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Effect of Low Glycemic Index Diet on Type 2 Diabetes

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Abstract:

The rising incidence of type 2 diabetes (T2D) is seriously affecting the quality of life of individuals worldwide. Patients with T2D need to take medication to control blood sugar level for a lifetime, but the problem of poor medication compliance has always troubled clinical workers, and the role of diet improvement as a treatment of diabetes "five carriages" is particularly important. In recent years, the importance of food glycemic index (GI) has been extensively studied, and an increasing number of studies advise using low-GI foods as the main source of carbohydrates rather than high-GI foods. In addition to improving a person's quality of life on a daily basis, a low-GI diet can help prevent and treat type 2 diabetes and lower the risk of its consequences, through controlling the amount of blood sugar and blood lipids. However, there are still some limitations about low GI diet, for example the complex calculating process results in a small number of clinical uses. Through a review of the literature, analysis of experimental data, and expansion of the research on the benefits of a low-GI diet in reducing T2D problems, this report validates the use of a low-GI diet.

Keywords: Type 2 diabetes; low glycemic index diet; complications.

1. Introduction

In recent years, with economic development and technological convenience, factors such as unhealthy diets, irregular routines, and the prevalence of diabetes has been on the rise year on year due to genetics, primarily T2D, making it a predominant global public health issue. The main characteristics of T2D are insulin resistance and insulin deficiency, which fail to decompose blood glucose in time and effectively, leading to the increase of blood glucose in patients. Additionally, T2D may also lead to some complications, mainly cardiovascular diseases, kidney diseases, neuropathy, eye diseases and infectious diseases. The International Diabetes Federation (IDF) analyzed the data using analytic Hierarchy Process (AHP) to calculate the number of individuals having diabetes in the whole world from 2000 to 2021 and the anticipated number of diabetics during the next 25 years. In the past 20 years, the number of T2D patients in China has increased by 11.84 million and 3.85 million globally, and the incidence is expected to continue to increase in the next few years.

Many types of diet have been developed since ancient times. Whether it is the same origin of medicine and food in the past, the diet plan made by different constituents used in Ayurveda, Chinese medicine, or the Mediterranean diet that has been passed down to the present, and the modern low-GI(glycemic index) diet, which is known by most of individuals in the world, are widely used in conditioning the body. After high GI foods go into the gastrointestinal tract, digestion turns faster, absorption rate becomes high, and blood sugar response is quickly caused. Low GI foods stay in the digestive tract for a long time, the absorption rate is low, the glucose release is slow, and the blood sugar response caused by low peak is slow to decline. Eating low GI food is conducive to the regulation of blood sugar and the improvement of fat metabolism disorders in diabetic patients. Fortunately, some studies have shown that low GI food can control the glucose level in human body, therefore helping to control the incidence of diabetes [1,2]. This paper reviews the role of low GI dietary routines in diabetes and its complications, effectively provide a theoretical foundation for developing low GI food regiments in line with diabetes and further preventing the occurrence and development of diabetes.

2. Low GI Diet and Type 2 Diabetes

2.1 Improve Glucose Metabolism

A study from China selected 103 middle-aged and elderly T2D patients and divided them into an observation group (n=52) and a control group (n=51). The subjects in the observational cohort were provided with a treatment intervention plan comprising a low GI diet, whereas those in the control cohort were instructed to adhere to a normal diet. Each patient's diet plan was different, and the study's group members created individualized diet plans for the

patients based on their height, weight, and eating habits, and provided them with diet education once a week. Such treatment lasted for three months. The group conducted a study examining the association between a diet with a low GI and blood sugar levels. (fasting and two hours after meals) by measuring blood sugar and HbA1c levels using enzymatic chemistry and high-performance liquid chromatography, respectively, three months after the intervention and at the initial stage. The study results showed that the patients' fasting blood sugar decreased by about 2 mmol/L within three months, their postprandial blood sugar decreased by about 3 mmol/L compared to before, and their HbA1c content decreased by approximately 3%. The study demonstrates that a diet with a low GI is an effective strategy for managing T2D [3].

In an additional Canadian investigation, the impact of a low GI diet on the regulation of T2D was examined. For the study, 147 people with T2D, including men and non-pregnant women aged 35-75 years, had a high-density lipoprotein index (HDL) of 130% or greater and a BMI of 24-40. After a period of dietary records, they were put on a target diet by a dietitian (around 55% carbohydrates, 15% protein, and 30% fat). The participants were randomly allocated to one of three dietary groups for a 12-month period. The groups were as follows: a diet with a high glycaemic index (GI) and a high carbohydrate (CHO) content; a diet with a high GI and a high CHO content; and a diet with a low GI and a high CHO content. The study was also individually tailored to people's different needs. Dietitians recorded the patients' diets and performed OGTT tests every three months, recording changes in HbA1c (primary), blood sugar, lipids, and CPR (secondary) after eating different types of diets. The results of the study showed that people who consumed a high GI diet had a lower LDL index than those who ate a low GI diet, and those who ate a low cho diet had lower CPR than those who ate a high GI diet. In the end, it showed that although the patients' HbA1c rose from about 6.1% to about 6.3% over the course of a year, and there was no significant difference between the three diets, HbA1c tended to decline among those on the low-GI diet [4].

2.2 Improve Living Quality

A 15-week intervention trial was conducted in Naples, Italy; West Lafayette, Indiana, North Central USA; and Gothenburg, Sweden. The experimental design included a 3-week baseline testing period and a subsequent 12-week controlled diet intervention phase. A total of 160 middle-aged and older adults with diabetes or cardiovascular disease participated, 87 of whom were assigned to the low-GI diet group and another 73 to the high-GI diet group. The results revealed that the low GI diet group exhibited more pronounced improvements in physical functioning, role physical, physical composition, vitality, role emotion and social function, when compared with the high-GI diet group. These findings indicate that a low GI diet may have a beneficial effect on quality of life in middle-aged and older adults [5].

3. Low GI Diet and T2D Complications

As T2D prolonged poor glycaemic control may trigger several pathological changes in diabetic patients, especially vascular complications, which may affect both small (microvascular) and large vessels.

The principal microvascular complications associated with diabetes mellitus include diabetic retinopathy, diabetic nephropathy and diabetic neuropathy. Of these, diabetic retinopathy is a significant contributor to blindness in adults, diabetic nephropathy may result in end-stage renal disease, and diabetic neuropathy may lead to sensory abnormalities, pain, and an elevated risk of amputation. Macrovascular complications primarily affect the cardiovascular system and include coronary heart disease, cerebrovascular disease and peripheral arterial disease. These complications markedly elevate the risk of mortality and disability in patients with T2D [6]. There is less research on the direct effects of low GI diets on complications, but there is some research suggesting that low GI foods and a healthy diet may have a positive impact on T2D complications

3.1 Diabetic Retinopathy

As of 2020, more than 103 million people with diabetes have been affected by diabetic retinopathy globally,will rise to 160 million by 2045 [7]. This lesion is primarily caused by retinal microvascular damage induced by prolonged hyperglycaemia, resulting in increased vascular permeability, haemorrhage, oozing and possible neovascularisation of the retina.There are usually no obvious symptoms in the early stages of diabetic retinopathy., so many patients do not experience symptoms such as vision loss, blurred vision, or visual field defects until the disease has progressed to an advanced stage. If not addressed adequately,diabetic retinopathy has the potential to result in permanent vision impairment.

It is typically divided into two different stages: non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). NPDR is the early stage, and its main features include retinal microangiomas, haemorrhagic spots, and solid exudates; PDR is an advanced stage of the disease characterised by the development of retinal neovascularisation. These newly formed blood vessels are inherently fragile, making them prone to rupture and subsequent bleeding., and can lead to severe visual impairment [8].

Low GI foods such as fruits like apples, peaches, kiwi

fruit and nuts like cashews, moong dal and peanuts are not only rich in antioxidants but also in vitamins. According to existing studies, the potential role of vitamins and antioxidants, including vitamins C and E as well as carotenoids, in the pathogenesis of diabetic retinopathy (DR) is a topic of ongoing research. There is evidence to suggest that these compounds may inhibit the development of neovascularisation in the retina, the substance facilitates blood flow and acts as a protective barrier against free radicals.. A Japanese study of patients presenting with a diagnosis of type 2 diabetes revealed the following: consuming at least 173.0 grams of fruit per day reduced the incidence of retinopathy by 50 percent compared to consuming 53.2 grams or less per day[9,10].

3.2 Diabetic Nephropathy

Diabetic nephropathy (DN) is a common and severe microvascular complication observed in patients with diabetes, which plays a significant role in the development of end-stage renal disease (ESRD). This condition is mainly due to renal microangiopathy caused by chronic hyperglycaemia, which leads to impaired glomerular filtration [11]. Resveratrol is a polyphenol compound found in low GI foodstuffs such as grapes, which exhibits a range of biological activities. A recent study demonstrated that resveratrol reduced proteinuria and renal fibrosis in diabetic mice. The results of several animal models indicate that antioxidant stress treatment strategies may be effective in maintaining normal renal function while halting or delaying the progression of DN [12].

3.3 Diabetic Neuropathy

Diabetic neuropathy represents one of the most prevalent complications associated with diabetes. It primarily stems from injuries sustained by the autonomic and peripheral nervous systems. This lesion presents in a variety of forms, including small fiber-dominant neuropathy, distal symmetrical polyneuropathy (DSPN), and treatment-induced neuropathy, of which DSPN is the most common. This condition often affects the lower extremities, resulting in patients potentially experiencing abnormal sensations such as numbness, tingling, or burning pain, as well as loss of sensation, which increases the risk of infection and foot ulcers, further elevating the likelihood of limb loss. In most cases, DSPN is a progressively worsening condition that may begin early with no apparent symptoms, but may eventually progress to severe DSPN with a high mortality rate [13].

During the skin healing process, inflammation should have gradually stopped after the removal of harmful microorganisms. However, if the inflammatory response is excessive or prolonged, the healing process will be impeded. Therefore, taking steps to reduce the level of inflammation can be effective in accelerating wound healing. Common low GI foods such as blueberries and spinach contain high levels of anti-inflammatory substances such as anthocyanins, vitamin K, lutein and carotenoids, which are known to promote wound healing[14,15].

3.4 Cardiovascular System

Cardiovascular disease (CVD) represents the primary cause of mortality among individuals with diabetes. Individuals with diabetes exhibit a fourfold increased risk of stroke compared to those without the condition. Furthermore, the mortality rate following a myocardial infarction is twice as high in non-diabetic patients.

A study involving a total of 23 female and 22 male overweight participants was conducted. These subjects participated in a 12-week energy restriction trial, which yielded a mean body mass index (BMI) of 33.2 kg/m², an average age of 56.7 years, and a glycated hemoglobin (GHb) level of 6.7%. Initially, the subjects followed a high saturated fat (SFA) diet for four weeks, during which their daily energy intake was maintained at 1,540 kcal, with 17% of this energy derived from SFA. Following this period, participants were randomly assigned to either a high glycemic index (GI) diet (75 units) or a low GI diet (43 units) for the subsequent eight weeks, with a daily caloric intake of 1,440 kcal. In this phase, carbohydrates comprised 60% and SFA constituted 5% of their total energy intake. Throughout the study, measurements of body weight, lipid profiles, plasma glucose levels, and glycated hemoglobin were collected at four-week intervals. Additionally, an oral glucose tolerance test (OGTT) was conducted at baseline, week 4, and week 12. Based on the results from the baseline OGTT, participants were categorized into low, median, and high glucose tolerance groups. The findings of the study indicated a significant 7.5% reduction in triglyceride concentrations and a 13.2% decrease in LDL-C levels between weeks 4 and 12 [16].

A subsequent three-year investigation involved 169 patients diagnosed with type 2 diabetes who participated in a three-year dietary intervention, with 86 individuals adhering to a low GI diet. The findings revealed that the low-GI diet led to a significant reduction in C-reactive protein (CRP) levels; however, there was only a negligible change in vessel wall volume throughout the duration of the study.

4. Conclusion

Low-GI diets have demonstrated significant potential for the prevention and management of T2D, the benefits for glycemic stabilization and possible positive impact on the reduction of diabetic complications have attracted the attention of healthcare professionals and researchers. Nevertheless, several obstacles remain before low-GI diets can be widely adopted in clinical practice, such as the

complexity of the mechanism of action. These intricate physiological responses render the formulation of uniform clinical guidelines a challenging endeavor, necessitating that healthcare professionals possess a more profound comprehension and the capacity to customize treatment regimens.

The extent of research on low-GI foods varies across the globe. In some regions, the lack of funding, equipment, or expertise may impede the ability to conduct in-depth studies, which could result in the current publication of GI databases being incomplete. Additionally, the GI of foods may be subject to alteration as a result of external environmental influences, particularly those associated with processing methods. In addition, although there is a method to determine the GI value in food in China, the relevant laws and regulations of GI are still imperfect, the lack of unified and standardized food labeling, and the lack of scientific and standardized guidance for enterprises to produce low GI food

For patients, long-term adherence to a low-GI diet is challenging. In addition to modifying their eating habits, they must also adapt to a potentially more complex dietary preparation process, which is particularly difficult for modern people who live a fast-paced lifestyle and demand high levels of food taste and convenience. Furthermore, socio-economic factors may also influence patients to consistently choose healthy but more costly low-GI foods. In the future, it is more necessary to explore the high-quality evidence-based evidence of UN, so that people can further see its development potential.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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