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The Relationship and Prevention Strategy of Plant-based Diet on Type 2 Diabetes Caused by Obesity

Yuxuan Jin

Faculty of Science, The Hong Kong Polytechnic University, Hong Kong, China
conglan@asu.edu.pl

Abstract. With the continuous improvement of living standards and changes in diet and other lifestyles, obesity and type 2 diabetes (T2DM) caused by obesity are on the rise, and they are gradually getting younger. Plant-based diet (PBD) is considered to have a positive effect on the prevention and control of T2DM because it reduces animal fat and unsaturated fatty acids and increases the intake of dietary fiber. By studying the concept of PBD and the mechanism of T2DM caused by obesity, this paper analyzed the relationship between PBD pattern and T2DM mellitus in depth. So as to explore whether a healthy vegetarian model can help reduce blood sugar, increase cellular resistance to insulin, reduce cellular oxidative stress response, and thereby reduce the risk of diabetes and related complications. Studies have shown that an overall PBD significantly increases the risk of T2DM. Future research should promote high-quality PBDs through society, deeply explore the preventive effect in different groups of people, as well as the compliance of the masses, formulate personalized prevention strategies, promote the popularization of health models, and reduce the incidence of T2DM.

Keywords: Type 2 diabetes, obesity, plant-based diet

1. Introduction

In recent years, residents' health problems have become increasingly prominent, and the incidence/incidence of chronic diseases is still on the rise [1]. At present, many residents suffer from diabetes. According to the latest data from The Lancet, more than 540 million people in the world are plagued by type 2 diabetes (T2DM). In China, this number exceeds 114 million, accounting for a quarter of the world's patients. The proportion of patients varies significantly between genders and age groups, especially among middle-aged and elderly people.

T2DM caused by obesity is a chronic disease, which is often dominated by hyperglycemia clinically, and more than 85% of T2DM patients are accompanied by overweight or obesity, and its complications are highly lethal and disabling [2]. With the improvement of living standards, health problems are increasing day by day, and the problem of overweight and obesity among residents has become increasingly prominent, and the proportion of patients of different genders and age groups has increased year-on-year. Complications such as T2DM caused by obesity not only affect physical and mental health, but also bring huge economic burdens to patients, families and society [3]. At present, there is no radical cure for T2DM, and the treatment is mainly dependent on drug control,

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but there are still certain limitations, such as many side effects such as hormone content, long-term medication and poor effect in some patients. In addition to drug treatment, diet has important significance in diabetes control [4]. With the continuous development of research, the relationship between plant-based diet (PBD) and T2DM has gradually attracted attention. Some studies have shown that a PBD rich in whole grains, vegetables, fruits, nuts and legumes improves blood sugar control and reduces the risk of T2DM. In addition, a PBD can help with weight loss, lower blood pressure and improved lipid levels, all important risk factors for T2DM. However, there is no systematic study on the correlation between the two, and few people have analyzed its potential mechanism [5].

Therefore, this paper collates and summarizes the relationship between PBD and T2DM caused by obesity and preventive strategies, summarizes the application of PBD in T2DM, and provides a certain theoretical reference for subsequent related studies.

2. Concepts and types of PBDs

In modern life style, diet is closely related to obesity and T2DM. High-sugar and high-fat diets are the main reasons. Excessive intake of refined carbohydrates, saturated fats, and trans fats, such as sugary drinks, fried foods, animal fats, etc., will quickly raise blood sugar and increase fat storage. Normal adipose tissue has a certain storage capacity. When too much fat is ingested, adipocytes will overexpand, hypertrophy or even rupture, releasing free fatty acids (FFA) into the blood circulation. When a large amount of FFA accumulates abnormally in non-adipose tissues such as liver and muscle, it will trigger lipid toxicity. These ectopically deposited FFA disrupt the normal metabolic homeostasis in cells, cannot effectively inhibit the process of glycogenolysis and gluconeogenesis, make blood sugar regulation dysfunction, and eventually aggravate insulin resistance and glucose metabolism abnormalities. The main defect of T2DM is insulin resistance, in which normal insulin levels lead to lower metabolic effects or require higher than normal levels of insulin to elicit a normal metabolic response [6]. However, long-term insulin resistance makes the function of islet beta cells decompensated, and the secretion of insulin decreases, which eventually leads to T2DM. In addition, the imbalance of dietary structure, the imbalance of the ratio of omega-6 to omega-3 fatty acids, and insufficient intake of dietary fiber will also promote chronic inflammation and increase the risk of T2DM.

Excessive consumption of saturated fats and trans fats in the daily diet is associated with an increased risk of disease. Saturated fats are predominantly found in animal fats and can lead to elevated levels of low-density lipoprotein cholesterol (LDL-C) in the blood, promoting abnormal fat accumulation in tissues such as the liver and muscles. Trans fats, commonly present in fried foods, can not only raise LDL-C levels but also reduce high-density lipoprotein cholesterol (HDL-C), thereby disrupting normal lipid metabolism. In contrast, unsaturated fats—particularly omega-3 fatty acids within polyunsaturated fats—are known to improve the blood lipid profile and exert beneficial effects in the prevention of obesity and T2DM.

2.1. Concept of PBD

PBD is a dietary pattern based on plant-based foods, emphasizing the acquisition of major nutrients from plant sources, covering grains, vegetables, fruits, beans, nuts, seeds, etc., to provide humans with rich dietary nutrients, while discouraging or avoiding animal food intake [7]. Its main feature is the exclusion of meat where fish are located, and in some cases, animal diets such as eggs and dairy products will also be excluded. At present, there is no specific and unified definition of PBD, and

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there are significant differences in its concept and scope of application in different research literatures [8]. Some studies regard it as synonymous with strict vegetarianism, excluding all animal products, while others define it as a flexible dietary pattern that is based on plant ingredients and allows one can consume a small amount of animal food. This cognitive difference makes plant The boundaries of the sexual diet present ambiguity and diversity [9]. 50% of the relevant PBD literature retrieved defined PBD as a vegan diet that completely excluded animal-based foods; About 33% of the literature includes dairy products in the concept of a PBD; And 20% of the literature defines PBDs as semi-vegetarian dietary patterns [8].

2.2. Types of PBDs

The concept of "PBD" covers traditional vegan diets, semi-vegetarian diets and even omnivorous diets, but its prominent feature is that it focuses on plant-based foods, which can be further divided into different types of diets according to the type and proportion of animal products contained in the diet (Table 1) [9].

Table 1. Comparison of different types of PBDs

Diet Type	Definition	Characteristic
Vegan	A diet that completely excludes all animal-derived foods	Due to more restrictions, trace elements such as protein, vitamin B6, vitamin B12, iron, calcium, and omega-3 fatty acids are prone to deficiency [10].
Vegetarian	Give priority to plant-based food, avoid or reduce the intake of animal-based food	Mainly rely on plant-based foods to obtain trace elements such as potassium, magnesium, and vitamin E, which can help reduce the risk of chronic diseases such as obesity, enhance the immune system, protect cardiovascular and cerebrovascular health, and reduce exercise fatigue [11].
Semi-vegetarian/Flexible	Predominantly plant-based foods, occasionally using small amounts of meat or animal products	High-quality protein can be obtained from fish, seafood, etc., and obtain calcium and zinc from egg milk.

A previous systematic review and meta-analysis evaluated six studies and found that vegetarian diets significantly reduced glycosylated hemoglobin levels compared to control diets [12].

A PBD pattern may increase the risk of inadequate intake and poor nutritional status of certain nutrients that are predominantly present in or more readily available from animal foods (e.g.: vitamin B12, iodine, iron, calcium, etc.), but can also improve the intake of other nutrients, which are more abundant in plant foods [13].

3. Relationship between PBD and T2DM

The prevalence of diabetes mellitus is mainly caused by lifestyle factors such as unhealthy diet, overweight or obesity, genetic predisposition, and lack of exercise. PBDs can not only effectively reduce body weight, but also significantly improve blood sugar and insulin control in T2DM, and play an anti-inflammatory and anti-oxidant role [7].

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3.1. Reduces insulin secretion pressure

PBDs have a significant effect on lowering blood sugar in patients with T2DM. Under the intervention of this dietary pattern, the food is rich in dietary fiber, so most of the fat is unsaturated fatty acids. For example, whole grain rice reduces triglyceride levels, Whole grain oats reduce total cholesterol and LDL cholesterol levels, can delay sugar absorption, improve glycosylated hemoglobin and LDL cholesterol, reduce insulin secretion pressure, and reduce blood sugar levels [7,14]. At the same time, the minerals contained in grains are conducive to the function of insulin, enhance the uptake and utilization of glucose by cells, improve insulin sensitivity, and thereby control blood sugar. In addition, vitamin c, which is rich in vegetables and fruits, can reduce cholesterol content and insulin resistance, thereby helping to regulate blood sugar [8]. The main defect of T2DM is insulin resistance, in which normal insulin levels lead to lower metabolic effects or require higher than normal levels of insulin to trigger a normal metabolic response.

3.2. Anti-inflammatory, anti-oxidant

Miscellaneous grains, vegetables, fruits, etc., are rich in dietary fiber, polyphenols, vitamins, and other bioactive compounds beneficial to health. These nutrients can help regulate gut microbiota, control body weight, and reduce inflammatory markers, thereby lowering the risk of diabetes [15]. It has been known from past studies that healthy plant foods are rich in a variety of phytochemicals (such as polyphenols, carotenoids, and saponins), which can reduce lipid peroxidation, DNA oxidative damage, inflammatory factors, and enhance antioxidant defense to promote β cell survival [16]. Anti-inflammatory nutrients such as monounsaturated fatty acids rich in grains, beans and other foods can also significantly reduce the level of inflammation and cell adhesion mediators during digestion, playing an anti-inflammatory role. At the same time, the flavonoids, glutathione and other antioxidant substances rich in fruits and vegetables in the PBD can protect the cell membrane, reduce the damage of free radicals to cells, and reduce the oxidative stress response of cells [9].

4. Prevention strategies of PBD for T2DM

Such as long-term high-calorie diet, obesity and other unhealthy lifestyles are the key factors inducing T2DM. Currently, systematic reviews and meta-analyses (SRMAs) of several randomized controlled trials (RCTs) have shown that interventions that improve dietary quality (e.g., low-calorie and low-fat diets) and increase physical activity levels are able to delay or prevent the onset of T2DM [17]. In Adventist Health study-2, the prevalence of T2DM in people aged 30 years and older was 2.6 times higher among non-vegetarians than vegans [18]. Therefore, constructing a scientific and reasonable PBD plays an important role in preventing T2DM caused by obesity.

The American Adventist Death and Health Study, which followed 8,401 Adventists over a long-term (17-year) period, found that those who adhered to weekly meat intake had a 74% increased risk of diabetes compared to long-term vegetarian (zero meat intake), while after adjusting for weight and weight changes, the risk of diabetes still increased by 38%. Meta-analysis found that vegetarian and vegan vegetarians were able to reduce the risk of T2DM, the risk of diabetes remained low after correction for body mass index, and the sensitivity to insulin was higher [7].

A total of 585 cases aged 35-74 years were screened in the natural population cohort project of Ningxia in Northwest China. The semi-quantitative food frequency questionnaire (SFFQ) was used to collect dietary data. According to the calculation method of PDI index, the average daily intake of

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13 kinds of foods was added together, and the total PDI was positively assigned to all plant foods and negatively assigned to animal foods. Logistic regression analysis showed that the risk of T2DM in the middle percentile group of PDI increased by 71% (OR = 1.71, 95% CI 1.12-2.62), the risk of T2DM in the middle percentile group of HPDI decreased by 43% (OR = 0.57, 95% CI 0.40-0.80), and the risk of T2DM in the high percentile group of UPDI increased by 42% (OR = 1.42, 95% CI 1.03-1.97) compared with the low percentile group ($P < 0.05$).

Replacing saturated fats with dietary monounsaturated and polyunsaturated fats and reducing the intake of sodium, cholesterol, processed meats, refined carbohydrates and sugary beverages can help reduce T2DM and additional diseases such as cardiovascular disease [19]. Replace refined rice noodles with miscellaneous grains, increase the intake of dietary fiber, reduce the digestion speed of carbohydrates, delay the absorption of glucose, and stabilize blood sugar; Increase the consumption of vegetables and fruits, supplement antioxidant substances, protect pancreatic islet β cells from free radical damage, and make insulin secrete normally; Replace animal fats with nuts and reduce saturated fatty acids to reduce the risk of T2DM.

Since obesity is a common risk factor for other metabolic diseases such as T2DM, a healthy PBD that emphasizes the intake of fruits, vegetables, whole grains, nuts and legumes has a lower energy density and helps to reduce weight. In addition, it can effectively prevent and treat T2DM caused by obesity to a certain extent [20]. At the same time, the support of social policies will create a good environment for the promotion of PBDs. Increase knowledge publicity and education activities will be used to improve awareness, reduce the production and sales prices of plant-based foods, and formulate PBDs. In the first year of weight management, encourage Residents lose fat and weight, so as to promote PBDs more comprehensively.

5. Conclusion

In recent years, changes in dietary patterns and unhealthy lifestyles have led to an increased risk of metabolic diseases such as T2DM, and they are becoming younger and younger. This article discusses the relationship and prevention strategies of PBD on T2DM caused by obesity. Therefore, it is found that adhering to a healthy PBD containing high fiber, vitamins, and low saturated fat can help reduce blood sugar and increase cellular resistance to insulin. Resistance, reducing inflammatory factors through antioxidant components, thereby reducing the risk of diabetes and its related complications. However, there is currently no clear definition of "PBD", and the concept still needs to be unified in the future. In addition, PBDs differ greatly from daily dietary patterns, adherence is not high, and there is a lack of clinical studies on how to intervene with different types of PBDs. In view of this, it is necessary to formulate a reasonable personalized diet plan in the future, conduct long-term follow-up, measure which method is most beneficial, improve compliance, and consider conducting large-scale and more rigorous prospective clinical studies to further explore the impact of this diet pattern on T2DM. The mechanism of action of diabetes provides new ideas for the study of T2DM.

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