenic adaptations that occur as a result of Tabata training in children and adolescents, calls for additional investigation. This study seeks to assess the effects of Tabata exercise on metabolic changes and body composition in overweight boys, with the hypothesis that Tabata training can significantly enhance lipid profiles and body composition.

2. Methods

2.1 Participants

The research employed a semi-experimental pre-test-post-test design. It specifically targeted overweight males aged 13 to 17 years, with a body mass index ranging from 24.9 to 25 kg/m^2, who had not participated in any sports activities or utilized sports supplements in the preceding six months. A total of 30 overweight teenage boys were selected for the study through available and voluntary sampling. The criteria for exiting the research included musculoskeletal injury during training sessions, participation in other sports activities, absence of two consecutive sessions, and failure to attend body composition and sampling process. The participants underwent blood sampling and body composition measurements using an in body model 290 device. The participants were subsequently assigned at random to two distinct groups: one group underwent Tabata training, consisting of 15 individuals, while the other group served as a control, also comprising 15 individuals. Comprehensive information regarding the research methodology was provided to the participants, who were then requested to sign consent forms. The Tabata training regimen was implemented over a duration of eight weeks, whereas the control group was directed to abstain from any sports activities throughout the duration of the study.

2.2 Measures

Anthropometric indicators such as height and weight were measured during a specific time in the morning. The height measurement was conducted using the Frankfurt plane method, where the head is positioned horizontally, the tail operation is performed, and the body is placed in a straight line while hands are comfortably held by the body. The Seka model 220 height measuring device from Germany, with a sensitivity of 0.01 m, was utilized for this purpose (21). As a result, the height of each individual was determined and recorded in centimeters.

The study involved the measurement of body composition indicators such as skeletal muscle mass, fat mass, and body weight using the Mark Inbody body composition analyzer, model 290, manufactured in South Korea. Prior to the test, each participant had to adhere to the following guidelines: 1) Sit on a chair for 15 minutes upon arrival at the laboratory after changing clothes. 2) Avoid engaging in vigorous physical activity for 48 hours before the test. 3) Fast for 9 to 10 hours the night before the test. Participants were also required to remove any metal objects from their body and be without clothes (except for underwear) during the test (22).

2.2.1. Instructions for Assessing Biological Indicators

A specialist collected 10 cc blood samples from the brachial vein of each participant in the morning, after a 72-hour fasting period. Upon arrival at the laboratory, participants rested for 20 minutes in a seated position while their heart rate and blood pressure were documented. The blood samples were then transferred to tubes containing EDTA. The serum was subsequently isolated from the blood utilizing a HEHICH centrifuge manufactured in Germany, operating at a speed of 3000 rpm, and was preserved at -80 degrees Celsius for subsequent biochemical analysis. The indicators of the plasma triglyceride lipid profile were quantified using a Hitachi model 912 apparatus from Japan, which employed the enzyme-calorimetric method (GPO-PAP) alongside Pars Azmoun kits from Iran, demonstrating a sensitivity of 1 mg/dL and a coefficient of variation of

1.6%. Total cholesterol concentrations were determined using Pars Azmoun kits from Iran and the enzymatic-calorimetric technique, with a sensitivity of 3 mg/dL and a coefficient of variation of 1.5%. Furthermore, low-density lipoprotein and high-density lipoprotein levels were assessed through a photometric-enzymatic method, also utilizing Pars Azmoun kits from Iran, which exhibited a sensitivity of 1 mg/dL and a coefficient of variation of 1.5%.

2.2.2. The Nutritional Status

The nutritional status of the participants was assessed with specific instructions to maintain their usual dietary habits throughout the training period. To reduce variability in daily food intake, each participant was required to document their diet over a three-day span, which occurred both during the pre-test phase and in the eighth week of the training regimen. The evaluation focused on total energy consumption as well as the contributions of carbohydrates, fats, and proteins (refer to Table 1) (23). The findings indicated no statistically significant differences in daily energy intake, carbohydrates, proteins, and fats among the groups, with p-values of 0.120, 0.321, 0.194, and 0.309, respectively.

Table 1. Energy Consumption and Macronutrients.

Variable	Tabata Training Group		Control Group	
	Pre-test	Post-test	Pre-test	Post-test
Energy (kcal per day)	2251.1±76.9	2292.5±90.4	2164.7±81.4	2187.6±94.8
Carbohydrates (grams per day)	264.4±14.4	257.9±15.2	255.9±9.1	228.2±10.8
PROTEIN (grams per day)	105.4±11.9	103.1±8.2	108.4±8.7	104.5±9.0
Fat (g/day)	95.4±8.1	91.4±4.7	93.3±7.5	89.2±5.2

2.3. Tabata Exercise Program

The Tabata training program was implemented over an eight-week period, during which participants attended three sessions weekly, culminating in a total of 24 sessions. The exercise regimen consisted of four-minute intervals for each exercise, structured as 20 seconds of intense activity followed by 10 seconds of rest. Each interval featured two different exercises, performed in eight repetitions, with a one-minute rest period between each round. The total duration of each training session throughout the study varied between 34 and 39 minutes. Before the training commenced, participants received comprehensive instruction on the exercises and the 20-point Borg scale for assessing perceived exertion during an initial session. At the end of each training session, participants were required to provide a Borg score that indicated their perceived level of difficulty regarding the exercises (see Table 2).

Table 2. Tabata Protocol Exercise Program.

Week	Activity	Time of Session	Intensity (RPE-20)
1-2	Forward and Backward Running + Touch Crunch Heel Sumo Squat, Plank Jacks Lateral Barrier Jump+ Flutter Kicks Squat Jump with Rotation + Knee to Squat Sprint + Jumping Langes Burpee whit Long Jump + Toe Touches Sit up Side to Side Shuffles + Cross Crunches	35 minutes	17-18
3-4	Turns 1 to 7 are Similar to the Exercises of Weeks 1-2 Seal Jack + Shoulder tap	38 Minutes	19-20
5-6	Narrow Stance Squat, Mountain Climbers, Toe Touches, Lunges, Jumping Jacks, Standing ABS Twist, Squat to Side	39 Minutes	19-20
7-8	Exercises Similar to the Fifth and Sixth	39 Minutes	19-20

2.4. Statistical Analysis

The analysis of the data was conducted employing a statistical covariance test. Before this analysis, the normality of the data distribution was assessed using the Shapiro-Wilk test, and the assumptions necessary for the covariance test across groups were verified. Descriptive statistics, including the mean and standard deviation (SD), were calculated. A significance threshold of $P<0.05$ was established, and all statistical evaluations were performed utilizing SPSS version 26 software.

3. Results

The demographic indicators reveal that the mean and SD of age for the Tabata training group are 14.87±1.45 years, while for the control group, it is 15.00±1.19 years. In terms of height, the values are 163.53±7.35 cm for the Tabata group and 164.13±8.06 cm for the control group. The weight statistics show 74.93±7.04 kg for the Tabata group and 77.62±7.92 kg for the control group. Lastly, the body mass index is 28.00±1.65 kg/m2 for the Tabata training group and 28.75±1.11 kg/m2 for the control group. It is important to highlight that the normal distribution for both groups was preserved in both the pre-test and post-test phases. Furthermore, no significant differences were found in age ($F=0.075$, $P=0.876$), height ($F=0.045$, $P=0.833$), body weight ($F=0.966$, $P=0.334$), or body mass index ($F=2.15$, $P=0.153$) during the pre-test assessment.

3.1. Body Composition Results

Analysis of covariance was utilized to assess changes in muscle mass, fat mass (indicated by body fat percentage), body weight, and body mass index. The findings regarding body weight changes among the groups indicate a significant decrease in the Tabata training group in comparison to the control group ($p=0.001$). Moreover, the results related to alterations in body fat percentage and body mass index reveal a substantial reduction in the Tabata training group when juxtaposed with the control group ($p=0.001$; $p=0.001$). Additionally, a noteworthy increase in muscle mass was recorded in the Tabata training group as opposed to the control group ($p=0.045$) (Table 3).

3.2. Lipid Profile Results

The results obtained from the statistical covariance analysis regarding changes in triglyceride levels revealed no significant differences among the groups (p=0.05). In contrast, the changes in total cholesterol and low-density lipoprotein levels across the groups showed a significant decrease (p=0.001; p=0.001). Furthermore, a notable increase in high-density lipoprotein was recorded in the Tabata training group relative to the control group (p=0.001) (Table 3).

Table 3. Results of Analysis of Covariance Related to Changes in Body Composition and Lipid Profiles Among Groups.

Variable	Groups	Pre-test	Post-test	Adjusted Mean	df	Intra-Group	Inter-Group
Body Weight (kg)	Tabata	74.93 ± 7.04	69.37 ± 7.16	70.57	1	*0.001	F=118.46
	Control	77.62 ± 7.92	77.80 ± 60.54	76.59		0.735	P=0.001*
Body Mass Index (kilograms per square meter)	Tabata	28.00 ± 1.65	25.91 ± 1.79	26.28	1	*0.001	F=89.35
	Control	28.75 ± 1.11	28.86 ± 1.09	28.50		0.571	P=0.001*
Muscle Mass (kg)	Tabata	19.36 ± 1.82	20.21 ± 1.99	22.50	1	*0.001	F=4.44
	Control	20.05 ± 2.04	20.40 ± 2.03	20.06		0.134	P=0.045*
Body Fat (percentage)	Tabata	25.94 ± 4.40	24.53 ± 4.12	25.45	1	*0.001	F=45.02
	Control	27.99 ± 3.97	27.87 ± 3.48	26.95		0.634	P=0.001*
Triglycerides (mg/dL)	Tabata	129.87 ± 25.56	108.60 ± 27.65	108.15	1	0.060	F=4.20
	Control	137.02 ± 39.17	133.13 ± 38.25	133.57		0.798	F=0.050
Total Cholesterol (mg/dL)	Tabata	25.09 ± 156.06	131.94 ± 25.42	129.66	1	*0.001	F=270.51
	Control	151.43 ± 23.94	149.83 ± 25.04	152.10		0.441	P=0.001*
Low-Density Lipoprotein (mg/dL)	Tabata	119.33 ± 14.19	104.13 ± 13.56	105.12	1	*0.001	F=102.27
	Control	121.73 ± 12.68	123.73 ± 10.22	122.74		0.152	P=0.001*
High Density Lipoprotein (mg/dL)	Tabata	40.20 ± 5.29	49.93 ± 5.73	51.19	1	*0.001	F=303.66
	Control	42.66 ± 4.49	42.00 ± 4.81	40.73		0.160	P=0.001*

A significance level of less than 0.05 is considered *

4. Discussion

The findings from an eight-week Tabata training program conducted with overweight adolescent boys demonstrate a marked reduction in various body composition metrics, including body weight, body mass index, and body fat percentage, when juxtaposed with a control group. In contrast, the Tabata training cohort exhibited a significant increase of 4.3% in muscle mass relative to the control group. Additionally, the lipid profile analysis revealed a considerable decline in total cholesterol and low-density lipoprotein levels among participants in the Tabata training group compared to their counterparts. While there was a significant elevation in high-density lipoprotein levels, no alterations in triglyceride levels were observed in the Tabata group, despite a 16.2% reduction not being evident in the overweight boys. These findings reinforce the beneficial effects noted in prior studies and are particularly relevant for fostering health in developing adolescents. In conclusion, the Tabata-style functional interval training regimen emerges as a viable and effective strategy for improving the cardiometabolic health of overweight adolescent boys.

The efficacy of high-intensity interval training (HIIT) for weight and fat reduction continues to be a subject of discussion, despite its growing popularity. The results of this study indicated that an eight-week Tabata-style interval training program effectively decreased fat percentage, body weight, and body mass index, while simultaneously increasing muscle mass. These results are consistent with earlier research (19,21,24,25). McPherson et al. (24) implemented a conventional HIIT protocol centered on running, which included four to six sets of 30-second sprints followed by a four-minute rest period. After a six-week intervention conducted three times weekly, participants exhibited a significant reduction in body fat percentage and fat mass, alongside a marked increase in lean mass, with body weight remaining stable. Similarly, Zhang et al. (25) corroborated the fat-loss benefits of HIIT, showing a reduction in both total body and localized fat mass after 12 weeks of training among obese young women. Additionally, Lu et al. (21) demonstrated that 12 weeks of Tabata-style interval training (comprising 8 repetitions of 20 seconds) improved cardiorespiratory fitness, decreased body fat, and positively influenced cardiometabolic responses in female university students. They suggested that integrating Tabata-style workouts into daily life could yield advantageous outcomes. Likewise, Leiboevich et al. (19) found a significant decline in body mass index and fat mass in sedentary women over a four-month duration. In alignment with previous studies, the alterations in body composition reflected a reduction in fat percentage, body weight, and body mass index, along with a modest increase in muscle mass when compared to the control group.

Additional findings were associated with alterations in lipid profiles, demonstrating enhancements in these markers among teenage boys, despite the lack of significance in triglyceride changes. The outcomes of the current investigation aligned with the results of previous studies (21,26-28).

The beneficial effects of interval training on lipid profiles have been documented in research involving overweight or obese males. Fisher et al. (29) reported significant improvements in lipid profile metrics among overweight or obese young men following a six-week training program. In a similar vein, Paaho et al. (27) observed that a 12-week regimen of high-intensity interval training effectively improved lipid profile metrics in obese and sedentary overweight boys. Additionally, Hajinia (26) indicated that interval training could positively influence lipid profile metrics in middle-aged men. The physiological adaptations associated with interval training suggest that the release of metabolites such as adenosine monophosphate and muscle-derived myokines may play a role in enhancing basal metabolic rates. For example, the secretion of muscle myokines, including

adiponectin, can affect adipose tissue and promote fatty acid oxidation (30). Furthermore, the release of catecholamines during and after exercise is essential for stimulating lipolysis and fatty acid oxidation, which in turn improves circulating lipid profiles (31). The upregulation of PGC1α in muscle cells is also crucial for mitochondrial biogenesis and the increase of oxidative enzymes, facilitating more efficient fatty acid utilization for energy production (32). Importantly, the application of Tabata interval training in the present study led to a significant decrease in body composition metrics and a marked improvement in lipid profiles, with the exception of triglyceride levels.

Lu et al. (21) proposed that Tabata training might be a viable alternative to conventional approaches for enhancing cardiometabolic health and physical fitness. Conversely, Etoshe and Poursoltani (28) observed that although Tabata training effectively reduced subcutaneous fat, it did not produce notable alterations in lipid profile indices among young active women. The focus on active female participants in their research may explain the divergence from the findings of the current study. In this investigation, overweight boys with no prior sports experience were examined, revealing that Tabata exercise could significantly enhance lipid profiles. This enhancement is likely linked to the elevation of the myokine irisin, which is recognized for its role in promoting the browning of white adipose tissue and increasing fatty acid oxidation, thereby leading to meaningful changes in body composition and lipid profiles (33). Furthermore, the brief intervals of Tabata training, which employed body weight as resistance and exerted high stretching pressure on skeletal muscles, were found to be comparable to the loads typically utilized in resistance training (34). The observed enhancement in muscle mass among participants can be attributed to processes occurring in oxygen-deprived muscle environments. Specifically, there is an increased stimulation of growth hormone secretion that coincides with the buildup of metabolic byproducts, such as lactate, within the muscle tissue (35). Moreover, a moderate production of reactive oxygen species (ROS) contributes to the promotion of muscle tissue growth (33). Research indicates that the activation of fast-twitch muscle fibers under conditions of hypoxia is advantageous for muscle hypertrophy (36). Additionally, the rise in effective metabolites, including insulin-like growth factor 1 and lactate, acts as a vital signal for the activation of the Akt/mTOR signaling pathway, which subsequently leads to the release of testosterone. Tabata training, characterized by movements that impose significant tension on both the upper and lower body skeletal muscles, likely stimulates mechanoreceptors in muscle cells, thereby promoting the activation of anabolic signaling pathways.

It appears that an increased training volume in Tabata training, resulting in higher muscle activity during workouts, may play a significant role in enhancing lipid profile indicators. The secretion of epinephrine impacts subcutaneous fat tissue and skeletal muscle cells, heightening the responsiveness of lipolysis by binding to the beta-adrenergic receptor (37).

Exercise compatibility enhances the activity of enzymes involved in fat oxidation, including citrate synthase and beta-hydroxyacyl coenzyme A dehydrogenase. Conversely, high-intensity interval training positively influences the regulation of fatty acid transporters, specifically FABPpm and FAT/CD36, which are crucial for augmenting overall fat oxidation within the body. Furthermore, exercise stimulates skeletal muscle contraction and promotes the expression of lipoprotein lipase, alongside the release of catecholamines, thereby increasing lipoprotein lipase activity. This enzyme is vital for the hydrolysis and reduction of blood triglycerides, which subsequently affects low-density lipoprotein levels. The findings of this study revealed a notable enhancement in lipid profile parameters, suggesting that exercise, by facilitating the uptake of free fatty acids through plasma carriers like albumin, significantly contributes to lowering triglyceride levels and plasma low-density lipoprotein. Although dietary habits remained unchanged before and after the training regimen, the absence of weekly caloric intake monitoring presents a limitation in this study. Additionally, the research did not consider variables such as psychological factors, gender differences, developmental variations, and interpersonal discrepancies, and the short duration of the study underscores the need for further research to evaluate long-term effects.

4.1. Conclusion

It is important to recognize that utilizing Tabata training can effectively enhance body composition and lipid profile indicators in adolescent boys, offering a time-efficient approach. Engaging teenagers in exercise programs throughout the week can yield significant health advantages concerning body composition and cardiovascular metabolic risk factors among overweight adolescents. Furthermore, the present research enhances the existing knowledge of Tabata training, demonstrating that the incorporation of various and relatively novel physical activities can be beneficial. Consequently, further studies involving diverse age groups with tailored program modifications are essential. Implementing Tabata exercises is necessary to assess their effectiveness within the intended community.

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Footnotes

Authors' Contribution: This study was carried out solely by the corresponding author.

Conflict of Interests: The researcher confirms that there is no conflict of interests in this study with any participant.

Data Availability: The data that support the findings of this study are openly available upon request from the corresponding author.

Ethical Approval: Approval for this study was obtained from the university. The author confirms that all steps and requirements of this study comply with ethical guidelines. Participants were informed about the characteristics of the study and gave written informed consent.

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