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Nutritional Strategies in the Management of Diabetes Mellitus: A Review

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Abstract

Diabetes mellitus is a long-term metabolic disorder of various etiologies hallmarked by chronic hyperglycemia. The prevalence is increasing worldwide, the burden of diabetes in India was approximately 77 million cases in 2019 and is expected to rise to more than 134 million by 2045. Dietary changes continue to be an important part of diabetes prevention and management, helping people achieve their ideal weight, regulate their blood glucose levels, and reduce their risk of complications. Nutrition-based methods, when combined with regular physical activity, can dramatically enhance long-term glycemic control and quality of life

Keywords: Diet; Essential Fatty Acid; Glycemic Index; Glycemic Load

Introduction

Diabetes mellitus is a long-term condition characterized clinically by high concentration of glucose in blood as well as disruptions in carbohydrate, protein, and fat metabolism as a result of reduced insulin action [1]. The raising prevalence of diabetes around the world has become a substantial public health problem as the disease ranks among the leading causes of blindness, kidney failure, and amputation. It is also an important risk factor for coronary heart disease and stroke [2]. Based on recent data on the prevalence of diabetes in different countries, the global count among adults aged 20-79 has increased from 285 million in 2010 to 439 million people by 2030 [3]. Many countries have seen shift in eating habits favor of increased calorie consumption as a result of urbanization and better economies [4]. Unhealthy diets have always seemed like a key reason to the development of diabetes. Men and women all over the world have gained weight in recent decades, owing largely to changes in dietary patterns and decreased physical activity levels. Food composition may play an important role in the prevention of diabetes [5, 6].

Classification of Diabetes Mellitus

Diabetes Mellitus is mainly classified into 3 broad categories, type 1, type 2, and gestational diabetes.

Type 1 Diabetes (T1D)

Insulin-dependent diabetes mellitus, also known as juvenile-onset diabetes, is characterized by the loss of insulin-producing beta cells in the pancreatic islets of Langerhans leading to insulin deficiency. This form of diabetes is further divided into immunological and idiopathic diabetes. Most type 1 diabetes is immune-mediated in nature, and beta-cell loss is a T-cell-mediated autoimmune attack [7].

Type 1 diabetes is caused by the autoimmune destruction of pancreatic beta cells, with certain antibodies present in the blood. It is partially inherited and several genes contain certain HLA genotypes that are known to affect the risk of diabetes. In genetically susceptible people, the development of diabetes can be caused by one or more environmental factors such as viral infections and diet [8].

Type 2 Diabetes (T2D)

Previously known as non-insulin-dependent diabetes, type 2 diabetes, or adult-onset diabetes, this kind of diabetes affects 90-95 percent of people [9]. It is characterized by insulin resistance, which may be relatively associated with decreased insulin secretion. Insulin receptors are thought to be involved in poor body tissue response to insulin. Since the specific defect is not clearly identified, diabetics are classified individually based on known defects. The condition is largely influenced by both lifestyle and genetic factors [10]. Many lifestyle factors, such as obesity, lack of exercise, poor diet, stress, and urbanization, are important for developing type 2 diabetes [11].

Gestational Diabetes

Gestational diabetes is a form of diabetes that develop during pregnancy in women without diabetes. This usually develops late in the 3rd trimester or early in the 4th trimester. It usually returns to normal soon after delivery. It impacts how the body utilizes glucose. The body's cells use glucose as a primary source of energy for growth and normal functioning. Abnormal blood sugar levels can be very dangerous for both the mother and the fetus during pregnancy [12]. In the future, women are at increased risk of diabetes (T2D). A 2008 study in the United States found that the number of American women entering pregnancy with pre-existing diabetes is increasing. The prevalence of diabetes in pregnant women has more than doubled in the past 6 years [13].

Role of Diet

Diet plays a vital role in controlling diabetes. Balanced diet, consistent exercise and medication are all crucial for managing diabetes. This reduces the complications and enhances metabolic control in individuals with diabetes [14]. By harmonizing food consumption with endogenous and/or exogenous insulin levels, diabetes management aims to enhance blood sugar control. Individuals with type 1 diabetes must modify their insulin dosage in order to balance it with appropriate diet and exercise. glycemic control may be improved for people with type 2 diabetes, impaired glucose tolerance, or impaired fasting glucose if they follow a nutritious diet, control their weight, and engage in physical exercise [15].

Carbohydrates

The main source of energy in the diet is carbohydrates, which are found in grains, fruits, vegetables, dairy products and sweets [16]. Proteins and fat have little to no effect on blood glucose levels, while carbohydrates do. The American diabetes association produced studies between 2001 and 2010 that focused on low-carbohydrates (less than 40% calories) diet treatments [17]. People who use oral diabetes medicines or long-acting insulin may benefit from eating a constant amount of carbohydrates at each meal to help control blood glucose levels. Thus, carbohydrate quantity is a better predictor of glycemic response, carbohydrate quality is crucial in terms of the glycemic index [18].

Food Glycemic Index (GI) refers to its glucose-enhancing effect, whereas Glycemic Load (GL) of food measures both quality (the GI value) and quantity (grams/serving) of carbohydrates. In a meta-analysis of surveillance studies, both are connected to higher risk of diabetes [19]. According to the GI rating scale, foods are graded from 1 to 100 according to a rise in blood glucose levels. In general, there are three categories of foods based on GI values, High-GI foods, moderate GI foods, and low GI foods. The glycemic index values are represented in fig.1. The majority of legume varieties, pasta, fruits, and dairy products continue to be categorized as low-GI foods. whereas Bread, rice, breakfast cereals, and snack items, including whole-grain versions, are available in high and low GI formats [20].

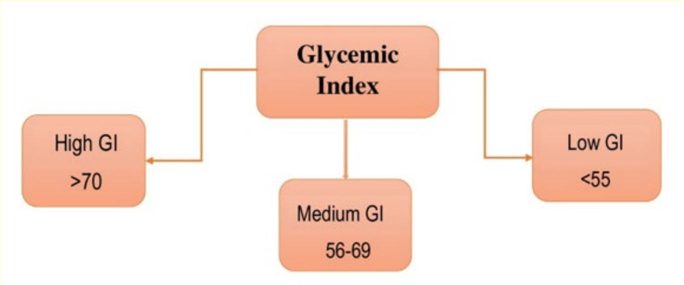

Figure 1: Glycemic Index Classification.

High glycemic index (GI) foods can greatly raise blood sugar levels after meals. In the experimental study, high GI carbohydrates damage pancreatic islet cells [21]. Low GI foods have been shown to cause post-meal hyperglycemia and hyperinsulinemia more than high GI foods. The mechanism by which low GI foods may increase beta-cell function includes reduced glucose toxicity, reduced serum FFA and increase levels of incretin hormone-like GLP-1, The role of low-GI foods in diabetes prevention and treatment is unknown [22]. The earliest study reports showed the prevention of type 2 diabetes by altering dietary GI, including regular exercise and selection of low GI food, low fat, high fiber diet. In that study, type 2 diabetes mellitus decreased by over 40% [23]. Though not as significantly as GI, the glycaemic load has also been associated with an increased risk of type 2 diabetes. The Chennai Urban Rural Epidemiology Study (CURES), a sizable cross-population study, demonstrated the detrimental effects of refined grains, primarily white rice, on the Chennai population and demonstrated a strong link with metabolic syndrome and type 2 diabetes. GL and carbohydrate consumption may be separate risk factors for type 2 diabetes in Asian Indians [24].

Worldwide, there is a significant consumption of commercial beverages that contain simple sugars, such as artificial sweet drinks (soft drinks, soda) and natural or commercial fruit juices that are frequently enriched with sugar. Their use has been repeatedly linked to an elevated risk of diabetes, according to observational studies [25-30]. Insulin resistance is encouraged by frequent use of fruit juices and sugary drinks for two primary reasons. Weight increases as a result of significant postprandial blood glucose and insulin rises in comparison to other foods and beverages, as well as high energy content and no satiety effect [31]. Numerous studies conducted over the past 40 years have demonstrated that low GI or GL diets help prevent and treat diabetes [32].

Dietary Fiber

Fiber is an indigestible part of complex carbohydrates, and since it decreases the glycemic index of foods, it has been investigated for many years in the treatment of diabetes [33-35]. Higher consumption of fiber or whole grains is independently linked to a lower risk of obesity and diabetes, according to observational research. Numerous other researches, especially those on fiber consumption and blood sugar control, show no effect, and the data on fiber intake and diabetes control are conflicting. The findings of a sizable meta-analysis indicate that consuming more grain fiber lowers the incidence of type 2 diabetes. Schulze and his colleagues suggest that both insoluble and soluble fiber can play a role in diabetes prevention. Fiber from fruits and vegetables did not significantly lower the risk of diabetes, according to the same study's findings [36].

Soluble viscous fibers are crucial for regulating satiety, insulin responses, and postprandial blood glucose. This is because it has the effect of postponing stomach emptying and intestinal nutrition absorption [37-39]. Consuming dietary fiber, especially cereal fiber, may reduce the incidence of type 2 diabetes. Both the proportion of glycosylated haemoglobin and the fasting blood glucose concentration appear to be slightly lower in people with type 2 diabetes who also consume glucan or psyllium on a daily basis. Forty Similar advantages are found in recent research that concentrate on whole grains rather than fiber. Consuming a lot of fiber and whole grains can also indicate a better way of living [41].

Fat

A significant risk factor for type 2 diabetes is excess body fat brought on by an imbalance between calorie intake and physical activity [42]. Clinical research on the role of dietary fat in type 2 diabetes has been conducted for many years. It is unknown how various dietary fatty acid types may affect insulin resistance and type 2 diabetes risks in the long run [43]. However, there is also evidence that the pathophysiology of type 2 diabetes is influenced by dietary variables [44]. Research on animals has demonstrated that the type of fat supplied to the diet influences insulin sensitivity via changing the membrane lipids' fatty acid content [45].

Vandam et al. [46] study the connection between meat consumption, fat, and and type 2 diabetes risk over 12-year period. They conclude that the high-fat diet and high intakes of saturated fat were associated with an increased risk of type 2 diabetes. However, these correlations disappeared after further adjustment to BMI. They also stated that frequent consumption of processed meat is associated with an increased risk of diabetes. High dietary fat content can lead to impaired glucose tolerance through several mechanisms, including decreased insulin binding to receptors, impaired glucose transport, decreased glycogen synthase, and accumulation of triglycerides stored in skeletal muscle [47-50]. The composition of fatty acids in the diet, in turn, affects the phospholipid composition of tissues, which may be related to the action of insulin by altering membrane fluidity and insulin signaling [51].

The impact of fat on diabetes risk depends on the type of fat consumed. Cross-sectional and case-control studies have reported that newly diagnosed diabetes has a higher intake of saturated fatty acids than healthy subjects [52]. In contrast, PUFA intake from dietary profiles or biomarkers was more consistently associated with better glycemic control and/or reduced diabetes risk in the observed subjects. The best biomarker for fatty acid intake is PUFA because linolenic acid (n6) and linolenic acid (n3) are positively correlated with insulin sensitivity. It is abundant in nuts and most vegetable oils [53].

The dietary intake of MUFA was positively correlated with type 2 diabetes mellitus treatment. Several epidemiological studies reported the beneficial effects of monounsaturated fatty acids [54,55]. Trans fats are highly risky compared to saturated fatty acids. It is linked with an elevated risk of diabetes and heart disease. Unfortunately, many barns and foods in Asia are not tested for trans-fat content. Partially hydrogenated vegetable ghee and vegetable oils popular in India can contain up to 50% trans-fat [56]. However, nutritional recommendations still vary depending on the effectiveness of different diets in achieving better glycemic control.

Vitamins and Minerals

The supplementation of vitamins and minerals plays a vital role in the management of diabetes mellitus. Oxidative stress is caused by the overproduction of free radicals in the body which is closely associated with insulin resistance and islet β-cell dysfunction and is an important factor in the development of diabetes. However, the intake of antioxidant vitamins improves insulin resistance and beta-cell function in type 2 diabetes mellitus [57]. The daily consumption of 1000mg of vitamin C reduced fasting blood glucose, HbA1c, and lipids levels in type 2 diabetes. In the same study, 500 mg of vitamin C supplementation in diabetics showed no change in fasting blood glucose and HbA1c [58]. In another study, the ascorbic acid (2 gm/day) and magnesium (600 mg/day) supplementation for 90 days were assessed in a diabetic patient, the result stated that there are no changes in glycemic control and lipid profile upon magnesium administration, whereas ascorbic improved the glycemic control and lipids [59].

Type 2 diabetes mellitus (TM2) is mostly caused by changing the magnesium status and is an important cofactor necessary for several enzymatic reactions, which are mainly involved in carbohydrate metabolism and phosphorylation of tyrosine kinase of the insulin receptor. The magnesium deficiencies in TM2 patients cause the tyrosine-kinase activity to be defective [60]. Magnesium intake was found to be inversely related to diabetes risk in a meta-analysis of prospective cohort studies [61]. Elevated magnesium intake is linked to a lower risk of diabetes, heart failure, and stroke [62]. Bagheri et al. demonstrated that magnesium supplementation in the diet reduces the risk of cancer death [63]. Therefore, magnesium plays an important role in managing diabetes.

Several studies have looked into the impact of chromium supplements on type 2 diabetes glycemic control [64]. It has been reported that the supplementation of chromium increases the binding of insulin to cells and activates insulin receptor kinase, leading to greater insulin sensitivity [65] thus raising the glucose and amino acid transport. The fasting blood glucose and HbA1c level were significantly reduced in type 2 diabetes upon chromium supplementation [66]. In diabetics, the deficiency of chromium is linked with high blood glucose, insulin, and lipid levels, which can interfere with diabetes management. Several studies reported the positive effect of chromium in type 2 diabetes, additionally, it improves lipid profile [67].

Role of Foods on Diabetes Prevention

Milk and Dairy Products

Milk products are high in protein, vitamins, and minerals, that are essential for a healthy diet. The meta-analyses of cohort studies suggested that dairy intake was associated with a reduced risk of developing diabetes [68-70]. Dairy products also contain saturated fats, therefore current nutritional guidelines do not recommend eating saturated fat because it increases the risk of various diseases [71]. The consumption of saturated fat is replaced by unsaturated fats [72]. The consumption of dairy products and milk increases total or low-density lipoprotein cholesterol levels [73].

The incidence of Type 2 diabetes in milk and dairy consumption has been reported in four prospective cohort studies [74-77]. Furthermore, Liu et al. [78] conducted a 10-year follow-up study of 37,421 participants to investigate the relationship between dietary SFAs and T2D risk. In that study, milk and milk products and SFAs derived from butter were not found to be statistically significant predictors of T2D risk although Cheese-derived SFA is associated with a low risk of T2D. The consumption of dairy products and cheese and dietary calcium were linked with a decreased incidence of metabolic syndrome in the DESIR prospective trial with a 9-year follow-up. The intake of calcium and dairy products was also associated with a lower incidence of type 2 diabetes. The link between low-fat dairy and a lower incidence of T2D appears to be reliable [79].

Coffee and Tea

Coffee is most widely consumed by Indian people. It has beneficial health effects and it contributes to dietary antioxidants [80]. Coffee consumption is not considered generally a part of healthy life. Caffeine, phenolic compounds, trigonelline, diterpenes, and soluble fiber are among the many bioactive compounds found in coffee [81]. There are several plausible mechanisms for coffee's beneficial effect on glucose metabolism. Coffee has been shown to contribute significantly to the diet's total in vitro antioxidant capacity [82,83].

Coffee consumption regularly is associated with a significantly lower risk of type 2 diabetes. The observed association's mechanisms are unknown, but animal and in vitro studies have suggested several plausible pathways [84]. Consumption of 4 to 6 cups of coffee a day, and more than 6 cups a day, reduces the risk of type 2 diabetes compared to less than 2 cups a day [85]. In the prospective cohort study, Salazar-Martinez and colleagues found a statistically significant inverse relationship between caffeine and normal coffee consumption and the incidence of diabetes [86]. Similar results have been reported by Huxley et al. [87], the study result reported that decaffeinated coffee and tea decrease the risk of diabetes.

Conclusion

A nutritious diet is crucial for both preventing and managing diabetes. A high-fiber diet can prevent the onset of diabetes, according to earlier epidemiological research. However, a high risk of diabetes mellitus is linked to a diet heavy in processed meat and trans fats. Increased consumption of polyunsaturated fatty acids lowers the chance of developing diabetes. There are certain advantages to including low-fat dairy products and moderate amounts of tea and coffee in the daily diet. Diabetes mellitus cannot be prevented by any one dietary approach. But maintaining a healthy lifestyle also requires frequent exercise and a balanced diet.

Conflicts of Interests

No conflict of interest.

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