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Research Progress on Lifestyle Intervention for Type 2 Diabetes

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Abstract: ***The prevalence of type 2 diabetes (T2DM) is continuously increasing worldwide and domestically. Most patients are newly diagnosed cases. This disease can induce multiple systemic complications. Lifestyle intervention is a primary intervention method recommended in the 2024 edition of the diabetes prevention and treatment guidelines. For patients with prediabetes, a 6-month lifestyle intervention should be implemented first, and if the effect is not satisfactory, drug treatment should be initiated. The onset of T2DM is influenced by uncontrollable factors such as genetics and age, as well as controllable risk factors such as obesity, diet, exercise, sleep, and psychology. Various lifestyle interventions can effectively improve metabolic indicators such as glycosylated hemoglobin, blood pressure, blood lipids, and body weight, reduce insulin resistance, decrease the use of hypoglycemic drugs, and delay complications. However, there are common problems such as poor intervention compliance and the loss of efficacy after interruption. Improving long-term adherence is the core clinical challenge. In the aspect of exercise intervention, both aerobic and resistance exercises can improve glycolipid metabolism. The combined training of the two has a better effect on improving pancreatic β-cell function, cardiopulmonary function, and cognitive function. Abdominal obesity and small thigh circumference groups benefit more from exercise. Morning fasting exercise is more beneficial than post-meal exercise in reducing glycosylated hemoglobin and visceral fat. Dietary intervention is the core of controlling blood sugar. Balanced diets such as those based on whole grains, fresh fruits, and soy products, plant-based diets, Mediterranean diets, and low-carbohydrate diets can all reduce the risk of disease and improve metabolic indicators. However, the Mediterranean diet has insufficient long-term adherence in the elderly population. Clinically, it is necessary to formulate easy-to-persist dietary plans based on patients' preferences. In terms of sleep, 7-8 hours of daily sleep is the optimal duration. Insomnia, abnormal sleep duration, and obstructive sleep apnea all increase the risk of T2DM. Fish oil n-3 polyunsaturated fatty acids can regulate the circadian rhythm and improve sleep. Melatonin should be used with caution as it can reduce insulin sensitivity. Continuous airway positive pressure ventilation can assist in improving blood sugar and kidney indicators in patients with sleep apnea and coexisting sleep disorders. Psychologically, depression and anxiety are genetically associated with T2DM. Community comprehensive care and cognitive behavioral therapy can alleviate negative emotions and improve the compliance of blood sugar self-management. In summary, multi-dimensional lifestyle interventions in exercise, diet, sleep, and psychology have significant value in the prevention and treatment of T2DM. Future research should focus on individualized intervention plans to address the practical problem of insufficient long-term adherence of patients.***

Keywords: Type 2 diabetes, Lifestyle intervention, Summary.

1. Introduction

Type 2 diabetes (T2DM) is a common endocrine and metabolic disorder that can cause microvascular, macrovascular lesions and complications in multiple systems such as the nervous system. It has received widespread attention recently. According to statistics, the prevalence of DM among global adults was 11.11% in 2024, equivalent to 589 million people [1]. In China, the prevalence of DM increased from 10.9% in 2013 to 12.4% in 2018-2019. Compared with the survey results from 2018 to 2019 and 2013, the majority of newly diagnosed DM patients still accounted for about 63.3% [2]. DM is a disease that requires long-term life management. Currently, the third-level prevention recommended in the 2024 guidelines prioritizes controlling risk factors and preventing the occurrence of T2DM, followed by early detection, early diagnosis, and early treatment [3]. The guidelines suggest that lifestyle intervention should be attempted first in the pre-diabetic stage, and if the effect is not satisfactory after 6 months, drug intervention should be considered. In view of this, this article reviews the lifestyle interventions for T2DM in recent years, with the aim of providing reference for clinical practice.

2. The Clinical Significance of Lifestyle Intervention

The causes of T2DM can be classified into two major categories [4]: the first is inherent and uncontrollable factors, and the second are controllable risk factors acquired later. Genetic factors, age, ethnicity, low birth weight, and gestational diabetes are all uncontrollable factors. Controllable risk factors after birth include obesity, dietary patterns, physical exercise, sedentary lifestyle, abnormal blood lipids, environment, psychological and social factors, and educational level, etc.

According to the 2024 Chinese Diabetes Prevention and Treatment Guidelines, lifestyle intervention remains the primary intervention measure [3]. Weight loss can significantly delay the occurrence of complications. Lifestyle intervention measures are effective in achieving remission, weight loss, and improvement of quality of life for patients with T2DM [5]. A randomized controlled trial involving 169 patients with T2DM showed that a lifestyle intervention combining a whole-food, plant-based lifestyle with moderate-intensity exercise was compared with standard medical care. Participants in the lifestyle intervention group reduced the use of hypoglycemic drugs and lost weight, with a decrease in glycated hemoglobin [6]. Based on lifestyle management, blood sugar, blood pressure, and blood lipids can be effectively controlled, and there is a certain improvement in renal function [7].

Lifestyle intervention is a huge challenge for patients. The

dropout rate of a randomized controlled trial was as high as 35% [8]. Digital education intervention can reduce fasting blood glucose to some extent and improve treatment compliance [9], but the effect weakens after the cessation of lifestyle intervention, and the long-term benefits have not been significantly improved [10]. Therefore, improving the compliance and persistence of T2DM patients with lifestyle intervention is the focus in clinical practice.

3. Exercise Intervention

Obesity is a crucial factor driving the occurrence and development of T2DM. It causes dysfunction of adipose tissue, triggers inflammatory responses, leads to ectopic lipid accumulation, and ultimately results in insulin resistance, thereby inducing T2DM [11]. Therefore, weight loss is the primary choice for obese patients with T2DM. There are various forms of exercise, including resistance training, aerobic exercise, and intermittent hypoxic exercise.

Studies have shown that both resistance training and aerobic exercise are effective in improving the metabolic levels of T2DM patients. When these two types of exercise are used alone, although there is no significant difference in HbA1c between the groups, the HbA1c, HOMA-IR, SBP, DBP, HDL, TG, and TC levels in both groups are reduced [12]. Compared with single exercise, the combination of aerobic and resistance training is more beneficial for improving β-cell function and controlling blood sugar [13]. At the same time, research has shown that combined aerobic, resistance, and balanced exercise not only improves metabolic-related indicators but also improves cardiopulmonary function, dynamic balance, and some cognitive functions [14].

There are certain differences in physical fitness among exercise interventions, which are related to fat distribution. Liu Dan et al. conducted a study involving 50 T2DM patients. Under the condition of receiving dietary management, they were randomly divided into the exercise group and the control group. The control group maintained a sedentary lifestyle for 2 weeks, while the exercise group maintained a sedentary lifestyle for 1 week and then received three sessions of aerobic and resistance training per week. The data after the intervention indicated that the blood glucose fluctuation stability of the exercise group was better than that of the control group. After in-depth analysis, it was found that patients with a higher degree of abdominal obesity and a smaller thigh circumference showed more significant improvement in blood glucose fluctuation after exercise intervention. Thus, visceral fat and muscle distribution are independent and significantly influencing factors that affect the changes in blood glucose variability indicators [15].

The timing of exercise is also a factor affecting T2DM. Rees et al. conducted an exercise time intervention on 16 T2DM patients for 16 weeks. The results showed that compared with the morning walking group before breakfast (FAST) and the post-meal exercise group (FED), the intervention in the FAST group significantly reduced HbA1c, and the reduction in visceral fat tissue was greater. This mode also reduced muscle volume and intramuscular fat content. Morning walking before overnight fasting and breakfast was meaningful for the consumption of ectopic fat [16].

4. Dietary Intervention

Dietary intervention is the core method for controlling blood sugar in patients with T2DM. According to the results of the epidemiological survey conducted by Yanbin Ye et al. in the South China region, the local dietary structure is significantly associated with the risk of T2DM. After further research, it was found that regardless of whether confounding factors were corrected, a high-fruit dietary pattern can reduce the risk of T2DM in the local population. Nutritional mechanism studies have shown that a balanced dietary structure that includes whole grains and carbohydrates, various fresh fruits, dairy products, fresh bean products, and legumes can effectively reduce the risk of T2DM [17]. Similarly, Xiu Yang et al. conducted a survey on the diet in Henan region and confirmed that the higher the score of the plant-based diet, the lower the risk of T2DM. The Mediterranean diet (MD) has similarities to this dietary structure. A large number of existing studies have confirmed that it can comprehensively improve the body's metabolic state [18]. A high-quality systematic review indicates that MD can lower fasting blood glucose, body mass index (BMI), low-density lipoprotein cholesterol, and blood pressure, and the reduction of these metabolic indicators has high clinical reference value [19]. Derrick et al. also conducted MD combined with exercise intervention on 22 obese or overweight patients with T2DM. After the intervention, the fasting blood glucose, glycosylated hemoglobin, and BMI of the subjects improved. However, this dietary structure has obvious compliance deficiencies [20]. Elena Massimino et al. conducted a cross-sectional dietary compliance survey of 138 elderly T2DM patients over the age of 65. Only 53% of the subjects could adhere to the MD for a long time at a high level, suggesting that the implementation and promotion of this dietary plan in elderly diabetic populations face practical obstacles [21].

Low-carbohydrate diet (LCD) is also an option. A study conducted on 100 patients with obesity or overweight and T2DM showed that LCD can better improve BMI, blood pressure, waist circumference, blood glucose levels, lipid profile, cardiovascular risk, kidney markers, and overall metabolic indicators compared to MD. This study has been recognized in several international guidelines [22].

Diet plays a crucial role in patients with T2DM, and improving patient compliance is the core of subsequent related research that should be focused on. When choosing dietary intervention, it is necessary to select a diet plan that is highly compatible with the patient's own wishes and can be followed for a long time.

5. Sleep Intervention

The risk of developing T2DM for patients with insomnia is 1.14 times that of those with normal sleep [23]. Studies from populations in North America and Asia have shown [24] that the duration of sleep is U-shapedly related to the risk of developing T2DM. A daily sleep duration of 7-8 hours is the optimal duration. Poor sleep quality, late bedtimes, and daytime naps exceeding 30 minutes are all potential risk factors for T2DM [25].

For T2DM patients with insufficient sleep, a 12-week digital

intervention was conducted [26]. The results indicated that the average sleep duration of the intervention group was extended by approximately 30 minutes, but it failed to significantly change the glycated hemoglobin level, suggesting that a small increase in sleep duration has limited effects on improving glucose metabolism levels. Melatonin is a common drug for improving sleep, but for T2DM patients, continuous oral administration of melatonin for 3 months can reduce insulin sensitivity by 12% [27]. Therefore, the clinical application requires strict control of the benefit-risk assessment of patients. A cohort study of 27,549 T2DM patients confirmed [28] that long-term supplementation of fish oil is significantly associated with improved sleep quality. Fish oil can upregulate the expression of core circadian clock genes Clock, Bmal1, and Per2. In vitro cell experiments showed that when hypothalamic neurons are destroyed by palmitic acid, the expression of core clock genes is inhibited, while DHA and EPA in fish oil can effectively restore this rhythm disorder. Mechanism studies revealed that n-3 polyunsaturated fatty acids can specifically bind to RORα protein, regulate the circadian rhythm oscillation of the body, promote the nuclear translocation of BMAL1 protein, and thereby stabilize the circadian rhythm system. In conclusion, marine-derived n-3 polyunsaturated fatty acids can improve the sleep state of T2DM patients by regulating the circadian rhythm pathway, and is a highly valuable dietary intervention method for abnormal sleep in diabetes.

Obstructive sleep apnea (OSA) is defined as recurrent partial (hypopnea) and complete (apnea) upper airway obstruction during sleep, which has been confirmed as one of the risk factors for type T2DM [29]. BMI plays a major mediating role in this process [30]. A controlled study involving 208 OSA patients and 208 healthy controls showed that the prevalence of T2DM and prediabetes in the OSA group was significantly higher than that in the general population. The prevalence of diabetes in the OSA group was 18.8%, while that in the control group was only 10.1%. The prevalence of prediabetes in the OSA group was 41.8%, significantly higher than 10.6% in the control group (all $P < 0.01$). Age, nocturnal hypoxemia, and daytime excessive sleepiness can effectively predict the risk of T2DM. BMI and apnea-hypopnea index are important predictive indicators for prediabetes. This suggests that the severity of OSA and obesity status are closely related to the progression of abnormal glucose metabolism [31]. For patients with OSA combined with T2DM, weight loss and lifestyle changes remain the primary options [32]. Continuous positive airway pressure ventilation (CPAP) can also be used as an auxiliary means. Some studies have suggested that the duration of using CPAP at night can improve HbA1c in patients with T2DM and OSA to varying degrees [33][34]. It can also reduce proteinuria and insulin resistance in patients with chronic kidney disease [35].

6. Psychological Intervention

Depression is a common mental disorder frequently occurring in the diabetic population. Foreign epidemiological studies have shown that compared with normal individuals, the prevalence of depression in patients with T1DM increases by 3 times, and the prevalence of depression in patients with T2DM increases by 2 times [36]. Baranova et al. conducted research and analysis on T2DM and depression through genetic correlation analysis, multi-gene overlap analysis, Mendelian randomization, cross-traits meta-analysis, and Bayesian co-location analysis. The results showed that T2DM was significantly positively genetically correlated with severe depressive disorder and depressive affect disorder [37].

The core of the treatment for anxiety and depression remains medication, and lifestyle intervention provides some assistance. The intervention in the Community-Based Integrated Care for Patients with Diabetes and Depression (CIC-PDD) in China is also a measure. In a randomized controlled trial involving 630 participants [38], the depression reduction rate in the intervention group was more obvious, and the self-management activities and medication compliance of T2DM patients improved. Online and offline intervention methods also benefited T2DM patients to some extent [39]. Cognitive Behavioral Therapy (CBT) is an evidence-based behavioral intervention. A systematic review on the treatment of T2DM with depression and anxiety indicated that CBT improved the depression, anxiety, and blood sugar conditions of T2DM patients [40]. Studies on the mechanism of CBT showed that physical activity during treatment, reducing the patient's BMI, led to the alleviation of depressive symptoms [41].

In conclusion, psychological intervention is an indispensable part of T2DM treatment.

7. Summary

All the existing lifestyle intervention methods such as exercise, diet, sleep, and psychology have been proven to effectively improve the metabolic-related indicators of T2DM. However, there is a common problem that patients often lack long-term compliance. The subsequent research should focus on the design of individualized intervention plans and the enhancement of the willingness to persist over the long term, with the aim of providing practical references for clinical prevention and treatment.

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