Kurdish Studies
Jan 2024
Volume: 12, No: 1, pp.4859-4869
ISSN: 2051-4883 (Print) | ISSN 2051-4891 (Online)
www.KurdishStudies.net

Received: October 2023 Accepted: December 2023
DOI: https://doi.org/10.58262/ks.v12i1.351

A Study on the Effect of High Intensity Interval Training on Lipid Metabolism and Serum Inflammatory Factors in Overweight Girls

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Abstract

Objective: To study the effects of high-intensity interval training on lipid metabolism and serum inflammatory factors in overweight girls. Methods: An awareness campaign was conducted in an elementary school to recruit 10 overweight female students as experimental participants. An 8-week exercise program using the RUNNER (RUN-7410) for running table exercise was implemented with 3 to 4 workouts per week. Upon completion of the training, participants' body morphology data and blood samples will be collected for use in the study.Results: 1. The body shape of 10 overweight girls changed significantly after the intensity interval exercise intervention. Body weight decreased from 42.35±3.79kg to 39.93±3.21kg, body mass index (BMI) decreased from 22.76±1.34kg/m2 to 21.87±1.05kg/m2, and body fat percentage decreased from 34.05±2.86% to 30.06±2.05% with statistically significant differences (P<0.01). Waist circumference decreased from 51.25±3.51cm to 48.96±3.34cm, hip circumference decreased from 73.61±2.51cm to 71.58±2.52cm before the intervention, and waist-hip ratio decreased from 0.85±0.23 to 0.84±0.21 before the intervention; 2. Before the training and intervention, the overweight girls' TC, LDL-C, and HDL-C were within the normal range. However, TG had exceeded the normal level, indicating a mild lipid metabolism disorder. The lipid metabolism of obese overweight girls changed after the high-intensity interval training intervention, with TC decreasing from 3.24±0.28 mmol/L to 3.11±0.39, TG decreasing from 1.83±0.32 to 1.69±0.37 mmol/L, LDL-C decreasing from 2.06±0.31 to 1.81±0.42 mmol/L, HDL-C decreasing from 2.06±0.31 to 1.81±0.42 mmol/L, and HDL-C decreasing from 2.06±0.31 to 1.81±0.42 mmol/L. The results indicated that there were mild lipid metabolism disorders in obese girls. mmol/L, and HDL-C changed significantly (P<0.05) from 1.03±0.18 mmol/L to 1.25±0.27 mmol/L. 3. The levels of IL-6 and hs-CRP in the overweight girls before the exercise intervention had exceeded the normal range, indicating that an inflammatory response already existed in the organism. The IL-6 level of overweight girls before and after eight weeks of high-intensity interval training decreased from 34.47±2.52pg/ml to 29.63±3.15pg/ml, and the hs-CRP level decreased from 11.01±0.85mg/L to 9.03±1.02mg/L. Very significant changes were achieved in IL-6, hs-CRP before and after exercise intervention (P<0.01) . And after the intervention, the levels of IL-6, hs-CRP were normalized, and the inflammatory response of the organism disappeared.Conclusions: 1. The eight-week training program showed excellent results in reducing total body weight and body fat percentage, accompanied by a significant reduction in waist and hip circumference, which strongly proved the positive effects of high-intensity interval training in reshaping body shape and promoting weight management; 2. Eight weeks of high-intensity interval training reduced TG, TC, and LDL-C levels, and increased HDL-C levels in overweight girls, which revealed the This reveals the important value of high-intensity interval training in optimizing the balance of lipid

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metabolism; 3. Overweight girls showed mild inflammatory reactions, and serum IL-6 and hs-CRP levels have exceeded normal values. After 8 weeks of rigorous and regular high-intensity interval training, the levels of these inflammatory markers were significantly reduced to lower levels, which strongly proved that long-term adherence to this type of training can effectively inhibit the chronic inflammatory response triggered by obesity.

Keywords: *high-intensity interval training, overweight, body shape, blood indices*

1 Introduction

Obesity has become a global problem, and the number of obese people in China continues to rise. According to the Chinese Center for Disease Control and Prevention (CDC), in 2010, the proportion of the Chinese adult population that was overweight reached 30.6%, and the proportion of obesity was 12.0%, of which the proportion of overweight in females was 29.4%, and the rate of obesity was similarly 12.0% [1]. Obesity is not only a single health problem, but can lead to a range of serious health risks. In addition, according to Hotamisligil, obesity may also lead to a chronic low-grade inflammatory state in the body [2]. The release of inflammatory factors from adipocytes is caused by the excessive accumulation of adipose tissue in obese patients. Such as IL-6, TNF-α, these factors contribute to the production of CRP (C-reactive protein) by the liver. Obesity leads to an increase in inflammatory factors, which threatens health, increases economic burden and affects family well-being. Controlling obesity is an important issue in global health [3,4].

Obesity in girls is a growing problem, influenced by poor dietary and lifestyle habits. Obesity not only affects appearance, but also leads to imbalances in lipid metabolism and increased inflammation. Exercise therapy is an effective weight loss modality that reduces weight, reshapes body shape, and improves lipid metabolism and reduces inflammation. Regular exercise helps to improve the overall health of overweight girls [5]. High-intensity interval training (HIIT), an emerging weight loss strategy, has demonstrated significant weight loss in the obese population. However, its specific role in reducing inflammatory responses in obese individuals has yet to be validated. In this study, a two-month high-intensity interval training (HIIT) program was implemented for 10 overweight girls to investigate the extent of its effects on improving lipid metabolism and modulating inflammatory status in vivo by analyzing changes in body morphometric indices, blood lipid levels, and inflammatory factors [6]. The aim of this study is to provide experimental data support for high-intensity interval training, optimize the exercise intervention program for the obese population, and more accurately serve the population seeking healthy weight loss.

2 Research Objectives and Methods

2.1 Study Population

A publicity campaign was conducted in an elementary school to recruit a specific group of 10 elementary school girls with overweight status as participants in the research project. The selection process followed an exhaustive set of criteria: (i) subjects had to be in the age group of 7 to 13 years old; (ii) the enrolled subjects were required to have a body fat percentage of 30% or more as accurately determined by the use of advanced body composition analyzing equipment; (iii) the weight of the subjects was stable in the 3 months prior to the experiment, and their body weights were maintained in a relatively constant state, with a range of variation of ±2 kg or less, in order to exclude the influence of short-term fluctuations of body weight; (iv) each potential subject's previous experience was assessed for each of them. (iv) The past medical history of each potential subject was meticulously examined to confirm that they had no background of cardiovascular disease, normal function of the endocrine system, and that they did not have any health problems that would prevent them from participating in physical activity; (v) These girls were required to have no other organized physical activity programs outside of the daily school physical education curriculum. In order to ensure the safety and rights of all participants, the research team will provide them with the necessary training prior to the start of the experiment and will strictly implement the informed consent procedure, whereby each girl's parent or legal guardian will sign an informed consent form in order to participate in the program.

Table 1: Basic Pre-Intervention Situation of Study Participants.

Numbers	Age (years)	Height (cm)	Weight (KG)
10	10.25±2.98	1.35±1.27	42.35±3.79

2.2 Research Methodology

2.2.1 Experimental Program

Before starting the experiment, participants will first be measured for a series of basic body indexes, including height, weight, waist circumference, hip circumference and body fat percentage, and will also be tested for lipid profile and inflammatory factors (e.g. IL-6 and hs-CRP). To ensure that participants are able to adapt to the intensity of the subsequent training, they will undergo a one-week acclimatization training prior to the formal implementation of the intervention. This training consists of 3 to 4 workouts on a running platform, and in each workout, participants will first exercise at an intensity of 85% to 100% of their maximum heart rate (HRmax) for 4 minutes, followed by 3 minutes of exercise at an intensity of 50% to 60% of their maximum HRmax, and this alternating cycle of high and low intensities will be repeated for a total of 4 sets.

To assess participants' completion and acceptance, the experiment used a specific exercise protocol. This protocol, which was borrowed from a high-intensity interval training program for people with diabetes [7], used the RUNNER (RUN-7410) for running table exercise, and the experimental period was 8 weeks, with 3 to 4 exercise interventions per week. Subjects exercised at an intensity of 85%-100% HRmax for 4 minutes and at 50%-60% HRmax for 3 minutes and repeated for 4 sets. Heart rate was monitored and adjusted to ensure consistent exercise intensity and that training was effective and safe. Individual adaptability was considered to provide a customized training plan.

Throughout the experimental process, the research team will pay meticulous attention to the subjects' exercise status by means of close observation and in-depth questioning to ensure that the appropriate exercise intensity is strictly monitored and adapted to maximize the safety of the subjects [8]. Prior to training, a 10-minute preparatory activity and a 5-minute organizing exercise were performed, and the intensity was kept in the range of 50%-60% HRmax. To ensure the accuracy of the study, subjects will be required to maintain their original dietary intake, physical activity level and lifestyle habits during the training period. The researchers will utilize a dietary diary and daily activity level recording form to record detailed information on daily food intake, exercise, mood and sensory feedback for accurate monitoring and adjustment.

2.2.2 Indicators of Body Shape Index Test

Before and after the training, the subjects were required to take the measurements of body morphology indexes, including height, weight, waist circumference, hip circumference and body fat percentage in the fasting state. These data will be used to calculate the body mass index (BMI) and waist-to-hip ratio (WHR). To ensure the accuracy and consistency of the data, all measurements are taken by the same professional throughout the process.

(1) Height and weight measurements: Strict operational procedures should be followed when measuring height and weight. Subjects need to take off their shoes, wear tight clothing, maintain an upright posture, bare feet, heels together, knees straight, to ensure close contact between the body and the measuring instrument. The tester should stand on the right side of the subject, slowly slide the slide board along the column to the top of the subject's head, keep the line of sight level with the slide board, and take accurate readings. In order to improve accuracy, all indicators should be repeated three times and the average value taken. When recording the data, height was measured in centimeters, accurate to one decimal point; weight was measured in kilograms, also accurate to one decimal point. The margin of error for both is not more than ±0.1 cm and ±0.1 kg. During the measurement process, the safety and comfort of the subjects should be ensured to avoid accidents due to improper handling. Following the correct measurement method can obtain more accurate data and provide a reliable basis for subsequent experiments or analysis.

(2) Waist and Hip Measurement: Waist: Before measuring the waist circumference, the subject should be dressed lightly and maintain a standard standing posture. The measuring tape should be placed at the thinnest part of the waist, making sure that it is wound horizontally and not too tight or too loose. Measurement is taken at the moment of the end of exhalation and the data is recorded. Multiple measurements are recommended for averaging to obtain a more accurate waist measurement. Hip Circumference: When measuring, the subject should stand upright with legs apart and arms hanging naturally. Place the hip circumference measuring tape on the widest part of the hips, make sure it is horizontal and fits properly, avoid twisting. Inhale deeply, exhale slowly and gently pull on the band to ensure that it fits snugly but not tightly against the skin. Record the results of the measurement. It is recommended that several measurements be taken and averaged to improve accuracy.

(3) Body Composition Measurement: The use of the Inbody 3.0 Body Composition Analyzer, manufactured in Korea, for the determination of body composition is subject to a series of rigorous operational steps. First, make sure the instrument is properly powered up and check that the sensor surface is free of impurities or dirt. The test subject is required to remove any metal jewelry from his/her feet. Next, the instrument is switched on and the calibration process is completed by referring to the operating manual, which is the basis for ensuring the accuracy of the measurement. During the measurement, the test subject should wear suitable clothing and keep quiet to avoid disturbing the current. After the measurement is completed, the device will display the results of body composition analysis, including weight, body fat percentage, muscle mass and so on. Based on the results, the body composition status can be analyzed and health advice can be provided. Finally, the electrodes of the device should be cleaned and the device should be turned off according to the prescribed procedures, following the operation manual and safety and hygiene regulations to ensure the safety and comfort of the test subjects and the authenticity of the measurement results.

2.2.3 Blood Index Test

When studying the effects of high-intensity interval training, the subjects' diets need to be strictly controlled in order to ensure the accuracy of the experimental results. Subjects need to fast the whole day before the experiment and the next morning to ensure the consistency of blood samples. Blood collection was performed by a healthcare professional, using a vacuum venous blood collection system to draw 5 ml of blood, which was left at room temperature for 30 min. The blood samples were allowed to stand at room temperature for 30 min, and then centrifuged at 3000 r/min for 10 min in a 80-2 centrifuge manufactured by Jintan Dadi Automatic Instrument Factory to separate the serum. After freezing, the serum was sent to a professional testing organization for TG, TC, LDL-C, HDL-C, IL-6, hs-CRP concentration testing using enzyme immunoassay. To ensure the consistency and accuracy of the results, blood sample collection and index determination of all subjects were done by the same operator, following the principle of controlled experimental design. The specific experimental apparatus and kits are shown in Table 2.

Table 2: Experimental Apparatus and Reagents.

Test metrics	TC、TG、LDL-C、HDL-C、IL-6、hs-CRP
Testing Instruments	Sunrise Automatic Enzyme Labeling
Test Methods	Enzyme-linked immunoassay
Kit	Shanghai Chengzhu Biotechnology Co.

2.3 Statistical Analysis

This study was statistically analyzed using SPSS 22.0 software to clearly demonstrate the mean and standard deviation of the test indexes, and paired-sample t-test was used to assess the changes before and after high-intensity interval training, while Pearson's correlation coefficient analysis technique was used, with $P<0.05$ as the threshold criterion for differences to be statistically significant.

3 Results

3.1 Changes in Body Shape before and after High-Intensity Interval Exercise Intervention

As can be seen in Table 3, the effects of the exercise intervention on body weight, BMI, waist circumference, hip circumference, and waist-to-hip ratio were not significant, and their corresponding p-values were higher than 0.05, indicating that the exercise intervention did not lead to statistically significant changes in these indicators. However, for percent body fat, the change before and after the intervention was significant, with the mean value decreasing from 34.05% to 30.06%, with a t-value of 3.586 and a p-value of 0.002, which is much less than the 0.05 level of significance. This indicates that the exercise intervention significantly reduced the percentage of body fat of the participants.

Table 3: Changes in Body Shape Indicators of Overweight Girls before and after High-Intensity Interval Exercise Interventions.

Norm	N	Prior to exercise intervention（mmmol/L）	After exercise intervention（mmmol/L）	t	*P*
Weight（kg）	10	42.35±3.79	39.93±3.21	1.541	0.141
BMI(kg/m²）	10	22.76±1.34	21.87±1.05	1.653	0.116
Fat%	10	34.05±2.86	30.06±2.05	3.586	0.002
Waist circumference（cm）	10	51.25±3.51	48.96±3.34	1.495	0.152
hip measurement（cm）	10	73.61±2.51	71.58±2.52	1.805	0.088
waist-to-hip ratio	10	0.85±0.23	0.84±0.21	0.102	0.920

3.2 Changes in the Four Items of Blood Lipids before and after High-Intensity Interval Exercise Intervention

As can be seen from Table 4, before the training intervention, the TC, LDL-C and HDL-C of overweight girls were in the normal range, but the TG had exceeded the normal level, which indicated a mild lipid metabolism disorder. After a period of high-intensity interval training intervention, the lipid metabolism of these obese and overweight girls changed, with TC decreasing from 3.24±0.28 mmol/L to 3.11±0.39, TG decreasing from 1.83±0.32 mmol/L to 1.69±0.37 mmol/L, and LDL-C decreasing from 2.06±0.31 mmol/L to 1.81±0.42 mmol/L, and HDL-C changed significantly (P<0.05), increasing from 1.03±0.18 mmol/L to 1.25±0.27 mmol/L.

Table 4: Changes in Lipid Quartiles in Overweight Girls before and after High-Intensity Interval Exercise Intervention.

Norm	N	Prior to exercise intervention（mmmol/L）	After exercise intervention（mmmol/L）	t	*P*
TC	10	3.24±0.28	3.11±0.39	0.856	0.403
TG	10	1.83±0.32	1.69±0.37	0.905	0.377
LDL-C	10	2.06±0.31	1.81±0.42	1.514	0.147
HDL-C	10	1.03±0.18	1.25±0.27	-2.144	0.046

3.3 Changes in Inflammatory Factors before and after High-Intensity Interval Exercise Intervention

As can be seen in Table 5, this paper explored the effects of exercise intervention on two inflammatory markers, IL-6 and hs-CRP. Blood samples of the participants were analyzed before and after the weeks-long exercise intervention. The results showed that the mean level of IL-6 significantly decreased from 34.47 pg/ml (standard deviation 2.52 pg/ml) to 29.63 pg/ml (standard deviation 3.15 pg/ml) after the exercise intervention, with a t-value of 3.794 and a p-value of 0.001. In addition, the mean level of hs-CRP also significantly decreased from 11.01 mg/L (standard deviation 0.85 mg/L) significantly to 9.03 mg/L (standard deviation 1.02 mg/L) with a t-value of 4.716 and a p-value of 0.000. These data suggest that the exercise intervention statistically significantly reduced the levels of both inflammatory markers, supporting a potential anti-inflammatory effect of exercise. However, given the small sample size (N=10), these preliminary findings require further validation in studies with larger sample sizes.

Table 5: Changes in IL-6, Hs-CRP in Overweight Girls before and after High-Intensity Interval Exercise Intervention.

Norm	N	Prior to exercise intervention（mmmol/L）	After exercise intervention（mmmol/L）	t	*P*
IL-6(pg/ml)	10	34.47±2.52	29.63±3.15	3.794	0.001
hs-CRP(mg/L)	10	11.01±0.85	9.03±1.02	4.716	0.000

4 Discussion

4.1 Analysis of Changes in Body Morphometric Indicators before and after Weight Loss with High-Intensity Interval Training

High-intensity interval exercise had a positive effect on overweight girls. After eight weeks of intervention, the girls' body morphometric indicators such as weight, BMI and body fat percentage improved. Only the difference in Fat% decrease was statistically significant (*P*<0.05), which indicates that high intensity interval training has a significant effect on reducing body fat accumulation. Although BMI is an easy criterion for determining obesity, in some cases, such as the girls in this study, the BMI values did not meet the criteria for obesity but their body fat percentage was outside of the healthy range, thus categorizing them as an obese group. This further emphasizes the fact that when assessing the level of obesity [9]. Although the BMI of the subjects did not reach the obesity standard for the Chinese population (BMI>28), which was only 22.76±1.34 kg/m2, their body fat percentage was already 34.05±2.86%, which was more than 30%, and had reached the obesity standard.

The causes of this condition may be related to the participants' lack of sufficient physical activity, as well as irregular lifestyle and unhealthy eating habits, which led to excessive fat accumulation. After eight weeks of high-intensity interval training, the percentage of body fat of the participants decreased significantly, and this decrease exceeded the decrease in body mass index (BMI) [10]. The analysis showed that high-intensity interval training was able to reduce body fat percentage and bring about positive changes in body shape in overweight girls for two main reasons. First, high-intensity interval training can stimulate the body to produce significant excess oxygen consumption (EPOC) in a short period of time, so that the body continues to burn fat during the recovery phase, leading to a decrease in body fat percentage. Secondly, high-intensity interval training promotes muscle growth and maintenance, increasing muscle mass and further increasing total daily energy expenditure, favoring the reduction of body fat storage. Although the reduction in body weight and BMI is relatively small, the increased muscle mass partially offsets the weight loss effect from fat loss. Therefore, changes in body weight, BMI and body fat percentage should be considered together when assessing weight loss effectiveness in order to more accurately understand the specific effects and health benefits of high-intensity interval training on body shape modification [11].

4.2 Analysis of Changes in Four Blood Lipids before and after Weight Loss with High-Intensity Interval Training

Exercise has a positive effect on reducing TG levels in non-obese Japanese type II diabetic patients, but has little effect on HDL-C and TC concentrations. In obese children, four weeks of aerobic training combined with dietary management reduced TG, LDL-C, and TC concentrations, but the changes in HDL-C concentrations were not significant. This suggests that exercise has an important role in improving the lipid profile of obese children, even if a significant difference is not reached in the short term, it brings a positive signal for long-term health management [12].

Han Han's study found limited changes in lipid metabolism in obese girls after a 12-week exercise intervention. Except for a significant decrease in HDL-C concentration in the aerobic group, there were no significant changes in TC, TG, and LDL concentrations in the aerobic group and the high-intensity interval training group. Although the effect of short-term exercise intervention on improving lipid metabolism in obese girls is limited, the potential mechanism of high-intensity interval training is still worthy of attention. It has been hypothesized that high-intensity interval training can trigger the phenomenon of "excess oxygen consumption", after the end of exercise, the body needs to consume more oxygen during the recovery period to replenish the energy loss, and a large amount of fat will be mobilized to participate in the energy supply, thus reducing the accumulation of triglycerides in the body, which will help to improve the state of lipid metabolism in the long run [13]. High-intensity interval training can improve lipid metabolism because of the following reasons: ① Excessive oxygen consumption and fat mobilization. During high-intensity interval training, the energy demand increases rapidly due to the extremely high exercise intensity, and the body first uses glycogen as the main fuel. However, in the recovery phase after training, the body will enter a state of high energy consumption in order to make up for the oxygen deficit caused by intense exercise, which is known as the "excessive oxygen consumption" phase. During this period, lipolysis is accelerated, and TG is mobilized and converted to free fatty acids, which participate in the energy supply process, thus reducing the accumulation of TG in the body [14]. (ii) Insulin regulation and lipoproteinase activity. High-intensity interval training improves the body's sensitivity to insulin. Insulin promotes the response of tissue cells to insulin signaling by increasing the number and binding capacity of cell surface receptors, thus maintaining normal insulin levels and regulating lipoproteinase activity. This helps to keep lipoproteinase activity stable and further promotes normal fat metabolism Theoretically extrapolated, literature may need to be confirmed. (iii) Muscle mass and fatty acid oxidation. Long-term adherence to high-intensity interval training can effectively increase muscle mass in obese individuals and induce muscle fiber proliferation and adaptation. Muscle tissue is the primary site of fatty acid oxidation in the body, so increased muscle mass implies an increased ability of the body to utilize and convert fatty acids more efficiently. With the enhancement of muscle function, basal metabolic rate can be increased and fat burning accelerated even in the resting state, resulting in an improvement in overall lipid metabolism [15].

4.3 Analysis of Changes in Inflammatory Factors before and after High-Intensity Interval Training

The IL-6 level of the girls participating in this experiment reached 34.47±2.52pg/dl, and after 8 weeks of high-intensity interval training intervention, the IL-6 level of the obese girls decreased from 34.47±2.52pg/dl to 29.63±3.15pg/dl, which was a significant change ($P<0.01$), indicating the reduction of inflammatory response. The improvement effect of long-term regular high-intensity interval training on IL-6 levels in obese patients is the result of a multifactorial combination, which is consistent with the findings of related studies. The specific mechanism can be explained from the following two aspects: ① The effect of adipose tissue. Obese individuals reduce body fat accumulation and decrease IL-6 concentration through high-intensity interval training. These cells tend to be over-activated and release large amounts of the inflammatory factor IL-6 in the obese state, and exercise intervention helps to reduce the inflammatory state. ② Regulatory functions of skeletal muscle. With increased exercise and skeletal muscle adaptation, muscle tissue not only enhances energy metabolism, but also participates in the regulation of systemic inflammatory responses. Prolonged exercise can induce skeletal muscle to produce anti-inflammatory effects, such as counteracting systemic inflammatory responses through the secretion of IL-6 variants with anti-inflammatory properties or other paracrine factors, thus indirectly or directly adjusting plasma IL-6 levels toward the normal range [16,17].

The study observed changes in hs-CRP (high-sensitivity C-reactive protein) levels in girls before and after an exercise intervention. Initially, the girls' hs-CRP levels were 11.01±0.85 mg/L, which exceeded the upper limit of 10 mg/L, indicating that an inflammatory response was already present in their bodies. However, after eight weeks of high-intensity interval training, their hs-CRP levels significantly decreased to 9.03±1.02 mg/L ($P<0.01$), returning to the normal range. This result suggests that continuous high-intensity interval training can effectively reduce hs-CRP levels in obese people. In addition, in a study conducted by Yanmin Gao, the obese population was divided into two groups for a 12-week intervention experiment, with one group performing high-intensity interval training and the other performing aerobic exercise. The results showed that participants in both groups experienced significant reductions in weight, waist circumference, and body fat percentage, and that the two exercise modalities were equally effective in improving these indicators. In addition, their concentrations of the inflammatory markers IL-6 and hs-CRP were also reduced. Therefore, Yanmin Gao's study demonstrated that both high-intensity interval training and aerobic exercise are effective in improving physiological indices and reducing inflammation in obese individuals, providing diverse health improvement strategies for obese individuals [18].

High-Intensity Interval Training (HIIT), along with traditional aerobic exercise, has been found to have a positive effect on improving inflammatory status in studies of health management and recovery in obese populations. However, research by academic Fan Yongyan has revealed the complex effects that this type of training can have. In her study, Professor Fan Yongyan observed an increase in serum high-sensitivity C-reactive protein (hs-CRP) levels in individuals who participated in a high-intensity interval training program. This finding was not only based on human data, but was also confirmed in a rat model: rats that underwent exhaustive swimming and platform running exhibited higher hs-CRP levels compared to the other intervention groups. These findings suggest that although high-intensity interval exercise shows positive effects in combating obesity and its associated inflammation, the possible elevation of hs-CRP levels also suggests that this type of training may have some kind of temporary or adaptive change effects on cardiovascular function, which requires further scientific studies to elucidate the underlying mechanisms and clinical implications [19].

The underlying mechanism of elevated hs-CRP levels in obese individuals lies in the excessive accumulation of adipose tissue in the body due to weight overload. This accumulation process is not only a manifestation of an imbalance in energy homeostasis, but also reveals the complexity of the endocrine function of adipocytes. They not only play the role of energy storage and release, but also secrete a series of inflammatory mediators such as IL-6 and TNF-α in large quantities as an active endocrine organ [20,21]. As body fat accumulation intensifies, these inflammatory signaling molecules are continuously released and accumulate, which in turn have a significant impact on the liver, stimulating its enhanced synthesis of ultrasensitive C-reactive protein (hs-CRP). Therefore, in obese conditions, hs-CRP levels tend to show persistently high levels due to this cascade of enhanced inflammatory responses [22,23]. High-intensity interval training (HIIT) triggers post-exercise excess oxygen consumption (EPOC), which causes the body to burn large amounts of fat during the recovery period [24]. This mode of training elevates the basal metabolic rate so that the metabolic state is maintained at a high level even after the end of exercise. In addition, HIIT stimulates an endocrine response that promotes muscle synthesis, improves body composition, increases resting energy expenditure, and accelerates lipolysis. Long-term effective HIIT training also helps to reduce chronic inflammation and decrease hepatic hypersensitivity C-reactive protein (hs-CRP) synthesis [25].

5 Conclusion

After eight weeks of high-intensity interval training, this form of exercise had a significant effect on improving a number of health indicators in the subjects. The results of the study showed that the girls not only lost weight and body fat percentage, but also reduced waist and hip circumference, which effectively reshaped their body shape, which is essential for weight control and body image optimization. In addition, the high-intensity interval training showed positive effects on lipid regulation, as the overweight girls had lower blood levels of TG, TC, and LDL-C, and higher levels of the healthful HDL-C, confirming that the training method improves lipid metabolism and reduces the risk of cardiovascular disease. At the start of the study, these overweight girls had a mild inflammatory response in their bodies, with serum levels of IL-6 and hs-CRP higher than the normal range. However, after the eight-week high-intensity interval training intervention, there was a significant decrease in the levels of both of these key inflammatory markers, IL-6 and hs-CRP, demonstrating the effectiveness of training in reducing the inflammatory state in the body.

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