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DIETARY INTERVENTIONS AS A CORNERSTONE OF DIABETES CARE

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ABSTRACT

Diabetes Mellitus, a Type 2 is considered the most common disease that is rising around the world. It is most complex metabolic disease that is manifested by a long-term hyperglycemia. The multifactorial origin of Type 2 diabetes mellitus is complicated and is related to Irremediable determinants such as age, progeny, ethnicity, and genetics and is also related with remediable determinants like dietary patterns, physical exertion, and tobacco smoking. It emphasizes the need for efficacious, adherable lifestyle changes, affordable and feasible clinical interventions. The objectives of narrative review article are to evaluate several studies to investigate relationship of type 2 diabetes mellitus with dietary pattern practices and its comorbidities. The significant risk factor for progressing comorbidities is the elevated of HbA1C level, Overweight, physical inactivity, Obesity, High intake of saturated fat, trans fat, and intrauterine growth retardation. It is possible that through diet management like Omega-3 Fatty acid rich diet, low GI food intake, and precision dietary management interventions used to improve optimization of raised HbA1C level, normalize glycemic status, glycemic control, and maintenance of weight loss. Thus, patients could be getting rid of developing the comorbidities. To give awareness about dietary knowledge, attitude, practices lead to control of disease complications. This review can collect evidence on the effects of diet like low carb diet, keto diet, Vegan diet, Mediterranean diet, and usage of complex carbs, high fiber, protein diet which can increase eating of fullness. It can help to improve the Glycemic control, weight loss, long term comorbidities, patient concordance, tolerability, and satisfaction. Based on evidence regarding diet, lifestyle, normal weight status, regular physical activity, prevent abdominal obesity, metabolic dysfunction, reduce saturated fats, Trans fat intake, and decrease risk of Diabetes mellitus of type 2.This review article tells how a regular intake of such food act as metabolic booster's results in postprandial glucose surges that causes hyperinsulinemia; disrupt insulin sensitivity, increase insulin resistance, obesity and metabolic disorders.

Keywords: *Diabetes mellitus, Metabolic Dysfunction, Medical Nutrition Therapy, Comorbidities, Glycemic control, Dietary Pattern and Interventions*

INTRODUCTION

Healthcare professionals may find it challenging to suggest which diet interventions or dietary factors are appropriate for patients due to the abundance of available modalities, despite the body of evidence clearly demonstrating the benefits of dietary modifications for the prevention of type-2 diabetes mellitus (T2DM). According to the review's findings, the risk of type 2 diabetes was considerably decreased by following healthy

eating habits like the Mediterranean and Dietary Approaches to Stop Hypertension (DASH) diets and consuming a lot of whole grains, low-fat dairy products, yoghurt, olive oil, chocolate, fiber, magnesium, and flavonoids (Toi et al., 2020). Nutrition treatment and well-crafted dietary recommendations are crucial for enhancing life expectancy and quality. But the deluge of nutrition information out there is of varying quality, leads to debate about the best strategies, and is likely to be confusing to both diabetics and medical professionals (*Diabetology*, 2023). The course of T2DM can be significantly altered by dietary changes. For people with type 2 diabetes, weight changes are important because substantial weight reduction can put the disease into remission, and even modest weight loss can improve cardiovascular risk factors and glycemic management (Ward-Ongley, 2024). To lessen the harmful effects of diabetes, diabetes management treatments usually include lifestyle modifications such as increased physical activity, dietary changes, quitting smoking, and keeping healthy body weight. Most patients find it difficult to make long-term lifestyle changes, particularly in the areas of nutrition and exercise. Healthcare providers that treat diabetic patients have a responsibility to help, monitor, and encourage them in this endeavor (Gortzi et al., 2024). A recent study found that daily energy expenditure, metabolic rate, and weight reduction results are not much impacted by the distribution of calories throughout the day. However, it has been noted that those who consume a higher percentage of calories in the morning report feeling less hungry, which may help them lose weight (Kim et al., 2024). Eating habits and type 2 diabetes are intimately linked, and various eating habits, including emotional, external, and controlled eating, can affect how the illness develops and is managed. In people with type 2 diabetes, restricted eating is frequently linked to strict dietary control and may have an impact on food consumption (Gal et al., 2024). Among the elderly population, diabetes is a very common medical disease. One-half of older adults have prediabetes, and more than 25% of those over 65 have diabetes. In the upcoming decades, it is anticipated that the number of older people with these illnesses will rise quickly. Diabetes in the elderly is a very diverse disease. Although type 2 diabetes is more common in elderly people than in younger people. Regular evaluation of the medical, psychological, functional, and social domains is necessary for managing diabetes in older people. Accurately classifying the type of diabetes and other variables, such as its length, the existence of complications, and treatment-related issues, like hypoglycemia anxiety, are crucial when evaluating older people with the disease (Satman et al., 2023). Diabetes that is initially identified during the second or third trimester of pregnancy and is obviously not pre-existing type 1 or type 2 diabetes is known as gestational diabetes mellitus (GDM. It is linked to several unfavorable pregnancy outcomes and is currently one of the most prevalent pregnancy problems observed globally. Although postpartum glucose levels typically recover to normal, women with GDM have a markedly higher chance of long-term type 2 diabetes (T2D), cardiovascular disease, hypertension, and stroke (Murphy et al., 2023). The prevalence of diabetes in adults aged 20 to 79 was 10.5% (536.6 million) in 2021, and it is predicted to rise to 12.2% (783.2 million) in 2045. People with type 2 diabetes have an increased risk of both macro vascular problems (cardiovascular comorbidities) brought on by hyperglycemia and insulin resistance, as well as micro vascular problems (retinopathy, nephropathy, and neuropathy). Risk factors include dyslipidemia, obesity, endothelial dysfunction, and vascular inflammation that results in atherosclerosis are common to both diabetes and hypertension. More than genetics, several factors, including food, physical activity, walkability, and air pollution (NO2 and PM 2.5), are associated with diabetes and CVDs in the general population (Lesgards, 2023).

In clinical practice and clinical research, the HbA1C test is the main instrument used to evaluate glycemic state, and it has a good correlation with problems from diabetes. The average glycaemia for two to three months is represented by the HbA1C. Laboratory tests for HbA1C that are accredited by the National Glycohemoglobin Standardization Program (NGSP) typically work exceptionally well. Therefore, at the time of initial assessment and as part of ongoing therapy, HbA1C testing should be done regularly for all individuals with

diabetes (ADAPPC, 2023). Achieving diabetes treatment objectives and optimizing quality of life are predicated on fostering healthy lifestyle choices and preserving mental health (standards of care in diabetes—2025). Diabetes self-management education and support (DSMES), medical nutrition treatment (MNT), regular exercise, good sleep, assistance in quitting vaping and tobacco products, health behavior counselling, and psychosocial care are all crucial to reaching these objectives (Care, 2024). To enhance clinical results, health status, and well-being in a cost-effective way, DSMES's overarching goals are to promote self-care practices, problem-solving skills, informed decision-making, and active cooperation with the healthcare team. DSMES programs consider the requirements, objectives, and life experiences of the person with diabetes and help them master the knowledge, decision-making, and skills required for the best possible diabetes self-care. Health care providers should consider the patient's treatment load, degree of social and familial support, and self-efficacy for self-care behaviors when administering DSMES (standards of care in diabetes—2024).

1. MNT for diabetes care:

Medical Nutrition Therapy (MNT) is an evidence-based, individualized nutrition care process provided to manage medical conditions. It involves assessment of nutritional status, formulation of a tailored meal plan, nutrition counseling, and ongoing monitoring to achieve specific health goals. In diabetes, MNT focuses on regulating blood glucose levels, improving metabolic outcomes, and preventing or delaying complications through appropriate dietary modifications. (Geneva, 2016). Type 2 diabetes mellitus (T2DM) is a complex, multifactorial metabolic disorder influenced by both genetic predisposition and environmental or lifestyle-related factors. Numerous genetic variants have been linked to T2DM, with several polymorphisms identified that affect dietary response as well as insulin secretion and sensitivity in peripheral tissues. Genome-wide association studies suggest that these genetic variations may account for a proportion of the overall risk of developing T2DM. Alongside genetic susceptibility, lifestyle factors play a critical role in disease onset and progression. Dietary habits are among the most influential modifiable risk factors (Siddiqui et al., 2024). Diets characterized by high energy density, ultra-processed foods, and Western-style eating patterns have been associated with an increased risk of T2DM. In contrast, healthier dietary patterns, particularly those rich in whole grains, legumes, nuts, fruits, and vegetables, are linked to a reduced risk. Diets high in refined carbohydrates, red and processed meats, and sugar-sweetened beverages appear to negatively impact glucose metabolism. Both the quantity and quality of carbohydrate intake are relevant, as higher carbohydrate consumption, elevated glycemic index and load, and low dietary fiber intake have been associated with increased diabetes risk (Toi et al., 2020). Obesity represents another major risk factor for T2DM, particularly when excess adipose tissue is concentrated in the abdominal region. Adipose tissue functions as an active endocrine organ, releasing cytokines and hormones that promote chronic inflammation and insulin resistance. Increased levels of free fatty acids, reduced adiponectin concentrations, and leptin resistance further impair metabolic regulation. These alterations contribute to insulin resistance in adipose, muscle, and liver tissues, thereby increasing the likelihood of T2DM and related cardiometabolic disorders (Micic & Cvijovic, 2008).

In individuals with type 2 diabetes or impaired glucose tolerance without established autonomic neuropathy, regular exercise has been associated with improvements in autonomic function, especially when measured through heart rate variability. Lifestyle counseling that included recommendations for at least 150 minutes of aerobic exercise per week demonstrated measurable improvements in autonomic parameters after one year. These findings suggest that early lifestyle interventions may help preserve autonomic function and delay the progression of diabetic autonomic neuropathy. There is growing evidence that lifestyle-based interventions, particularly dietary modification and increased physical activity, can be effective in individuals with diabetes. However, the findings from existing studies should be interpreted carefully, as many

investigations involve small sample sizes and are not adequately powered (Albers et al., 2007)

Nutrition screening and referral typically begin when a healthcare provider identifies a patient who may benefit from MNT for diabetes or related medical conditions. The referral contains relevant clinical information and medical diagnoses to guide individualized nutrition care. Nutrition intervention involves counseling and collaboration with the patient to establish individualized goals and strategies. Techniques such as motivational interviewing, goal setting, and self-monitoring are commonly applied to improve dietary habits and lifestyle behaviors. Monitoring and evaluation include tracking changes in dietary intake, physical activity, biochemical markers (e.g., lipid profile), and patient progress toward established goals. Follow-up visits are used to adjust nutrition plans and reinforce education. Documentation is an essential component of MNT, as the dietitian records assessments, diagnoses, interventions, and outcomes, and communicates findings with other healthcare professionals. Quality management systems may also be used to analyze aggregated patient data and improve the effectiveness and delivery of nutrition services (Gans et al., 2003). The primary aim of diabetes management is to maintain daily glycemic control and reduce the risk of acute and long-term complications, particularly cardiovascular, retinal, and renal diseases, which pose major challenges to global health systems (Ceriello et al., 2022).

2. Carbohydrate Focused Dietary interventions:

Self-management education in patients with type 2 diabetes involves nutrition therapy. The existing guidelines include a hypo caloric diet in the overweight patients with the objective of losing weight and enhancing glycemic regulation and low glycemic index carbohydrate in the diet, but it is not clear what the ideal percentage (E) of carbohydrate in the diet should be. (Sainsbury et al., 2018). The carbohydrate, plus monosaturated fat should supply 60 70 percent of energy intake, which is recommended by the ADA in 2002, and moderate-carbohydrate diets are becoming more popular. Found to be an additional risk factor of both micro vascular and macro vascular complications. We selected the medium carbohydrate, more protein, more energy balanced diet (40% carbohydrate, 34% protein, 26% fat) because it was necessary to allow the maximum diversity in the carbohydrate distribution to occur because of the limitations in the ability to shift between meal high concentrations of carbohydrate and protein/fat. Moderate-carbohydrate interventions, which isocalorically replaced carbohydrates by protein, were found to augment weight loss, fat loss to spar lean mass (Pearce et al., 2008).

The sources of free sugar intake are sugars, preserves, confectionery and non-alcoholic drinks all of which contribute about a quarter of our daily carbohydrate intake (McArdle et al., 2016). One of the main functions of carbohydrates is to be a main and favorable source of body energy, and this helps to provide about half of the daily energy intake at the population level. Staple foods are carbohydrate rich foods that are eaten regularly on daily basis as main foods and they are potatoes, rice and whole grains, bread and pasta. Fruit, milk, beans and certain starch vegetables are also sources of carbohydrates. Carbohydrates are then digested by the small intestinal enzymes and are absorbed as glucose molecules after intake into the body. Insulin helps in the uptake of the glucose that is in the blood into the cells, after which it is directly changed into energy or stored as glycogen Carbohydrates cannot all be digested in the small intestine and the undigested components go to the large intestine (colon); these are known as dietary fiber (Churuangsuk et al., 2020). Several dietary strategies influence glycemic control through multiple metabolic pathways (Figure 1).

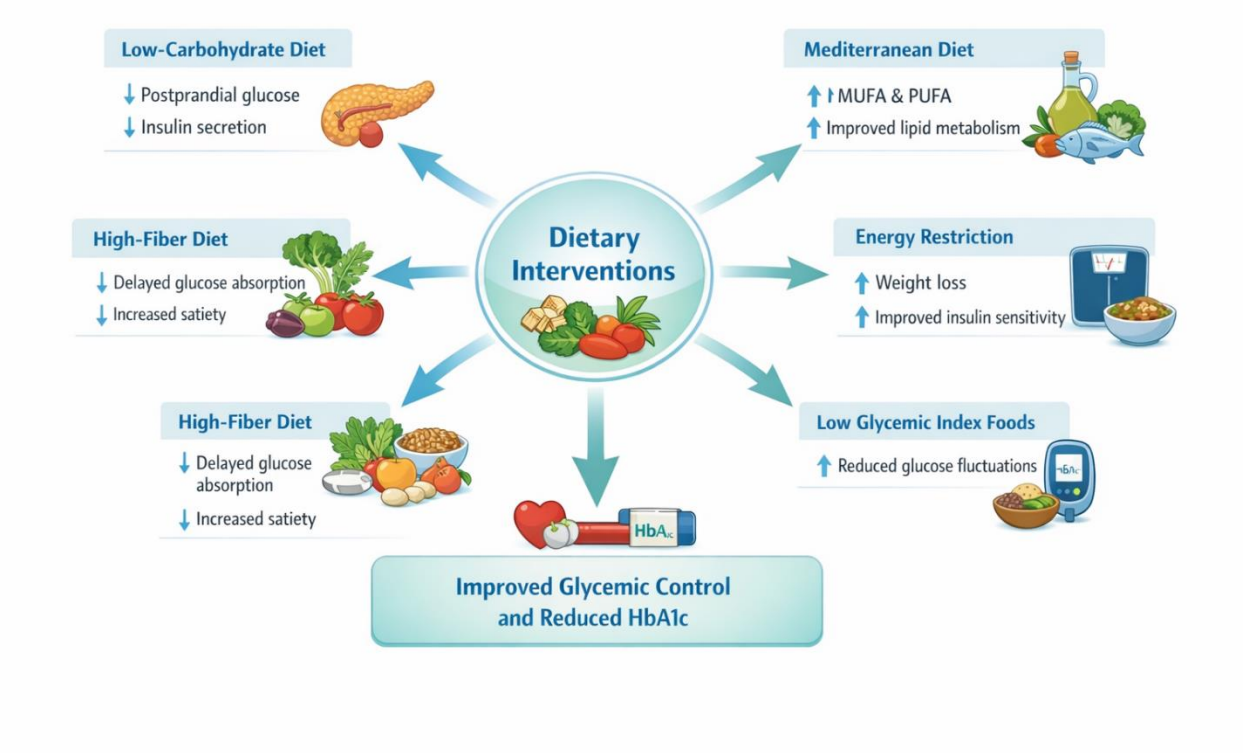

Figure 1. Mechanisms by Which Dietary Interventions Improve Glycemic Control

The beneficial impact of low-GI foods is higher among diabetic patients than normal individuals, due to the impairment of the glucose metabolism regulation of diabetic patients, especially during the postprandial period, which predisposes the former to the dietary impact of glucose on plasma glucose (Riccardi et al., 2008). Low carbohydrate intake is generally acknowledged to be under 130 g/day, which equals under 26 percent of total energy as carbohydrates. An intake beyond 230g per day is in line with no limit of carbohydrate, yet we discover that a number of our patients with diabetes or obesity are consistently in excess of a number of times this quantity on a daily basis (Kelly et al., 2020).Two effective dietary methods have been shown to put type 2 diabetes (T2D) in remission low-energy diets (LEDs) and low-carbohydrate diets (LCDs). The approaches vary in their rationale and implementation but all of them include carbohydrate restriction either as an overtly set end or as a side effect of decreasing total energy intake (Nicholas et al., 2021).

The rationale behind the carbohydrate-insulin model is that excessive consumption of carbohydrate or a high proportion of carbohydrate to fat or protein causes endocrine dysregulation characterized by hyperinsulinemia, which is the fuel partitioning with carbohydrate being redistributed to adipose tissue at the expense of Despite the fact that the low-carbohydrate diets have been clinically tested and were found to induce the model predicted metabolic and endocrine effects (that is, the necessary decrease in insulin and increase in fat oxidation), the diets have not provided the anticipated weight loss effect (Sievenpiper, 2020). All this controversy and uncertainty is projected in the clinical practice of even the best qualified professionals of all to offer therapeutic nutritional intervention-dietitians. A more recent survey of their clinical practice in the UK revealed that half (48) of dietitians were recommending patient restriction of carbohydrate intake (occasionally or frequently) and only 35% of dietitians said that they would classify between 30 and 39 percent of the total energy intake as realistic. Considering our comprehensive mixed clinical experience throughout the years of use of low-carbohydrate diets in patients with obesity or type 2 diabetes (Kelly et al., 2020). Various dietary patterns such as low-carbohydrate, Mediterranean, and high-fiber diets have demonstrated beneficial effects on glycemic

control and metabolic outcomes in individuals with type 2 diabetes (Table 1).

Table 1. Major Dietary Interventions for Type 2 Diabetes Management

Dietary Intervention	Key Components	Proposed Mechanisms	Clinical Outcomes Reported
Low-Carbohydrate Diet (LCD)	<130 g/day carbohydrates; higher protein and fat intake	Reduces postprandial glucose spikes, decreases insulin secretion, promotes fat oxidation	Improved glycemic control, reduction in HbA1c, weight loss, improved insulin sensitivity
Mediterranean Diet	High intake of olive oil, fruits, vegetables, whole grains, nuts; moderate fish; low red meat	High unsaturated fats improve lipid metabolism; antioxidants reduce inflammation	Improved glycemic control, reduced cardiovascular risk, weight reduction
High-Fiber Diet	Whole grains, legumes, fruits, vegetables; ≥20 g fiber per 1000 kcal	Slows gastric emptying, reduces glucose absorption, improves satiety	Reduced HbA1c, improved lipid profile, reduced diabetes risk
Low Glycemic Index Diet	Foods with low GI such as legumes, oats, barley	Slower carbohydrate digestion reduces postprandial glucose rise	Lower blood glucose fluctuations and improved insulin sensitivity
Calorie-Restricted Diet (CR)	Reduced daily energy intake (e.g., 800 kcal/day in some interventions)	Promotes weight loss, improves insulin sensitivity, decreases hepatic glucose production	Reduced BMI, improved fasting glucose, improved lipid profile
High-Protein Diet (HPD)	Protein intake >16% of total energy	Increased satiety, increased thermogenesis, reduced caloric intake	Greater weight loss and improved metabolic outcomes

3. Fiber-Enriched Diets and Glycemic Regulation

Dietary fiber has been linked to a reduced risk of the onset of coronary heart disease, stroke, hypertension, diabetes, obesity, and some gastrointestinal disorders (Anderson et al., 2009). According to the Codex Alimentarius Commission (CAC), dietary fiber refers to carbohydrate polymers (that consist of ten or more monomeric units) that are not digested by the natural enzymes found in our small intestine (Giuntini et al., 2022). Carbohydrate polymers occur naturally in food, extracted polymers occurring in food raw materials, and synthetic polymers are in this category, if their health benefits are scientifically proven. Most commonly dietary fiber is classified according to solubility into soluble and insoluble. Insoluble fiber is unable to dissolve in water, and is also referred to as roughage, and it adds bulk to feces (Bulsiewicz, 2023). Wheat bran, cellulose, and lignin are some of the common sources of insoluble fiber. On the contrary, soluble fiber is soluble in water, can create viscous solutions, and is composed of insulin, wheat dextrin, beta-glucans, and guar gum (Bulsiewicz, 2023). Adding dietary fiber in carbohydrate dense solid and liquid foods can greatly decrease the amount of glucose absorption following food intake. Taste and acceptability of it can however be harmed by the quantities needed to obtain the benefits hence constraining its application as a functional food ingredient. Moreover, food processing can modify the physicochemical properties of the dietary fiber to decrease the viscosity of soluble fractions and consequently to decrease their functional impact (Ozyurt and Ötles, 2016). Dietary fiber intake has been linked with multiple metabolic benefits and reduced risk of chronic complications associated with diabetes (Figure 2).

Figure 2. Protective Role of Dietary Fiber in Preventing Diabetes Complications

The glycemic index is a relative indicator of the influence of carbohydrates of various foods on the level of glucose in the bloodstream. An increased consumption of the overall dietary fiber, particularly cereals and fruits, has been strongly and negatively associated with the risk of gestational diabetes mellitus (GDM) (Zhang et al., 2006). High-GI foods produce higher rises in blood glucose levels and need more insulin than low-GI foods (Schulze et al., 2004). High GI diets can be a direct cause of insulin resistance. Animal research showed that high amylopectin or glucose diets induce rapid and intense insulin-resistance in comparison to amylose-based diets (Anderson et al., 2004). High density lipoprotein (HDL) plays the role of reverse cholesterol transport that carries cholesterol in the peripheral tissues back to the liver and thus prevents cholesterol deposition in the tissues. Meta-analyses that evaluated the effects of GI on lipid profiles concluded that low-GI diet had a significant effect in reducing total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) than high-GI diets (Yanai and Tada, 2018). Adiponectin is an adipose tissue secreted cytokine that circulates in high levels in the blood. High levels of adiponectin in the blood lead to low risk of diabetes. It has also been found out that the intake of cereal fiber and glycemic load correlate with plasma levels of adiponectin among diabetic men (Qi et al., 2006)

Dietary fiber can be classified as plant, synthetic, animal, and microbial sources. In most of the existing studies, the attention is paid to plant-based fibers that are sourced by the means of soybean, rice bran, corn, wheat bran, and fruits. There is slow exploitation of the new sources such as cumin processing residues as potential sources of fiber. Total fiber content, soluble dietary fiber (SDF) content, physicochemical properties, and physiological actions of fibers of various origins are different (Yang et al., 2017). Some of the ways by which dietary fiber can potentially affect the susceptibility to diabetes are its effect on satiety and body weight control. Multiple studies have demonstrated fullness following meals and decreased hunger following high-fiber diets when the energy intake was maintained constant and when the subjects were allowed to eat ad hoc. Nonetheless, other studies have determined that there are no notable effects (Weickert and Pfeiffer, 2008).

Most diabetes guidelines propose that carbohydrates should be 50-60 percent of total daily energy intake with preference on whole grains, vegetables, fruits, and legumes. The levels of fiber intake include high (20 g per 1000 kcal), moderate (10-19.9 g per 1000 kcal) and low (less than 10 g per 1000 kcal) (Anderson et

al., 2004). Different macronutrients exert varying metabolic effects that influence diabetes progression and complications (Table 2).

Table 2. Nutritional Components and Their Metabolic Effects in Type 2 Diabetes

Nutritional Component	Primary Food Sources	Physiological Effects	Impact on Diabetes Outcomes
Dietary Fiber	Whole grains, legumes, fruits, vegetables	Delays gastric emptying, increases satiety, slows glucose absorption	Improved glycemic control and reduced diabetes risk
Polyunsaturated Fatty Acids (PUFA)	Fatty fish, nuts, seeds	Improves lipid metabolism, reduces inflammation	Lower cardiovascular risk in diabetic patients
Monounsaturated Fatty Acids (MUFA)	Olive oil, avocados, nuts	Improves insulin sensitivity and lipid profile	Better glycemic regulation
Low Glycemic Index Carbohydrates	Oats, barley, legumes	Slower digestion and glucose release	Reduced postprandial hyperglycemia
Protein-Rich Foods	Fish, poultry, legumes, dairy	Increases satiety and energy expenditure	Supports weight management
Refined Carbohydrates and Added Sugars	Sugar-sweetened beverages, confectionery	Rapid glucose absorption causing hyperglycemia	Increased risk of insulin resistance

4. Fat Quality Modification and Cardiovascular Risk Reduction

The mere replacement of saturated fatty acids (SFA) with polyunsaturated (PUFA) fats or monounsaturated (MUFA) fats partially may reduce the amount of fasting serum or plasma total cholesterol and LDL cholesterol. In the case of dietary fat quality, we tend to consider the proportionality of saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fat. It also involves verification of quantities and balance of the essential fatty acids like the linoleic acid (LA) and alpha-linolenic acid (ALA) and the long chain omega 3 fatty acids (n-3 LCPUFA) such as eicosatetraenoic acid (EPA) and docosahexaenoic acid (Schwab et al., 2014). Consumption of polyunsaturated fatty acids (PUFA) in combination with an intake reduction of saturated fatty acid (SFA) has long been play a part in preventing cardiovascular diseases. Nevertheless, the American Diabetes Association does not particularly emphasize the importance of linoleic acid (LA) as an important component of the dietary quality in the prevention of diabetes. This could be due to the fact that there are no clinical trials that explicitly aim at the evaluation of diabetes incidence as a primary outcome (Schulze, 2021).

Replacement of saturated fats by other macronutrients, especially polyunsaturated fats, has been associated with reduced cardiovascular disease. Further research evidence on the general population supports the conviction in such conclusions. Although additional studies are necessary to give a more specific range of advice on the dietary inclusion of fat and cardiovascular risk in patients with type 2 diabetes, the existing data indicate that it is necessary to replace saturated fat in the diet with other types of macronutrients in the diet, including polyunsaturated fats (Schwab et al., 2021).Metabolic research has indicated that saturated fat actually reduces the insulin sensitivity, and unsaturated fats most often increase the rate of glucose metabolism. Replacing saturated fats with monounsaturated fats is likely to have a positive effect on the lipoprotein profiles and better glycemic regulation in individuals with type 2 diabetes (Tanasescu et al., 2004). The participants of the ACCORD study were actually not bad at switching their game with food: reducing fat somewhat in one full year and maintaining this till the 3-year mark. That little reduction in fat actually contributed to reducing triglycerides

and body weight by the first year, but had little effect on such parameters as HbA1c, blood pressure, and HDL/LDL (Kirk et al., 2013).

Dietary fat is a combination of fatty acids - primarily saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA). The quality of these fats, however, may even have an effect on the chance of getting type 2 diabetes since the research conducted demonstrates various results on the insulin sensitivity, when you are consuming either SFA, n-6 PUFA that it has or n-3 PUFA. As low insulin sensitivity is one of the greatest risk factors of diabetes type 2, the quality of fats in diet might be improved to reduce the cases of diabetes type 2 among the population (Galgani et al., 2008).

The mechanisms by which dietary fatty acids are related to the risk of diabetes are poorly understood even though traditionally it is believed that the quality of fats is the main determinant of the cell membrane fatty acid composition, and consequently, cell membrane functionality (Risérus et al., 2009). All-cause mortality, cardiovascular disease (CVD), coronary heart disease (CHD), ischemic stroke, and type 2 diabetes are factors that are not associated with saturated fats. Conversely, trans fats have been linked to higher all-cause mortality, total CHD and CHD-related death probably because of high intake of industrial trans fats as opposed to ruminant trans fats (de Souza et al., 2015). The physiological functions of adipokines propose that the changes of their production and release in obesity could cause the occurrence of obesity and associated ailments. Controlling adipokines may provide new approaches to preventive and curative measures of obesity, diabetes type 2 and heart diseases (Goralski and Sinal, 2007). The change in the metabolic risk pattern has been associated with abdominal obesity, assessed by anthropometry, and excessive visceral or ectopic fat, determined by imaging. A combination of these metabolic abnormalities predisposes to type 2 diabetes and different heart diseases (Després, 2012).

The derivatives of fatty acids influence energy metabolism through activating the receptors of the insulin activity and lipid metabolism named peroxisome proliferator-activated receptors (PPARs). An increase in insulin sensitivity, lipid profiles, and cardiovascular risk can be achieved using PPAR -binding drugs, including PPAR agonists (e.g., thiazolidinediones) and PPAR activators (e.g., fibrates). In addition to that, agents that inhibit both PPAR and PPAR g may have even greater utility in the prevention of type 2 diabetes and cardiovascular disease (Lebovitz, 2005). Diabetes patients also tend to have a shift in the distribution of body fat due to the disease and medications that are normally used (19-21). Nevertheless, I do not know how geographical fat accumulation actually relates to cardiometabolic outcomes in diabetic individuals (Qiu et al., 2024). Mediterranean diet, which is full of unsaturated fats, serves to reduce the level of fasting glucose, in fact, reduces the risk of developing type 2 diabetes. Here, Esposito et al. (n‘=215) divided individuals who just received the diagnosis of type 2 diabetes into two groups which were fed either on Mediterranean-style or low-fat. Four years later, the participants of the Mediterranean diet not only reduced more weight, but also enjoyed better blood sugar regulation than the low-fat group (Billingsley et al., 2024).When genetic risk is neglected, replacement of refined starches and sugars with polyunsaturated fats appears to reduce the risk of type 2 diabetes, yet replacement of carbs with monounsaturated fats may go against one and increase the risk. The information also correlates with the existing knowledge about the blood sugar reactions, polyunsaturated fats only benefit when substituting total power. In essence, this supports the health promotion initiative by the masses favoring polyunsaturated fatty foods such as nuts, seeds and fatty fish (Merino et al., 2019)

5. Energy Restriction and Weight Management Diets

Overweight and obesity are excessive body weights that are a significant risk factor in the onset of type 2 diabetes mellitus (T2DM). Approximately, 3 out of 4 T2DM patients are overweight or obese. Weight reduction will greatly enhance metabolic health and even the slightest loss of 5-10% of body weight will result in better glycemic control, lipid profiles and blood pressure (Carter et al., 2016). With the ongoing increase in level of obesity among the general population, excess body fat is being

increasingly witnessed among patients with type 1 diabetes. Studies indicate that obesity is also a possible cause of the early occurrence of diabetes type 1 among young people. This is even aggravated by the fact that intensive management of diabetes is usually associated with weight gain. The subsequent consequences are well-recorded and comprise heightened insulin resistance, worsening of glycemic control, the need to take more medications, and the risk of cardiovascular complications (Overland et al., 2018).

Weight loss is found to reduce blood glucose and enhance insulin sensitivity. Major weight loss may even lead to a type 2 diabetes mellitus (T2DM) remission (Gray et al., 2021). Even a small weight reduction of 5% of overall body weight can result in better glycemic regulation in people with T2DM who are overweight or obese. The long-term cohort studies indicate that variations in body mass index (BMI) are highly predictive of variations in the levels of HbA1c. Patients who lose weight have a higher probability of achieving their target HbA1c than those who do not change their weight or gain weight (Wilding, 2014). Any restrictive energy diet will invariably produce and maintain weight loss, either by constrained total energy, by particular food classes, or by particular nutrients, so long as it is not wholly compensated by augmented caloric intake or diminished energy expenditure. Even though there are more effective approaches that are more effective with certain people or practitioners, specific dietary compositions can be more effective in attaining the best weight management (Churuangsuk et al., 2022)

Calorie restriction (CR) is a type of diet that has enough nutrients and minimizes total energy consumption. It has been shown that calorie restriction enhances sensitive insulin and attenuates the acute insulin reaction to glucose in case of obese individuals. As a matter of fact, insulin sensitivity can be increased by a maximum 40% and there is also increased β-cell sensitivity to glucose. In one study, four dietary phases were followed by seven obese patients with non-insulin-dependent diabetes mellitus (NIDDM), including the maintenance of weight over seven days, calorie restriction to 800 kcal/day over seven days, a two-month weight loss diet (very low-calorie diet 400 kcal/day) followed by four weeks of gradual refeeding, and (iv) and a calorie restriction of seven days at 800 kcal/day. The outcome of this intervention was a high reduction of body weight/BMI, which dropped down to 27.5 ± 1.3 from 32.8 ±2 kg/m2. There were significant decreases in fasting plasma glucose, hepatic glucose production, and fasting plasma triglycerides, as well as, increases in insulin sensitivity and insulin secretion with even short-term calorie restriction (800 kcal/day) (Shakoor et al., 2021).

The efficacy of low-fat diets in preventing and treating diabetes is questionable, as low-fat diets usually contain a greater percentage of carbohydrates, which is the main nutrient that influences the levels of postprandial blood glucose and insulin secretion (Sylvetsky et al., 2017). High-carbohydrate, high-fiber, low-fat diet is also found to lead to loss of weight in high-risk adults of developing type 2 diabetes. A low carbohydrate diet (LCD) is a diet where carbohydrates are restricted to less than 130g of total daily energy or less than 26% of total daily energy as carbohydrates. As it is evident now, the American Diabetes Association (ADA) remarks that lowering carbohydrates in diets is as effective at weight loss as low-fat and calorie-restricted diet (Meng et al., 2017). Low-carbohydrate diets (LCDs) also have been demonstrated to be effective in obesity management by decreasing total body fat and body mass index (BMI). They are also linked to positive changes in cardiovascular risk factors, such as decreased blood pressure, low-density lipoprotein (LDL), and triglyceride levels and increases in high-density lipoprotein (HDL). In the presence of diabetes mellitus, there is evidence that LCDs reduce insulin resistance, lower the levels of fasting blood glucose and HbA1c (Pavlidou et al., 2023).

Among the most common and studied dietary patterns is the Mediterranean diet (MD) that has been associated with reduced risk of various chronic diseases, including metabolic ones such as diabetes and obesity. The InterAct Consortium study (2011) examined how the MD is related to the risk of developing insulin-independence diabetes and the researchers determined that a close adherence to the diet resulted in a significantly reduced risk of developing this type of diabetes. In a similar

study, a 112,493-adults cohort study of UK Biobanks, who were aged 40-69 years old and had neither cardiometabolic disease nor insulin-independent diabetes showed that increased adherence to the MD was linked to a lower risk of diabetes (Pavlidou et al., 2023). Intermittent energy restriction (IER) is a type of eating that involves both the short periods of reduced food intake and the unrestricted eating. Experiments in obese animals demonstrate that IER has the potential to decrease glucose and insulin levels, which suggests its possible usefulness in the prevention of type 2 diabetes (T2D) (van den Burg et al., 2023). In a meta-analysis of 12 studies on interventions lasting at least one month and involving 545 participants in total, it was found that intermittent energy restriction (IER) reduces fasting glucose levels and HOMA-IR significantly (Stanek et al., 2022). Intermittent energy restriction (IER) can be regarded as safe in patients with type 2 diabetes whose management is not based on medication, and the risk of hypoglycemia is low or has no impact. IER however needs changes in medication, and close monitoring especially in the initial stages to those taking sulfonylureas and/or insulin (Carter et al., 2018).

High-protein diets (HPD) and standard-protein diets (12%-16% of energy as protein) are both effective in reducing body weight and fat in obese people, but HPDs are more effective. Protein comes with benefits over carbohydrates in increasing satiety and energy expenditure, which contributes to a negative energy balance in people and leads to weight loss. A prospective cohort study established that each 1 kg of weight loss lowers the risk of type 2 diabetes by 16%. A meta-analysis also noted that a 2.56-3.42 kg average of weight loss interventions were linked to an 18% decreased all-cause mortality risk (Ma et al., 2023). It is believed that insulin resistance is caused by a sedentary lifestyle, changes in glucose metabolism and mitochondrial functionality in age. It has been established that combining diet with exercise is of great importance in reducing the plasma insulin levels and enhancing insulin sensitivity in middle aged obese and older overweight. An Increasing global rate of type 2 diabetes (T2D) is creating immense social, individual, and economic consequences. The patients of T2D usually exhibit hyperglycemia because the process of glucose regulation deteriorates over time. Certain causes of disease development and onset include high-calorie diets and physical inactivity. There is ample evidence to support the idea that physical activity and dietary interventions have the potential to diminish morbidity and mortality in patients with T2D. To combat this global health challenge, the strategies that should be implemented involve physical activities, and reversal of the condition at the population level. T2D has also been managed by calorie-restricted diets. Hence, future studies ought to examine long-term lifestyle interventions such as very low-calorie diets with exercise to determine their effect on T2D remission (Shakoor et al., 2021). As the prevalence of obesity and type 2 diabetes increases, the importance of effective long-term treatment of T2D will become more crucial. New approaches are required to boost enduring management and with diabetes ever rising in popularity, prevention is coming to the fore. Among the approaches to be examined in the future are intensive lifestyle changes like residential programs; public health and community-based strategies to change environmental aspects that decrease physical activity and promote energy consumption, and more vigorous approaches to weight maintenance (Hensrud, 2001).

6. Culturally adapted and patient centered dietary interventions

Nutrition adaptation or cultural modification of nutrition programs has been promising in enhancing issues of dietary intake. Nevertheless, such changes should be made with a lot of care so that the current dietary disparities are not enhanced unintentionally (Livingstone et al., 2023) Although the customization of strategies by cultures makes them more relevant and acceptable, they must be planned well to create balanced access and value to the various populations. Patient-centered care focuses on the identification and observance of the needs, values, preferences, and psychosocial environment of an individual in the provision of healthcare. This method is related to better decision-making, enhanced patient-provided communication, and a better quality of life among people who live with

diabetes. Nutrition support clinicians use patient-centered and evidence-based models to make individuals go through nutrition therapy choices affecting clinical outcomes and well-being (Wedemire et al., 2022). Precision or personalized nutrition in the management of diabetes has become more viable as a result of technological progress. One broadly applicable diet cannot be universal in a population with a varied genetic makeup and dietary practices. Personalized nutrition programs provide better advice compared to universal population-based interventions. To provide more precise and dynamic nutritional guidance, personalized nutrition focuses on offering an alternative to the general population-level nutritional recommendations (Chen and Chen, 2022) Patient-centered care should be based on the understanding that people with diabetes are different. The variations in cultural background and lifestyle, as well as experience of life lived, render the standardized counseling methods inappropriate. Eating habits are tightly connected with the cultural practices and lead to individual and group identities. Social determinants that influence them include the family structure, social networks, religion, education, health literacy, body perception, food access, and environmental factors. Thus, the cultural, social, environmental, and personal factors should be included in diabetes nutrition education. It is still important to address the needs of various populations (Shapiro and Grajower, 2024). Social and cultural factors have a strong impact on adherence to the dietary recommendations in diabetes. Cultural diversity, preferences of food, local food availability, and poverty should be taken into account when developing health-promotion programs (Juárez-Ramírez et al., 2019).The level of diabetes in Asia has reached epidemic levels and culture and dietary practices have been a factor in this rise. The major staple food in the Asian diet is rice and other carbohydrates are taken less often. Excessive intake of white rice has been identified with the rise in diabetes frequency and prevalence (Medagama and Widanapathirana, 2015)

These results underscore the relevance of the consideration of food habits that prevail in cultures during the intervention planning. Diabetes management is also influenced by religious beliefs. In Indian migrants, the participants said that prayer decreased stress and managed diabetes better, and some thought that they could prevent or cure disease through blessings by religious leaders. Health behaviors are thus subject to religious views. These beliefs should be considered by healthcare professionals, religious leaders addressed when necessary, and management strategies should be developed in a way that the faith is not interfered with, but the misconceptions are corrected (Ahmad et al., 2022). Patient-centered communication is the practice of active listening to patients and allowing them to be involved in the process of decisions. The study indicates that more adherence is produced with patient-centered communication. The aspects of provider-patient interaction of high quality are linked to better self-management and self-efficacy. Nonetheless, self-management needs to be committed to good eating habits, physical exercises, blood glucose monitoring, and medication adherence to be effective. Lifestyle lifelong work cannot be achieved without pharmacotherapy only (Chen et al., 2024). Individualized nutrition plans involve the examination of the present dietary habits, tastes and metabolic objectives. The goals of nutrition therapy are to be developed jointly. The strategies of meal planning should be based on the cultural inclinations, literacy, preparedness, and capability of transforming. Patients should be assisted to meet metabolic goals with respect to their preferences (Franz et al., 2014). The adherence to the dietary recommendations is also influenced by social support and the socioeconomic status. These are some of the modifiable factors that should be considered by the healthcare providers to achieve better outcomes (Doglikuu et al., 2021). The concept of shared decision-making (SDM) has been actively encouraged to enhance patient-centered communication in chronic care. SDM is a participatory exercise where healthcare decisions are made by the providers and the patients together. It blends intellectual knowledge, emotional involvement as well as relationship co-operation. Using SDM, patients are more conversant with the health outcomes and make decisions that are in line with their

expectations and cultural values. In diabetes care, SDM facilitates the education of diet, bridges knowledge gaps, especially in older adults, and helps to combat difficulties associated with the planning of the diet (Zhang et al., 2024). Replacement with low glycemic index foods has been proved to lower the levels of HbA1c as well as more acceptable when some culturally familiar foods are used. The lack of glycemic control leads to increased complications as opposed to Europeans. Lack of motivation, poor nutrition awareness, poor lifestyle adherence to advice, ignorance of the severity of the disease, and poor family support make diabetes management in this group more difficult (Farhat, 2023). The health eating pattern is one of the best interventions in the self-management of diabetes. The barriers are related to food cost, inaccessibility to healthy foods, cultural food habits, and inability to change the eating habits to accommodate diabetes-friendly foods. Poor cooking experiences and poor understanding of serving sizes make the preparation of the meals difficult. Dietary management can be enhanced through education on good cooking and monitoring of carbohydrates. Some of the practical steps involve the reduction of added salt, using herbs and spices, substituting solid fat with vegetable oils, reducing sugar and fat in recipes, increasing the amount of fiber consumed, selecting healthier methods of cooking, adding vegetables to meals, checking nutrition labels, and cooking at home (Venkatesh et al., 2024). Diabetes management and prevention of complications have remained focused on a balanced diet. Goal-focused lifestyle interventions with video education, culturally appropriate, have been shown to lead to better clinical outcomes, health literacy, and self-care behaviors (Pardhan et al., 2023). Dietary adherence has always been reported as the most challenging part of diabetes management by the patients. Even though the primary care providers are some of the most important providers of nutrition education, they claim that they have inadequate training and little time. Nutrition counseling can be delegated, and the practitioner might be unaware of the environmental and cultural barriers that patients experience (Bross et al., 2022).

Conclusion:

This narrative review emphasizes that dietary interventions involve a cornerstone of diabetes management with strong evidences involves significant benefits. Multiple Randomized control trials and meta-analysis results that organized dietary patterns produce clinical reduction in HbA1C and fasting glucose, improves body weight, lipid profile. Variability in diet defines and sustainability remains challenges. It affirms that individualized evidence based dietary strategies are essential components of diabetes management, increased clinical results, and reduce disease burden. Nutrition Counselling and dietary education interventions play a significant role in disease prevention and management. The type 2 diabetes mellitus patients require diabetes management education includes dietary management through health care providers to motivate, empower and encourage them and talks about nutritional habits, dietary behaviors and food preparations. They should have orientations about family, thoughts, beliefs, traditions and social norms. Active and effective dietary education is essential to combat disease, reduce the onset and risk of progression of disorder, reduce the symptoms, and prevent the comorbidities.

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