Kurdish Studies
Jan 2024
Volume: 12, No: 1, pp.4851-4858
ISSN: 2051-4883 (Print) | ISSN 2051-4891 (Online)
www.KurdishStudies.net

Received: October 2023 Accepted: December 2023
DOI: https://doi.org/10.58262/ks.v12i1.350

Mitigation of Overweight Problems in Children: A Study of the Combined Effects of High-Intensity Interval Training and Dietary Interventions

Xinghao Wang[1], Qiao Meng[2], Qian Wang[3], Taofeng Liu[*4]

Abstract

Objective:To study the combined effects of high-intensity interval training and dietary interventions in order to assess their effects on body mass index, cardiovascular function and endothelial cell function in overweight children. Methods: At our institution, we included 300 overweight children who were seen between June 2021 and July 2023. According to the randomized numerical allocation method, we divided them into a high-intensity interval training intervention group and a combined intervention group, with 150 cases in each group. The high-intensity interval training group includes 75 males and 75 females, while the combined treatment group also includes 75 males and 75 females. We will observe the performance of children in these two groups in terms of body mass index, cardiovascular function and endothelial cell function. Results: After evaluating the intervention, the combined intervention group presented a more superior performance in terms of CO and VDC indices, with values that significantly exceeded those of the group that received only high-intensity interval training. In contrast, HR and TCR levels were lower in this group than in the high-intensity interval training group, with statistically significant differences ($p < 0.05$). After the intervention, ET-1 and vWF levels were lower in the combined intervention group than in the high-intensity interval training only group. At the same time, FMD and NO levels in this group were nevertheless higher than those in the high-intensity interval training group, and there was a statistically significant difference ($P < 0.05$). After performing the intervention, the combined intervention group demonstrated superior results in terms of waist circumference and BMI, with statistically significant differences ($P < 0.05$). Meanwhile, the lipid indices of the combined intervention group were more favorable than those of the high-intensity interval training group after the intervention, with a statistically significant difference ($P < 0.05$). Conclusion: By combining high-intensity interval training and dietary intervention, we can promote fat consumption, enhance the antioxidant capacity of the body, and strengthen the cardiorespiratory function and other mechanisms in overweight children, which can effectively improve the body mass index, cardiovascular function, and endothelial cell function of children. The effect of this combined intervention is remarkable and has the potential to be worthwhile for clinical application.

Keywords: *high-intensity interval training, dietary intervention, overweight children*

Introduction

In recent years, children and adolescents have become the focus of attention of society, schools

[1] Department of Sport, Gdansk University of Physical Education and Sport, 80-336 Gdansk, Poland, Email:wangxinghao1988@163.com
[2] Email:mengqiao1996@163.com
[3] Pediatrics Department, Liaocheng people's Hospital, Liaocheng, Shandong, 252000, China
Email: laurel_827@163.com
[4] Physical Education Institute (Main Campus), Zhengzhou University, Zhengzhou, Henan, 450001, China.
*Corresponding author Email: liutaofeng1988@163.com

and families with the improvement of living standards, changes in dietary habits, and increased pressure to advance to higher education. However, studies have shown that many parents and teachers tend to focus more on their children's academic performance, while ignoring the negative effects that a long-term irrational diet may have on their physical health (Li, 2022) [1]. Childhood and adolescence is a critical time for individual learning and ability enhancement, while physical health forms the cornerstone of future learning and life. If children and adolescents develop long-term habits of high-fat, high-oil and low exercise, it may lead to slowed metabolism, elevated blood glucose and kidney damage, which in turn triggers uncontrolled blood pressure and induces hypertension. At the same time, long-term lack of exercise may also lead to increased waist circumference and weight, increasing the risk of obesity (Mu, 2022) [2].

High-intensity interval training (HIIT) is unusual in that it involves the performance of intense physical activity for a very short or moderate period of time, in conjunction with intervals of low-intensity activity or rest in order to obtain the benefits associated with intermittent exercise (Yu, 2023) [3]. Recently, there has been a growing tendency among researchers and experts to view high-intensity interval training (HIIT) as an intervention to address childhood obesity (Cao, 2023) [4]. In the meantime, dietary intervention is viewed as a strategy that aims to develop an appropriate dietary program for the child. The core objective of the program is to regulate the dietary intake of the children while ensuring that they receive an adequate supply of nutrients. In this way, dietary interventions can effectively improve children's health indicators and help them maintain good health (Liu, 2023; Yang, 2023; Wang, 2023) [5-7]. The aim of this study was to investigate the combined effects of high-intensity interval training (HIIT) and dietary modification on the dramatic changes in body mass index (BMI), cardiovascular function, and the function of endothelial cells in overweight children. We seek to provide overweight children with a highly effective method of weight loss through this integrated intervention to improve their overall health and enable them to grow up in a healthy and enjoyable environment.

1 Information and Methods

1.1 General Information

The present study was conducted on a total of 300 overweight children, 150 males and 150 females each, spanning the age range of 6 to 12 years in our hospital during the period from June 2021 to July 2023.The study was conducted on a total of 300 overweight children, 150 males and 150 females each, spanning the age range of 6 to 12 years in our hospital. The study used randomized numerical assignment to divide these children into two groups, i.e., high-intensity interval training intervention group and combined intervention group, each comprising 150 children. In the high intensity interval training intervention group, there were 75 male and 75 female children whose mean age was (9.51±1.92) years. In the combined treatment group, there were 75 male and 75 female children with a mean age of (9.490±1.95) years. Comparison between the two groups in terms of sex ratio and mean age showed that the difference between the two groups did not reach a statistically significant level ($p>0.05$), so they were similar in these aspects.

Inclusion Criteria:

Met the diagnostic criteria for childhood obesity in the survey of the prevalence of overweight and obesity among children and adolescents in China.

Not taking any weight loss drugs in the last three months.
No inborn metabolic abnormalities.
Body mass index (BMI) of 28 kg/m2 (Li, 2022) [8].
The children and their families were required to sign an informed consent form.
The study protocol needed to be approved by the hospital ethics committee.

Exclusion criteria:

Children with severe cardiovascular or endocrine diseases.
Children with regular exercise and taking weight loss medication within the last three months.
Children with psychiatric abnormalities.
Children with severe abnormalities in cardiac, pulmonary, hepatic, or renal function.

These criteria will be used to screen children for the purpose of the study to ensure the feasibility and accuracy of the study.

1.2 Treatment Method

In the high-intensity interval training intervention group, we implemented high-intensity interval training for a specific group of children. In this process, professional instructors first guided them to carry out adequate warm-up activities to effectively prevent sports injuries, such as muscle strains. High-intensity interval training is an effective training method to improve cardiopulmonary function and metabolic level. The specific content of high-intensity interval training is designed as follows: firstly, a 15-minute jogging session is initiated as warm-up and basic aerobic training to help the body gradually adapt to the exercise state. This was followed by a 6-minute 20-meter sprint run to work on explosive power and speed. A 30-second full-speed run is scheduled immediately afterward at 100% intensity of maximal aerobic speed, then switches to a recovery jog at 50% maximal aerobic speed as an interval. This high - low intensity cycle was repeated 10 times, with a 5-minute rest period provided at the end of each training set. The entire high-intensity interval training portion took less than 50 minutes in total. In the final phase, to ensure good recovery, children will participate in recovery jogging and stretching exercises to help the body gradually relax and return to normal (Yuan,2023) [9].

Dietary intervention was used in the combined treatment group on top of the high intensity interval training intervention group. To ensure the health of each child, the exact daily nutritional intake required was calculated based on their age, height and weight. This program was designed to meet the key nutrients needed for growth and development while controlling total energy intake. Specifically, protein accounts for 20% of total energy, fat for 25%, and carbohydrates for 55% of total energy. The entire joint intervention program will last for 9 weeks in order to comprehensively improve the rehabilitation of the target population through scientifically sound exercise and nutrition (Li,2023) [10].

1.3 Observation Indexes

The ZXG-G automatic cardiovascular function test diagnostic instrument was used for cardiac function testing. The process begins with the input of the child's height, waist circumference, and blood pressure data into the instrument, followed by a sensor that is secured to the pulse of the child's radial artery. Stabilized waveform data is captured and the healthcare provider is able to output cardiovascular function measures including heart rate (HR), cardiac output (CO), total circumferential resistance (TCR), and vasodilatation coefficient (VDC).

For both groups of fasting children, we withdrew 3 ml venous blood samples from them 9

weeks before and after the intervention. Blood was processed by centrifugation using a 5-cm centrifugal radius and 3000 r/min and refrigerated at -80°C. After 10 min, endothelin-1 (ET-1), vascular hemophilic factor (vWF), flow-mediated vasodilatation (FMD), nitric oxide (NO), and lipid levels were assayed. Concentrations of ET-1, vWF, FMD, NO, HDL-C, LDL-C, TC and TG were determined by enzyme-linked immunosorbent assay (ELISA). The procedure consisted of diluting these substances to an optimal concentration using inclusion buffer and incubation at 37°C for 4 h, followed by three washes with washing solution to remove unbound substances. Antigen-containing samples are added to form antigen-antibody complexes, which are then washed and specific antibodies are immobilized. Subsequently, enzyme-labeled specific antibodies are added to bind to the complex, reflecting the presence of specific antibodies by the amount of enzyme. After the addition of a substrate to develop the color, the indicators are quantified by the shade of color.

Measurement of waist circumference, waist to hip ratio and BMI involved measurement of the child's waist and hip circumference using a soft measuring tape and height was recorded. Weight was measured by a weight scale. Ultimately, the BMI was calculated by dividing the weight by the square of the height by the formula (BMI=Weight/Height^2).

1.4 Statistical Methods

Data analysis was executed using SPSS 20.0 software. In the assessment of variance, t-test for independent samples was applied to compare measures between groups, while changes in data before and after the intervention were compared by repeated measures data analysis. In repeated measures analysis of variance (ANOVA), results with p-values below 0.05 were considered statistically significant.

2 Results

2.1 Comparison of Cardiovascular Function Indexes

After the intervention, a number of physiological indicators in the two groups of children changed significantly. Specifically, compared with the pre-intervention period, the CO and VDC levels of the two groups increased significantly, while the heart rate (HR) and T-cell receptor (TCR) levels decreased significantly. The combined intervention group showed a more significant improvement in CO and VDC indices, with values significantly higher than those of the group that received only high-intensity interval training. On the contrary, the HR and TCR levels in this group were lower than those in the high-intensity interval training group, and these differences were statistically significant ($P < 0.05$), and the detailed data are shown in Table 1.

Table 1: Comparison of Cardiovascular Function Indexes between the Two Groups of Children before and after Intervention (±s, n=150).

Groups	HR(number /min)		CO[V/(L•min)		TCR(dyn•s•cm^5)		VDC index	
	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention
High Intensity Interval Training Set	88.59±2.02	75.70±1.44	5.68±1.49	6.99±1.57	1389.69±54.49	1152.03±14.21	1.26±0.41	2.29±0.55
Joint Intervention Group	88.64±1.44	72.44±5.22	5.71±1.55	8.20±2.32	1389.71±35.85	957.33±12.88	1.29±0.14	3.35±1.09
t	0.247	7.373	0.171	5.290	0.004	124.335	0.848	10.633
P	0.805	0.000	0.864	0.000	0.997	0.000	0.397	0.000

2.2 Comparison of Endothelial Cell Function Indexes

After the intervention, ET-1 and vWF levels generally decreased in both groups, while FMD and NO levels increased significantly compared to the pre-intervention levels. Further comparison of the different intervention modalities revealed that the combined intervention group showed a better decrease in ET-1 and vWF levels than the high-intensity interval training group only. Meanwhile, the FMD and NO levels in this combined intervention group were significantly higher than those in the high-intensity interval training group, and these differences were statistically significant ($P < 0.05$), as shown in Table 2.

Table 2: Comparison of Endothelial Cell Function Indexes before and after Intervention in two Groups of Children (□ ±s, n=150).

Groups	ET-1(ng/L)		vWF(%)		FMD(%)		NO(^mol/L)	
	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention
High Intensity Interval Training Set	90.29±4.11	72.13±5.64	185.27±19.66	146.97±14.49	10.24±1.23	14.57±2.36	45.67±8.54	51.64±9.99
Joint Intervention Group	90.33±2.13	65.91±4.34	185.31±18.23	120.62±8.77	10.30±2.77	16.99±4.42	45.72±7.22	60.97±2.42
t	0.106	10.705	0.018	19.054	0.242	5.915	0.055	11.117
P	0.916	0.000	0.985	0.000	0.809	0.000	0.956	0.000

2.3 Comparison of Waist Circumference, Waist to Hip Ratio and BMI

In terms of waist circumference and BMI, both groups of children showed significant negative changes after receiving the intervention, i.e., the pre-intervention levels were lower. Further studies revealed that the combined intervention group showed superior performance in terms of waist circumference and BMI index compared to the group that received only high-intensity interval training, and there was a statistically significant difference between the two ($P < 0.05$), as detailed in Table 3.

Table 3: Comparison of Waist Circumference, Waist-to-Hip Ratio and BMI between the Two Groups of Children Before and after Intervention (□ ±S, N=150).

Groups	Girth (cm)		Waist-to-hip ratio		BMI(kg/m²)	
	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention
High Intensity Interval Training Set	110.37±8.51	100.41±4.54	0.99±0.42	0.96±0.14	36.52±2.02	34.57±4.56
Joint Intervention Group	110.35±7.44	95.48±2.21	0.96±0.44	0.93±0.15	36.54±1.46	29.69±2.52
t	0.022	11.958	0.604	1.791	0.098	11.475
P	0.983	0.000	0.546	0.074	0.922	0.000

2.4 Comparison of Blood Lipid Indexes

After the intervention, the lipid indexes of both groups showed a decreasing trend and improved compared to the pre-intervention period. After the intervention, the lipid indexes of the group that performed the combined intervention were significantly lower than those of the group that performed only high-intensity interval training, and this difference was statistically significant ($P < 0.05$). For detailed data, please refer to Table 4.

Table 4: Comparison of Lipid Indexes between the Two Groups of Children before and after Intervention (□ ±s, mmol/L, n=150).

Groups	HDL		LDL		TC		TG	
	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention	pre-intervention	post-intervention
High Intensity Interval Training Set	2.32±0.16	2.01±0.45	3.55±1.02	2.77±0.45	5.64±1.20	4.61±1.29	2.95±0.23	2.81±0.34
Joint Intervention Group	2.30±0.44	1.35±0.68	3.61±1.24	1.69±0.56	5.66±1.68	3.58±1.06	2.96±0.55	1.26±0.35
t	0.523	9.913	0.458	18.412	0.119	7.555	0.205	38.904
P	0.601	0.000	0.648	0.000	0.906	0.000	0.837	0.000

3 Discussion

In the face of the growing problem of childhood overweight, experts point to multiple factors behind it, including genetic inheritance, psychological burden, and the negative effects of lifestyle, such as unbalanced diet and insufficient exercise. This combined problem not only increases the chances of chronic diseases such as hypertension and diabetes, but also poses a serious threat to children's overall health. Although the current understanding of the causes of obesity has yet to be deepened, overconsumption of food, lack of physical activity and irrational dietary patterns have been identified as major contributing factors. On this basis, the medical community tends to combat obesity by adjusting the dietary structure, especially by reducing carbohydrate intake (Yang,2023; Shu,2023; Wang,2023) [11-13]. Meanwhile, encouraging children to take the initiative to participate in physical activities at school is seen as a more comprehensive and effective solution, which can not only help them lose weight but also maintain healthy body metrics. Past reliance on dieting to lose weight has been found to have possible negative effects on normal growth and development of children, including causing anemia (Lien, 2024) [14]. Therefore, a comprehensive intervention that combines goal-oriented exercise with strict dietary management is now more recommended. This approach is not only effective in promoting energy expenditure and fat burning, but also helps to prevent and control a variety of chronic diseases such as hyperglycemia and hypertension, providing a healthier environment for children to grow.

After the intervention, after high-intensity interval training and combined comprehensive intervention, some key indicators such as heart rate (HR), total cholesterol (TCR), endothelin-1 (ET-1), plasma von Willebrand factor (vWF), waist circumference, waist-hip ratio, body mass index (BMI), high-density lipoprotein cholesterol (HD), low-density lipoprotein cholesterol (LDL), total cholesterol (TC), etc. showed a significant downward trend.

Higher-intensity interval training involves an interval exercise pattern dominated by lower intensity and rest. High-intensity interval training (HIIT) has long been used primarily to train high-level athletes, but has been relatively little utilized in general fitness and sick populations. Research findings have shown that HIIT is safe and effective for the general population and even for individuals with chronic metabolic diseases (Jiang, 2023) [15]. In a study by Guo et al. (2023) [16], 20 patients with coronary artery disease participated in two sets of power cycling exercise, each set of 15 seconds at 100% power with a 15-second interval for a total of 20 repetitions. However, serum cardiac troponin T levels did not change significantly at 20 minutes and 24 hours after exercise compared to pre-exercise. In a study by Ji et al. (2023) [17], eight men were subjected to HIIT and moderate-intensity continuous exercise with equivalent energy consumption. The results indicated

that the subjects were more inclined to receive HIIT, possibly due to the relatively shorter duration of HIIT exercise and the avoidance of intervals leading to uncomfortable symptoms. It was found that by implementing a dietary modification approach, the appetite response could be significantly slowed down and the frequency of consuming high-calorie foods reduced. This process not only provides additional key nutrients such as ferrous succinate and calcium carbonate to meet the mineral and vitamin requirements of human growth and development, but also helps to convert excess fat into glucose, which is ultimately oxidized and broken down to provide energy for the body (cited in: Li, 2022) [18]. At the same time, the intake of water and CO2 can accelerate the process of body fat catabolism and metabolism, producing a very different effect. By performing high-intensity interval training, not only can you boost your basal metabolic rate, but you can also promote the depletion of body fat and skeletal muscle content, improve lipid metabolism, and stimulate metabolic responses in a short period of time. This type of training effectively eliminates fat from areas that are difficult to lose fat, such as the waist and abdomen, significantly enhances muscle oxidization and accelerates energy expenditure. At the same time, it also prevents exercise-induced decreases in blood glucose concentration and effectively improves the abnormal elevation of various body indicators (Yu,2023) [19]. It was found that after the combined intervention, the combined intervention group performed better in CO and VDC indicators, with values significantly higher than those of the group that only performed high-intensity interval training. In contrast, HR and TCR levels were lower in this group than in the high-intensity interval training group, and this difference was statistically significant ($p < 0.05$). The group that received high-intensity interval training had higher post-intervention levels of ET-1 and vWF compared to the combined intervention group. In contrast, FMD and NO levels were significantly higher in the combined intervention group than in the high-intensity interval training group, and this difference was statistically significant ($P < 0.05$). In addition, the combined intervention group also performed better in terms of waist circumference and BMI, and the difference was statistically significant ($P < 0.05$). Finally, with regard to lipid indices, the levels in the combined intervention group were lower than those in the group that received only high-intensity interval training, and this difference was also statistically significant ($P < 0.05$).

4 Conclusion

Overall, the high-intensity interval training combined with dietary intervention method has positive effects on overweight children. Through the mechanisms of promoting fat consumption, enhancing the body's antioxidant capacity, and improving cardiorespiratory function, the method effectively improved children's body mass index, cardiovascular function, and endothelial cell function.

References

[1] Li Haowen, Li Jianjun, Li Guixian. (2020). Analysis of the effects of combined intervention of exercise, diet, and health education on overweight and obesity in preschool children. World Complex Medicine (06), 80-82.

[2] Mu Suxia, Dang Xiaoli, Yang Chengli. (2022).24 w Effect of aerobic exercise combined with modified low-carbon diet intervention on body composition and endothelial cell function in overweight/obese children. Chinese Health Engineering (03), 377-380.

[3] Yu Wenlan. (2023). Exercise combined with dietary intervention up-regulates miR-374a-5p and down-regulates inflammatory factors to improve bone quality in male obese adolescents Master's thesis, Wuhan Institute of Physical Education.

[4] Cao Ridge, Yu Fengyuan, Gao Rongman, et al. (2023). Effects of high-intensity interval training exercise on the physical health of obese elementary school students. Chinese School Health (12), 1863-1866.
[5] Liu Hongmei, Li Jingjing, Gao Tingting. (2023). Analysis of the intervention effect of diet and nutrition combined with exercise therapy on childhood obesity. Systematic Medicine (14),155-158.
[6] Yang Ningyu. (2023). Evaluation of the effect of comprehensive dietary intervention with exercise guidance for type I diabetes mellitus in children. Heilongjiang Medical Science (03),188-190.
[7] Wang Yue. (2023). The effect of physical activity combined with dietary intervention on weight loss in adult obese patients, Master's thesis, Capital Institute of Physical Education.
[8] Li Zidong. (2022). Role of FGF23-αKlotho-FGFR1 Axis in the Improvement of Bone Metabolism in Obese Male Adolescents by Exercise Combined with Dietary Intervention Master's Thesis, Wuhan Institute of Physical Education.
[9] Yuan Jiuchen, Zhang Yao. (2023). Meta-analysis of the effect of high-intensity interval exercise on weight loss in secondary school students compared with regular physical education program. Sports World (11), 153-155+159.
[10] Li Ly, Cao Ridge, Zou Yu, et al. (2023). Effects of high-intensity interval training on visceral fat and cardiorespiratory fitness in obese children. Journal of Physical Education (04), 138-144.
[11] Yang Xiangchun, Wang Fei, Li Haibo. (2023). Metabolic changes of serum biochemical indexes in obese children. China Modern Physician (36),63-67.
[12] Shu Fuping. (2023). Association between childhood obesity and obstructive sleep apnea based on age stratification. Journal of Hubei Institute of Science and Technology (Medical Edition) (06),506-509.
[13] Wang Yuehong, Lv Huiling, Shao Shenfo, et al. (2023). Quantile regression analysis of the association between blood pressure and obesity in children and adolescents. Jiangsu Preventive Medicine (06), 687-691.
[14] Lian Xuegang, Gao Lanping. (2024). Correlation between dietary habits and precocious puberty in obese children. Clinical Research (01),190-192.
[15] Jiang, Kaiyuan, Cui Di, Li Xiaodong. (2023). Effects of high-intensity interval training method on body composition and blood pressure in male college students. Sports Horizons (23), 91-93.
[16] Guo Suxia, Yuan Weina, Liu Dan, et al. (2023). Research progress on exercise prescription for cardiac rehabilitation in patients with coronary artery disease--an example of high-intensity interval training. Health Research (06), 678-682.
[17] Ji Luning. (2023). Application of high-intensity interval training in physical training of junior short-track speed skaters. Ice and Snow Sports Innovation Research (21),178-180.
[18] Li Yan, Ren Chulan, Zhang Yang. (2022). Progress of lifestyle intervention in the treatment of obese polycystic ovary syndrome. Journal of Practical Chinese Medicine (01), 75-79.
[19] Yu Feng, Li Li, Ma Yila, et al. (2023). Effect of different cycles of low-carbohydrate dietary intervention on weight loss in overweight/obese people. Modern Medicine (10), 1378-1386.