The Role of Low-GI Diet in Reducing the Risk of Diabetes and Its Complications

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Abstract. Globally, the number of people with diabetes is increasing annually and the incidence is a trend toward younger populations. Therefore, people gradually realize the connection between excessive sugar intake and chronic diseases such as diabetes, which some people improve their eating habits and actively reduce sugar intake. Current research shows that a low glycemic index (GI) diet has significant potential in the management and prevention of diabetes and its complications. However, there is still insufficient research on the long-term effects of low-GI diets on different individuals and GI formulation mechanisms. This article analyzes the role of low-GI diets in reducing the risk of diabetes and its complications. The study shows that low-GI diets could effectively modulate gut microbiome, control blood glucose levels, improve insulin sensitivity, and contribute to weight management and reduce cardiovascular risk. This study provides a reference for how to improve and control diabetes with a low GI diet, but problems such as GI computerization have not been solved. Future research could further explore the continuous impact of low GI diet on the long-term dimension, and increase attention to the different responses of individuals to low GI diet, so as to optimize personalized diet intervention programs and better manage diabetes.

Keywords: Low-GI Diet; diabetes; insulin sensitivity.

1. Introduction

With the rapid economic development and the intense pressures of work and study, people's lifestyles have undergone significant changes. Many individuals turn to high-sugar foods as a way to alleviate stress, leading to a sharp increase in the consumption of these foods. This diet trend has made diabetes a major challenge for global public health.

Diabetes is a non-communicable chronic disease, which is characterized by abnormal metabolism of sugar in the body, reflecting an individual's glucose metabolic state in daily life. Globally, diabetes is one of the causes of mortality and other complications. According to research by Dr. Kanyin Liane Ong, there were 539 million people with diabetes globally in 2021, and the number of people with diabetes is also expected to increase year by year. The global age-standardized prevalence of diabetes was 6.1%, and the majority of people with diabetes are concentrated among the elderly [1]. In addition to its direct effects on blood glucose regulation, diabetes significantly increases the risk of developing serious complications such as cardiovascular disease (CVD), kidney failure, nerve damage, and vision problems. Therefore, it is crucial to take preventive measures and raise awareness to avoid the onset and progression of diabetes.

The glycemic index (GI) measures how a particular food containing carbohydrates affects blood sugar levels compared to a standard reference food, usually glucose or white bread. Initially developed to assist individuals with diabetes in making informed food choices, the recommendation was to opt for foods with a lower GI [2]. A low GI diet is dietary approach, which aims to reduce the consumption of foods that impact blood glucose levels. Low GI foods typically include naturally occurring and minimally processed carbohydrates, such as whole grains, vegetables, and fruits. These foods have a lower impact on post-meal blood glucose levels. This article aims to explore the role of a low-GI diet in reducing these risks and promoting better health outcomes [3].

2. Low GI diet & Diabetes

2.1. Definition and Measurement of GI

The concept of GI was initially introduced by Jenkins and and his colleagues in 1981 [4]. GI compares the effect of test foods with that of a reference food (usually glucose or white bread) on blood sugar levels. The calculation method is shown in formula (1).

$$GI = \left(\frac{IAUC_{test}}{IAUC_{reference}}\right) \times 100. \quad (1)$$

IAUCtest: Incremental Area under the Curve for test foods. It usually refers to the area formed by the increase in blood glucose levels relative to baseline during the following 2 hours after the subjects consume a test food containing 50 grams of available carbohydrates.

IAUCreference: Incremental Area under the Curve for reference foods. It usually refers to the area formed by the increase in blood glucose levels relative to baseline during the same period after the subjects consume a reference food (usually glucose or white bread) containing 50 grams of available carbohydrates.

In the conduct of GI testing, participants are required to fast overnight prior to the experiment to ensure they are in a fasting state, thereby eliminating potential confounding effects on the test result. The definition of GI has a wide range of applications, which is not only applicable to food, but also to whole meals or meals [4].

2.2. Types and Pathological Mechanism of Diabetes Mellitus

Diabetes mellitus has several types, but this article primarily focuses on the two main types: Type 1 diabetes (T1DM) and Type 2 diabetes (T2DM).

T1DM is an autoimmune disease characterized by the destruction of insulin secreting beta cells in the pancreas, leading to insufficient insulin secretion. It affects the uptake of glucose by tissues, thus causing hyperglycemia. Insulin deficiency also promotes fat decomposition and ketone body production, which may lead to a serious complication - diabetes ketoacidosis (DKA). [5]

The characteristics of T2DM are insulin resistance and relative insulin deficiency. In the early stages, insulin resistance stimulates beta cells to increase insulin secretion, but over time, this compensatory mechanism becomes ineffective, leading to hyperglycemia. Even worse, it could induce complications such as CVD, coronal art disease, peripheral art disease, etc. [5]

2.3. Diabetes Mellitus and Its Complications

Diabetes is a chronic metabolic disease characterized by elevated blood sugar levels, which will lead to a series of serious complications over time. For example, diabetes nephropathy, diabetes retinopathy and diabetes neuropathy, CVD.

3. Benefits of a Low-GI Diet in Diabetes Management

A low GI diet provides many benefits for people with diabetes, contributing to better overall health and disease management.

3.1. The Influence of Food GI on Gut Microbiome

The low-GI foods are rich in dietary fiber, which fiber acts as a prebiotic, being fermented and utilized by gut bacteria. Thereby fiber promotes the growth of beneficial bacteria and maintains a healthy gut microbiota. The gut microbiota is essential for human health and participates in multiple physiological processes within the body. According to a study by Sonnenburg and Sonnenburg, long-term deficiency of microbial accessible carbohydrates (MACs) could lead to a loss of diversity in the gut microbiota, resulting in adverse effects on body functions, such as increased risk of inflammation and weakened barrier function. [6]

In this experiment, specific human gut microbiota was transplanted into sterile mice without a natural gut microbiota. This process created a 'humanized' mouse model to simulate the human gut microbiota environment. The mice were divided into two groups: one group was fed a high-MAC diet, while the other group, serving as the control, was fed a low-MAC diet. Long term dietary intervention and regular collection of fecal samples, and analysis of gut microbiota composition and metabolic activity through methods such as 16S rRNA sequencing and short chain fatty acid (SCFAs) measurement. [6]

The conclusion from the experiment illustrates that a low MAC diet significantly reduces gut microbiota diversity. It could be inferred that a low GI diet enhances the intake of dietary fiber, which is a complex carbohydrate that could be fermented and utilized by gut bacteria. Therefore, low GI diet is beneficial for maintaining a healthy gut microbiota.

3.2. The Influence of Food GI on Blood Glucose & insulin sensitivity

According to research over the last decade, the conclusion shows that a low GI diet could have advantages in reducing the incidence of diabetes and improving blood sugar control. Bhupinder Kaur and her team conducted an experiment involving 13 healthy young male participants with an average age of 25.3 years (BMI 21.6 kg/m², fasting blood glucose 4.7 mmol/L). The participants wore a continuous glucose monitoring system (CGMS™) for 3 days and were tested in two phases, consuming biscuits with different GI values. The results showed that even within the low GI range, foods with different GI values have varying impacts on postprandial blood glucose responses. Specifically, within the low GI classification, the exact GI value still has a significant influence on blood glucose control [4].However, the sample size of 13 participants is relatively small, which may limit the generalizability of the findings. Future studies with larger sample sizes and more detailed measurements are needed to fully understand the nuances of how different low GI foods affect postprandial blood glucose levels.

According to the study by David and his team (2008), low GI diets could not only have an impact on controlling blood glucose levels of T2DM but also improve insulin sensitivity.

In this randomized controlled trial (RCT), patients with T2DM were randomly assigned to a low GI diet group, a high grain fiber diet group, or a conventional diet control group, and the intervention lasted for several months. The results show that the average HOMA-IR index of the low GI diet group decreased from baseline 3.5 to 2.8 and HbA1c levels in the low GI diet group decreased by 0.5%. These indicators illustrate that low GI diet significantly increased insulin sensitivity, reduced long-term blood glucose control indicators (such as HbA1c level), stabilized postprandial blood glucose level, and effectively managed T2DM. [7]

3.3. The Influence of Food GI on Maintaining Weight

A low GI diet could also be helpful for weight management. The more refined the food, the higher the GI value, but the satiety it provides is relatively lower. Low GI foods have a great sense of satiety and reduce food intake of people; simultaneously increasing fat oxidation to reduce carbohydrate usage. These two mechanisms reduce dependence on carbohydrates, thereby achieving the goal of weight control (Brand-Miller et al., 2002). [8]

In 2019, Zafar et, al. analysed 101 studies to test the hypothesis that low GI diets could reduce hunger by decreasing postprandial blood glucose fluctuations. This study identified relevant literature through a systematic review and quantitatively analyzed the data using meta-analysis. A stratified analysis and regression model evaluation were conducted to assess the effects of different control diet types, blood glucose control, initial BMI values, and dietary GI index. Low GI diets can lead to significant weight loss in the short term (typically within 6 months or less), with a weighted mean difference (WMD) of -0.64 kg (95% CI: -1.13 to -0.15). Low GI diets also have a similar effect in the long term, although the effects are less pronounced compared to the short term. Therefore, low GI diets could serve as an effective intervention for obesity, which not only prevents excessive weight gain but also reduces the risk of chronic diseases associated with obesity [9].

3.4. The Influence of Food GI on Complications of Diabetes

A diet rich in low-GI foods could improve the body's response to insulin [6]. It is significant for both T1DM and T2DM. At the same time, effective management of blood glucose levels may contribute to the mitigation of CVD complications, such as coronary artery disease and stroke, as well as gastrointestinal symptoms associated with diabetes. [6]

4. Potential Nutritional Challenges of a Low-GI Diet

Although a low GI diet is effective in lowering blood sugar, there are also some drawbacks that should be considered. In a low-GI diet, the focus is generally on carbohydrates with low GI values, without considering fats, proteins, and other nutrients. Therefore, some foods with low GI values may not be a good source of nutrition, such as margarine (GI of 0) and hot dogs (GI of 28). [10]

The GI value of food is influenced by many objective factors, which include variety, cooking method, and fruit maturity. The GI value of different varieties of pineapples also varies. Most studies have found that the GI value of pineapples is around 65, but one study showed that the GI value of Nigerian bananas is 95. A single variety of food is easily influenced by geography and couldn't be given the same GI value through a formula. It is also difficult to calculate the GI value of a mixed diet [9]. For example, the GI value of a vegetable salad composed of common low-GI vegetables, such as lettuce (GI of 15), cucumber (GI of 15), radish (GI of 15), avocado (GI of 10), and broccoli (GI of 20), cannot be precisely calculated [11].

5. Conclusion

This study explores the role of a low GI diet in reducing the risk of diabetes and its complications. Rapid economic development and slightly higher work pressure are some of the reasons why people choose a high sugar diet. As a result, the global incidence rate of diabetes increases and tends to be younger. A low GI diet could effectively lower postprandial blood glucose levels and improve insulin sensitivity, which controls long-term blood glucose. It also could promote the growth of beneficial bacteria and maintain a healthy gut microbiota environment, which is beneficial for people to manage weight and health. The implications of this study are significant for public health.

There are also certain limitations to the research. Firstly, there is a lack of research on the long-term effects of low GI diets. Secondly, there may be deviations in the calculation method of GI values, as the same food may exhibit different GI values in different processing methods or food states. Finally, due to the limited sample size, some conclusions may not have universal applicability, especially when applied to specific populations such as children or pregnant women. In the future, more research will focus on the long-lasting impact on patient and develop effective long-term diets that could promote human health.

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