Effect of high-intensity interval training on blood glucose control, adipocytokine secretion and oxidative stress response in patients with T2DM

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ABSTRACT

Objective: To investigate the effect of high-intensity interval training on blood glucose control, adipocytokine secretion and oxidative stress response in patients with T2DM. Methods: A total of 92 patients with newly diagnosed T2DM who were treated in this hospital between July 2016 and July 2017 were divided into the control group (n=46) and HIIT group (n=46) by random number table method. Control group received conventional hypoglycemic therapy, HIIT group received hypoglycemic combined with high-intensity interval training therapy, and the intervention lasted for 3 months. The differences in blood glucose control, adipocytokine secretion and oxidative stress response were compared between the two groups before and after intervention. Results: Before intervention, the differences in blood glucose index levels in peripheral blood as well as the contents of adipocytokines and oxidative stress indexes in serum were not statistically significant between the two groups of patients. After 3 months of intervention, blood glucose indexes FPG, FINS and 2hPBG levels in peripheral blood of HIIT group were lower than those of control group; adipocytokine APN content in serum was higher than that of control group whereas LEP, Resistin and CHEM contents were lower than those of control group; oxidative stress indexes MDA and ROS contents in serum were lower than those of control group whereas T-AOC content was higher than that of control group. Conclusion: Routine hypoglycemic therapy combined with high-intensity interval training can further control the blood glucose levels, regulate the secretion of adipocytokines and reduce the systemic oxidative stress response.

1. Introduction

Type 2 diabetes mellitus (T2DM) is the most common clinical endocrine disease. At present, the number of patients is large in China and the annual growth rate is high, which has become the most important disease endangering the health of middle-aged and elderly people[1,2]. The application of hypoglycemic drugs is a major means to control the newly diagnosed T2DM, but the poor lifestyle and other reasons lead to poor hypoglycemic effect of drugs alone in some patients, so some scholars suggest optimizing the patients’ lifestyle at the same time of drug treatment, and to change the exercise habit is the most important. High-intensity interval training is a way to enhance the athletes' aerobic endurance in the athletic field, which has been gradually used for the adjuvant treatment of chronic diseases, and helps to reduce the obesity extent and enhance the body's metabolic rate[3,4]. At present, there is not much research about the curative effect of high-intensity interval training in patients with T2DM, it was adopted as the auxiliary intervention means and added in the overall treatment of patients with newly diagnosed T2DM in this study, and the effectiveness of the intervention solution was explored from the blood glucose level, adipocytokine secretion and oxidative stress.
2. Information and methods

2.1 Case information

A total of 92 patients with newly diagnosed T2DM who were treated in this hospital between July 2016 and July 2017 were chosen as the research subjects and divided into the control group (n=46) and HIIT group (n=46) by random number table method. There were 25 males and 21 females in the control group, and they were 45-77 years old; there were 25 males and 21 females in the HIIT group, and they were 46-79 years old. There was no significant difference in gender and age distribution between the two groups of patients with newly diagnosed T2DM (P>0.05), and the members of the hospital ethics committee approved the study.

2.2 Inclusion criteria

(1) In accordance with the diagnostic criteria for T2DM; (2) receiving no relevant treatment before; (3) those who or whose family members signed the informed consent.

2.3 Exclusion criteria

(1) Combined with hyperthyroidism, hypothyroidism, pheochromocytoma and other endocrine system disorders; (2) with paralysis or limb dysfunction, and unable to conduct exercise training; (3) with cognitive dysfunction or dysgnosia, and unable to conduct basic communication; (4) combined with lower limb ulcer and other severe diabetic complications.

2.4 Intervention

Control group of patients received clinical routine drug intervention, the drug was metformin and the specific dosage was adjusted according to the individual condition. Based on conventional drug intervention, high-intensity interval training group received the high-intensity interval training, specifically as follows: one adaptive training (moderate intensity) was done 1d before the training started, and the normal intensity exercise intervention began from the next day. Patients conducted warm-up on the cycle ergometer and wore a heart rate monitor, the heart rate was controlled at 0%-50% of maximum heart rate, high intensity training started after 5 min and lasted for 1 min, the heart rate was maintained at 70%-90% of maximum heart rate, then they rested for 1 min, and the above cycle was repeated. The above training was repeated for 4 times in the first week, 8 times in the second week, 10 times in the third week, and then 10 times a week for 3 weeks.

2.5 Observation indexes

Before intervention and after 3 months of intervention, morning fasting blood and 2 h postprandial blood on the same day were collected from the two groups of patients to determine the fasting plasma glucose (FPG), fasting insulin (FINS) and 2 h postprandial blood glucose (2hPBG) levels. The fasting peripheral blood serum was obtained at the same point in time, radioimmunoassay was used to detect the serum contents of adipocytokines adipocytokinin (APN), leptin (LEP), Resistin and chemerin (CHEM), and enzyme-linked immunosorbent assay was used to determine the serum contents of oxidative stress indexes malondialdehyde (MDA), reactive oxygen species (ROS) and total antioxidant capacity (T-AOC).

2.6 Statistical methods

Blood glucose indexes, adipocytokines and oxidative stress indexes were input in statistical software SPSS 24.0 as measurement data, the statistic P was calculated (P<0.05 was set as the standard of statistical significance in the differences).

3. Results

3.1 Blood glucose indexes

Comparison of FPG (mmol/L), FINS (pmol/L) and 2hPBG (mmol/L) levels in peripheral blood between two groups of patients before and after intervention was as follows: before intervention, the differences in FPG, FINS and 2hPBG levels in peripheral blood were not statistically significant between the two groups of patients (P>0.05). After 3 months of intervention, FPG, FINS and 2hPBG levels in peripheral blood of both groups were lower than those before intervention; FPG, FINS and 2hPBG levels in peripheral blood of HIIT group were lower than those of control group (P<0.05), shown in Table 1.

Table 1.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>FPG Before intervention</th>
<th>FPG After 3 months of intervention</th>
<th>FINS Before intervention</th>
<th>FINS After 3 months of intervention</th>
<th>2hPBG Before intervention</th>
<th>2hPBG After 3 months of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>46</td>
<td>9.38±0.97</td>
<td>6.59±0.75</td>
<td>92.17±10.48</td>
<td>74.38±8.12</td>
<td>13.47±1.94</td>
<td>11.38±1.62</td>
</tr>
<tr>
<td>HIIT group</td>
<td>46</td>
<td>9.32±0.95</td>
<td>5.84±0.62</td>
<td>92.35±10.29</td>
<td>62.59±7.07</td>
<td>13.29±1.86</td>
<td>9.14±0.93</td>
</tr>
<tr>
<td>t</td>
<td></td>
<td>0.193</td>
<td>7.283</td>
<td>0.251</td>
<td>9.583</td>
<td>0.164</td>
<td>8.746</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>&gt;0.05</td>
<td>&lt;0.05</td>
<td>&gt;0.05</td>
<td>&lt;0.05</td>
<td>&gt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Note: compared with same group before intervention, *P<0.05.
3.2 Adipocytokines

Comparison of adipocytokines APN, LEP, Resistin and CHEM contents in serum between two groups of patients before and after intervention was as follows: before intervention, the differences in APN, LEP, Resistin and CHEM contents in serum were not statistically significant between the two groups of patients (P > 0.05). After 3 months of intervention, APN contents in serum of both groups were higher than those before intervention whereas LEP, Resistin and CHEM contents were lower than those before intervention; APN content in serum of HIIT group was higher than that of control group whereas LEP, Resistin and CHEM contents were lower than those of control group (P < 0.05), shown in Table 2.

3.3 Oxidative stress indexes

Comparison of oxidative stress indexes MDA (nmol/mL), ROS (μmol/L) and T-AOC (U/mL) contents in serum between two groups of patients before and after intervention was as follows: before intervention, the differences in MDA, ROS and T-AOC contents in serum were not statistically significant between the two groups of patients (P > 0.05). After 3 months of intervention, MDA and ROS contents in serum of both groups were lower than those before intervention whereas T-AOC contents were higher than those before intervention; MDA and ROS contents in serum of HIIT group were lower than those of control group whereas T-AOC content was higher than that of control group (P < 0.05), shown in Table 3.

4. Discussion

Patients with newly diagnosed T2DM mostly depend on drugs to rapidly control blood glucose levels, but the occurrence of T2DM is closely related to the improper diet, lack of exercise and so on, lifestyle intervention is regarded as the important means to help optimize the T2DM condition, and exercise intervention is a more popular way. High-intensity interval training is a common way in the athletic field to improve the endurance of the athletes, which is characterized by short exercise length and high-low intensity alternation, and can make the heart rate increase in a short time and burn more calories[5-7]. At present, the high-intensity interval training mode has been successfully used in the treatment of heart failure and obesity, but its application value for T2DM patients has not been further studied. In this study, high-intensity interval training was used for the adjuvant treatment of patients with newly diagnosed T2DM, and the effect of this intervention method on the patient’s condition was explored.

Abnormal increase in fasting and postprandial blood glucose is the primary indicator for clinical diagnosis of T2DM and also a reliable measure of the disease severity. There is obvious insulin resistance in T2DM patients, and the level of insulin for them to achieve normal hypoglycemic function is higher, so they are mostly with high level of FINS[8-10]. The results of this study showed that the levels of FPG, FINS and 2hPBG in both groups reduced after different therapies, indicating the hypoglycemic effectiveness of both therapies; the decrease in FPG, FINS and 2hPBG levels was more significant in HIIT group after treatment, indicating that adjuvant high-intensity interval training therapy could further optimize the levels of blood glucose control in T2DM patients.

There are many factors causing insulin resistance in T2DM patients,
and many studies have confirmed that the abnormal secretion of adipocytokines is involved in it. APN is a polypeptide hormone secreted by adipose tissue, and it is abnormally lowly expressed in serum of T2DM patients, which is speculated to be an important factor in the occurrence and development of T2DM[11,12]. LEP is a polypeptide hormone encoded by the obese gene, it is secreted by adipocytes and then released into blood, and recent studies have shown that it is closely related to glycolipid metabolism and obesity. Animal experimental studies have found that the decreased LEP secretion caused by LEP gene mutation can lead to insulin resistance[13,14]. Resistin is regarded as the important bridge between obesity and insulin resistance, it is secreted by fat cells, then acts on the liver cells and reduces their sensitivity to insulin, and both domestic and foreign studies have shown that there is high expression of Resistin in the serum of severely obese patients[15,16]. CHEM can regulate adipocyte differentiation and metabolism, decrease insulin sensitivity and lead to insulin resistance, and the theory has been demonstrated in animal models[17,18]. The study results showed that APN contents in serum of both groups increased whereas LEP, Resistin and CHEM contents decreased after treatment, and the change in above indexes of HIIT group was bigger after treatment, it shows that adjuvant high-intensity interval training therapy can be more effective to adjust the secretion of adipocytokines, and this is the internal cause of relieved insulin resistance and optimized blood glucose control in the patients.

Oxidative stress reaction is an important cause of T2DM, and the specific mechanisms may be as follows: (1) long-term high blood glucose may cause excessive expression of ROS in the body, which can directly damage islet β cells and promote β cell apoptosis; (2) ROS can induce the increase of uncoupling protein 2 expression and decrease the insulin secretion stimulated by glucose to cause islet β cell damage; (3) oxidative stress reduces the sensitivity of peripheral tissue to insulin[19-21]. Under persistent hyperglycemic state in patients with T2DM, the ROS and oxide metabolite MDA are continuously released and increase the systemic oxidative stress response, and they interact with each other to further cause islet β cell damage and aggravate the T2DM. T-AOC can reflect the antioxidant capacity of the body, and its level is negatively correlated with the severity of T2DM[22,23]. The study results showed that serum ROS and MDA contents of both groups decreased whereas T-AOC contents increased after treatment, and the adjuvant high-intensity interval training therapy is better in inhibiting the degree of oxidative stress in patients with T2DM.

To sum up, hypoglycemic drugs combined with high-intensity interval training intervention can more effectively control the blood glucose levels, balance the adipocytokine secretion and suppress the oxidative stress reaction in patients with newly diagnosed T2DM, it is an efficient and feasible way of intervention, and it is worthy of popularization and application in clinical practice in the future.

References


