Journal of Hainan Medical University

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Effect of exercise and dietary intervention on lipid metabolism, insulin sensitivity and microinflammatory state in obese children

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ARTICLE INFO

Article history:
Received 28 Jul 2017
Received in revised form 9 Aug 2017
Accepted 19 Aug 2017
Available online 28 Aug 2017

Keywords:
Obesity
Adipocytokines
Insulin sensitivity
Inflammatory response

ABSTRACT

Objective: To study the effect of exercise and dietary intervention on lipid metabolism, insulin sensitivity and microinflammatory state in obese children. **Methods:** A total of 156 children who were diagnosed with obesity in Zigong Third People′s Hospital between May 2014 and December 2016 were selected as research subjects and randomly divided into the intervention group who received exercise and dietary comprehensive intervention and the control group who received no special intervention. Before enrollment as well as 5 weeks and 10 weeks after enrollment, the serum contents of adipocytokines and inflammatory response indicators were detected, and the insulin sensitivity was assessed. **Results:** Serum Leptin, Chemerin, TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents as well as FBG and F-Ins levels of intervention group 5 weeks and 10 weeks after enrollment were significantly lower than those before enrollment while Adiponectin and Vaspin contents were significantly higher than those before enrollment; serum Leptin, Chemerin, Adiponectin, Vaspin, TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents as well as FBG and F-Ins levels of control group 5 weeks and 10 weeks after enrollment were not different from those before enrollment. **Conclusion:** Comprehensive exercise and dietary intervention can improve the lipid metabolism, insulin sensitivity and microinflammatory state in obese children.

1. Introduction

In recent years, with the improvement of living standard and the development of economic level, the incidence of overweight and obesity in China has been increasing, and the proportion of overweight and obese children and adolescents is larger[1,2]. Obesity and overweight in children and adolescents will continue into adulthood and increase the risk of chronic diseases such as cardiovascular disease, diabetes and other chronic diseases in adult stage[3]. Abnormally accumulated fat tissue in obese children can cause the abnormal secretion of a variety of adipocytokines and inflammatory cytokines, lead to the pathological state of insulin resistance and micro-inflammation, and then participate in the occurrence and the development process of diseases such as diabetes and atherosclerosis. Exercise and dietary intervention are the common means of intervention for obese and overweight people, they can effectively reduce weight, reduce fat area and improve blood lipid metabolism[4,5], but it is not yet clear about the changes in adipocyte inflammation and inflammatory cytokines. In the following studies, we specifically analyzed the effects of combined exercise and dietary intervention on lipid metabolism, insulin sensitivity and microinflammatory state in obese children.

2. Research subjects and methods

2.1 General information of research subjects

A total of 156 children who were diagnosed with obesity in Zigong Third People′s Hospital between May 2014 and December 2016 were selected as research subjects, all the children were with BMI > 28 kg/m^2, secondary obese children were ruled out, and the parents signed the informed consent. The 156 obese children were divided into two groups by random number table, each with 78 cases. The

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Fund Project: Zigong Major Science and Technology Planning Self-financed Project No: 2012Z23.

intervention group received comprehensive exercise and dietary intervention, including 44 men and 34 women that were 6-13 years old, and with BMI (32.15±4.69) kg/m^2; the control group received no special intervention, including 46 men and 32 women that were 6-12 years old, and with BMI (32.45±4.92) kg/m^2. There was no significant difference in general information between the two groups of obese children (P>0.05).

2.2 Comprehensive intervention methods

Dietary intervention method for intervention group was as follows: they received catering by the school restaurant during the school time and took food under the supervision of the head teacher and life teacher, breakfast was mainly milk and eggs, and the lunch and dinner are mainly one meat diet and three vegetable dishes and should avoid high-heat food; in the weekend, the food was prepared by the parents, which should avoid high-calorie food, and ensure the protein and vegetable intake. The exercise intervention method was as follows: the intensity of the exercise is appropriate when it reached 60%-70% of maximum heart rate, and the exercise was conducted 6 d a week, 1-2 times every day, and for 1.0-1.5 h each time. The intervention lasted for 10 weeks in a row.

2.3 Serum index detection

Before enrollment and 5 weeks and 10 weeks after enrollment, 5 mL of fasting peripheral venous blood was collected and centrifuged to separate serum, then the enzyme-linked immunosorbent assay kit to detect the contents of Leptin, Chemerin, Adiponectin, Vaspin, TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1, and the electrochemical luminescence kit was used for determining the contents of FBG and F-Ins.

2.4 Statistical methods

SPSS 19.0 software was used for t test of the data differences between two groups, and P<0.05 indicated statistical significance in differences.

3. Results

3.1 Serum lipid metabolism indexes

Before enrollment as well as 5 weeks and 10 weeks after enrollment, analysis of serum adipocytokines Leptin (μg/mL), Chemerin (pg/mL), Adiponectin (μg/mL) and Vaspin (μg/mL) between two groups of patients was as follows: serum Leptin, Chemerin, Adiponectin and Vaspin contents were not significantly different between two groups of patients before enrollment. Compared with same group before enrollment, serum Leptin and Chemerin contents of intervention group 5 weeks and 10 weeks after enrollment decreased significantly while Adiponectin and Vaspin contents increased significantly; serum Leptin, Chemerin, Adiponectin and Vaspin contents of control group 5 weeks and 10 weeks after enrollment were not significantly different.

3.2 Insulin sensitivity indexes

Before enrollment as well as 5 weeks and 10 weeks after enrollment, analysis of insulin sensitivity indexes FBG (mmol/L) and F-Ins (U/mL) between two groups of patients was as follows: serum FBG and F-Ins contents were not statistically different between two groups of patients before enrollment (P>0.05); compared with same group before enrollment, serum FBG and F-Ins levels of intervention group 5 weeks and 10 weeks after enrollment decreased significantly, and serum FBG and F-Ins levels of control group 5 weeks and 10 weeks after enrollment were not significantly different.

Table 1.

Changes in serum Leptin, Chemerin, Adiponectin and Vaspin contents before and after enrollment.

Groups	n	Time	Leptin	Chemerin	Adiponectin	Vaspin
Intervention group	78	Before enrollment	20.38±2.94	88.31±10.79	10.72±1.32	5.61±0.78
		5 weeks after enrollment	16.24±1.81^{a*}	72.37±8.38^{a*}	16.94±1.91^{a*}	7.85±0.89^{a*}
		10 weeks after enrollment	12.15±1.28^{ab}	61.92±8.47^{ab}	19.32±2.25^{ab}	8.52±1.02^{ab}
Control group	78	Before enrollment	20.14±2.58	88.22±9.37	10.54±1.23	5.54±0.72
		5 weeks after enrollment	20.52±2.49	88.91±9.84	10.71±1.38	5.60±0.79
		10 weeks after enrollment	20.33±2.72	87.41±8.39	10.82±1.29	5.68±0.71

*: indexes between intervention group and control group were significantly different; ^{a}: compared with indexes of same group before enrollment, there were significant differences; ^{b}: compared with indexes of same group 5 weeks after enrollment, there were significant differences.

Table 2.

Changes in serum FBG and F-Ins levels before and after enrollment.

Groups	n	Time	FBG	F-Ins
Intervention group	78	Before enrollment	7.71±0.89	13.25±1.85
		5 weeks after enrollment	6.42±0.74^{a*}	9.25±1.05^{a*}
		10 weeks after enrollment	6.11±0.62^{ab*}	7.32±0.88^{ab*}
Control group	78	Before enrollment	7.78±0.83	13.31±1.77
		5 weeks after enrollment	7.91±0.89	13.28±1.58
		10 weeks after enrollment	7.82±0.84	13.38±1.60

*: indexes between intervention group and control group were significantly different; ^{a}: compared with indexes of same group before enrollment, there were significant differences; ^{b}: compared with indexes of same group 5 weeks after enrollment, there were significant differences.

Table 3.

Changes in serum TNF-α, IL-6 and hs-CRP contents before and after enrollment.

Groups	*n*	Time	TNF-α	IL-6	hs-CRP
Intervention group	78	Before enrollment	1.61±0.20	11.42±1.46	3.89±0.52
		5 weeks after enrollment	1.14±0.15[a*]	8.35±1.03[a*]	2.21±0.28[a*]
		10 weeks after enrollment	0.89±0.11[ab*]	6.93±0.88[ab*]	1.74±0.20[ab*]
Control group	78	Before enrollment	1.63±0.19	11.64±1.55	3.91±0.47
		5 weeks after enrollment	1.60±0.18	11.29±1.27	3.83±0.52
		10 weeks after enrollment	1.64±0.22	11.47±1.41	3.94±0.49

[*]: indexes between intervention group and control group were significantly different; [a]: compared with indexes of same group before enrollment, there were significant differences; [b]: compared with indexes of same group 5 weeks after enrollment, there were significant differences.

Table 4.

Changes in serum MCP-1, VCAM-1 and ICAM-1 contents before and after enrollment (pg/mL).

Groups	*n*	Time	MPC-1	ICAM-1	VCAM-1
Intervention group	78	Before enrollment	236.26±36.12	103.52±12.36	92.10±11.28
		5 weeks after enrollment	172.56±20.35[ab*]	70.75±9.35[ab*]	78.21±9.25[ab*]
		10 weeks after enrollment	125.21±15.67[ab*]	54.68±7.84[ab*]	49.32±5.58[ab*]
Control group	78	Before enrollment	234.65±32.58	101.98±13.28	93.41±10.25
		5 weeks after enrollment	237.02±34.12	102.59±11.38	92.49±9.53
		10 weeks after enrollment	235.42±31.92	103.42±14.41	93.21±11.38

[*]: indexes between intervention group and control group were significantly different; [a]: compared with indexes of same group before enrollment, there were significant differences; [b]: compared with indexes of same group 5 weeks after enrollment, there were significant differences.

3.3 Serum inflammatory response indicators

Before enrollment as well as 5 weeks and 10 weeks after enrollment, analysis of serum inflammatory cytokines TNF-α (ng/mL), IL-6 (pg/mL) and hs-CRP (μg/mL) as well as chemotactic cytokines MCP-1, VCAM-1 and ICAM-1 between two groups of patients was as follows: serum TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents were not significantly different between two groups of patients before enrollment (P>0.05); compared with same group before enrollment, serum TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents of intervention group 5 weeks and 10 weeks after enrollment decreased significantly, and serum TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents of control group 5 weeks and 10 weeks after enrollment were not significantly different.

4. Discussion

Obesity is the metabolic disease characterized by abnormal adipose tissue deposition and lipid metabolism disorder, there are persistent insulin resistance and micro-inflammatory state in the patients, and they will increase the risk of cardiovascular disease, diabetes and other diseases[6,7]. Exercise and diet intervention are commonly used by obese people to regulate lipid metabolism, and promote triglycerides, cholesterol and other lipid metabolism through exercise and a reasonable diet. Adipose tissue has strong endocrine characteristics, which can synthesize and secrete a variety of adipocytokines and participate in the regulation of glucose lipid metabolism and insulin sensitivity. Leptin and Chemerin are adipocytokines with a damaging effect, which can antagonize the insulin-signaling pathway transduction and lead to insulin resistance[8]; Adiponectin and Vaspin are adipocytokines with protective effect, which can promote glucose uptake and utilization, and significantly increase insulin sensitivity[9,10]. In order to define the effect of exercise and dietary interventions on lipid metabolism in obese children, the changes in serum levels of above adipocytokines were analyzed in the study before and after enrollment, and the results showed that serum Leptin and Chemerin contents of intervention group decreased significantly while Adiponectin and Vaspin contents increased significantly after enrollment; serum adipocytokine contents of control group were not significantly different before and after treatment. This suggests that the comprehensive exercise and diet intervention can regulate the synthesis of adipocytokines, increase the secretion of protective adipocytokines, and inhibit the secretion of damaging adipocytokines.

The abnormal secretion of adipocytokines is an important pathological link of insulin resistance in obese people. Leptin can on the one hand, directly antagonize the transduction of insulin biological signal, and on the other hand, promote the decomposition of free fatty acids and affect the uptake and utilization of glucose by skeletal muscle[11]; Chemerin can antagonize the biological activity of insulin by CCRL2, CMKLR1 and other receptors[12]; Adiponectin and Vaspin inhibit the secretion of various insulin antagonists in the body, which in turn can increase insulin sensitivity and improve glucose lipid metabolism[13,14]. Insulin resistance caused by the disorder of adipocytokine secretion will further cause elevated blood glucose and compensatory hyperinsulinemia, which

is characterized by relatively deficient insulin secretion. In order to define the effect of exercise and dietary interventions on insulin sensitivity of obese children, the changes in insulin sensitivity indexes before and after enrollment were analyzed in the study, and the results showed that serum FBG and F-Ins levels of intervention group decrease significantly after enrollment, and serum FBG and F-Ins levels of control group were not significantly different before and after enrollment. This suggests that comprehensive exercise and diet interventions can improve insulin resistance and blood glucose metabolism, and correct relatively insufficient insulin secretion.

There is persistent micro inflammation state in patients with obesity, and a variety of inflammatory mediators are abnormally synthesized and secreted, which on the one hand, are associated with the abnormal release of cytokines in adipose tissue, and on the other hand, related to the decreased insulin sensitivity and insulin resistance. TNF-α, IL-6 and hs-CRP are proinflammatory cytokines, TNF-α changes in early stage of inflammation, and can mediate the cascade activation of inflammation, IL-6 is a cytokine with many biological activities and has a promoting effect on the secretion of a variety of inflammatory mediators, and hs-CRP is the acute phase protein which is synthesized from liver cells and is consistent with the process of inflammatory response[15]; MCP-1, VCAM-1 and ICAM-1 are cytokines with chemotaxis and adhesion effect, which can promote the adhesion and chemotaxis of monocytes to inflammatory sites, and thus mediate the amplification activation of inflammatory responses[16,17]. In order to further clarify the influence of exercise and dietary interventions in the inflammation degree in obese children, the changes in serum inflammatory cytokines and chemotactic cytokines were analyzed before and after enrollment, and the results showed that serum TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents of intervention group decreased significantly after enrollment, and serum TNF-α, IL-6, hs-CRP, MCP-1, VCAM-1 and ICAM-1 contents of control group after enrollment were not significantly different. This indicates that combined exercise and diet interventions can reduce the inflammatory response levels and reduce the secretion of inflammatory cytokines and chemotactic cytokines in obese children. Comprehensive exercise and dietary intervention for obese children can improve lipid metabolism, increase the secretion of protective adipocytokines and inhibit the secretion of damaging adipocytokines, and it can also improve insulin sensitivity and micro-inflammatory state.

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