



Review: Dietary Intake and Type 2 Diabetes

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ABSTRACT

Diabetes occurs as a result of deficient insulin or inability of the body to make use of insulin effectively. Some range of dietary interventions can provide useful approaches for managing people with type 2 diabetes, including the regulation of blood glucose and lipid parameters, and for reducing the risks of acute and chronic diabetic complications. Dietary intake is measured to assess food, nutrient, or bioactive intake of individuals, groups, or populations. The purpose of collection of measurements varies from individual assessments in clinical situations or the adequacy of intake of population groups to use in research, relating diet to health status. Dietary intake measurement also determines daily eating pattern of an individual including specific foods and calories consumed and relative quantities. The role of vitamin D diet in glucose homeostasis is associated with insulin secretion, insulin resistance, and systemic inflammation and this is one of its important non-skeletal functions. In addition, there is a link between the consumption of dairy products and a lower risk of type 2 diabetic. Moreover, a low glycemic index (GI) diet is more effective in controlling glycated hemoglobin and fasting blood glucose than a high GI diet in patients with type 2 diabetes. Nutritional approaches employed in managing patients with type 2 diabetic may also involve the use of enteral nutrition, including oral nutritional supplements (ONS). In conclusion, in order to reduce the problems of diabetes, lifestyle changes usually dietary interventions, are adopted.

Keywords: Diabetes, Diet, Health, Nutrients, Hyperglycemia

INTRODUCTION

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone secreted by the pancreas that regulates blood sugar. Hyperglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes and over time leads to serious damage to many of the body's systems, especially the nerves and blood vessels. Diabetes is a metabolic condition that is characterized by chronic hyperglycemia and results from interplay of genetic and environmental factors 29,12,4. Its prevalence is on the increase in the UK and worldwide, partly due to changes in lifestyle that predispose individuals to obesity and being overweight 29,12,26. It is estimated that about 90% of adults currently diagnosed with diabetes have type 2 diabetes and based on a World Health Organization (WHO) report, about 422 million adults were living with diabetes in 2014 compared with 108 million in 1980 and this condition caused about 1.5 million deaths in 2019³⁶. The United States of America has about 30.3 million adults living with diabetes, and 1.5 million estimated new diabetes cases are diagnosed every year, representing an increasing prevalence of this condition¹⁸. Diabetes presents a major public health challenge despite the developments in technology and the pharmaceutical industry¹⁸. These problems may be in the form of acute or chronic complications and changes in body composition can be profound. In this regard, Almusaylim conducted a cross-sectional and longitudinal study to evaluate the associations between variations in glycemic status and changes in total body, trunk, appendicular fat mass, and lean mass in men. The longitudinal analyses demonstrated that changes in total body fat mass and lean mass, and appendicular lean mass differed among glycemic groups. In addition, glucose dysregulation was found to be related to adverse changes in total body and appendicular lean mass³.

In 2014, 8.5% of adults aged 18 years and older had diabetes. In 2019, diabetes was the direct cause of 1.5 million deaths. To present a more accurate picture of the deaths causes by diabetes, however, deaths due to higher-than-optimal blood glucose through cardiovascular disease, chronic kidney disease and tuberculosis should be added. In 2012, there were another 2.2 million deaths due to high blood glucose. Between 2000 and 2016, there was a 5% increase in premature mortality from diabetes. In high-income countries the premature mortality rate due to diabetes decreased between the year 2000 and 2010 but then increased between 2010 to 2016. In lower-middle-income countries, the premature mortality rate due to diabetes increased across both periods. By contrast, the probability of dying from any one of the four main non-communicable diseases (cardiovascular diseases, cancer, chronic respiratory diseases or diabetes) between the ages of 30 and 70 decreased by 18% globally between 2000 and 2016.

Types of diabetes

Type 1 diabetes

Type 1 diabetes (previously known as insulin-dependent) is characterized by deficient insulin production and requires daily administration of insulin.

Type 2 diabetes

Type 2 diabetes (formerly called non-insulin-dependent) results from the body's ineffective use of insulin. The majority of people with diabetes have type 2 diabetes. This type of diabetes is largely the result of excess body weight and physical inactivity. Symptoms may be similar to those of type 1 diabetes, but are often less marked. As a result, the disease may be diagnosed several years after onset, after complications have already arisen. Until recently, this type of diabetes was seen only in adults but it is now also occurring increasingly frequently in children. It's often linked to being overweight or inactive, or having a family history of type 2 diabetes. Symptoms include excessive and frequent excretion of urine (polyuria), thirst (polydipsia), constant hunger, weight loss, blurred vision and fatigue. These symptoms may occur suddenly. Treatments include diet, exercise, medication and insulin therapy.

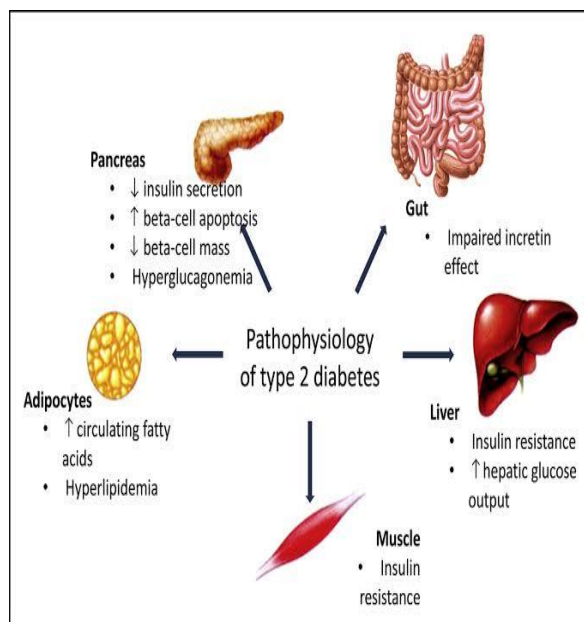


Figure 1; Pathophysiology of Type 2 Diabetes (DeFronzo *et al.*, 2015).

Dietary intake

Dietary intake measurements are used to assess food, nutrient, or bioactive intake of individuals, groups, or populations. The purpose of collection of measurements varies from individual assessments in clinical situations (nutrition screening) or the adequacy of intake of population groups (nutrition surveillance) to use in research relating diet to health status, particularly in epidemiology. Measurements are also used to establish exposure to food-borne contaminants, in the evaluation of nutritional intervention programs, and to develop nutritional guidelines for governmental health policy. Dietary intake also refers to the daily eating patterns of an individual, including specific foods and calories consumed and relative quantities. Dietary Reference Intakes (DRIs) is a generic term for a set of nutrient reference values that includes the Recommended Dietary Allowance (RDA), Adequate Intake (AI), Tolerable Upper Intake Level (UL), and Estimated Average Requirement (EAR).

Health impacts

Over time, diabetes can damage the heart, blood vessels, eyes, kidneys, and nerves. Adults with diabetes have a two- to three-fold increased risk of heart attacks and strokes¹⁶. Combined with reduced blood flow, neuropathy (nerve damage) in the foot increases the chance of foot ulcers, infection and eventual need for limb amputation.

Diabetic retinopathy is an important cause of blindness, and occurs as a result of long-term accumulated damage to the small blood vessels in the retina. Diabetes is the cause of 2.6% of global blindness¹⁶.

Diabetes is among the leading causes of kidney failure¹. Modest weight loss of 5-10 kg in one year can significantly improve health outcomes.

Key facts

The number of people with diabetes rose from 108 million in 1980 to 422 million in 2014. Prevalence has been rising more rapidly in low- and middle-income countries than in high-income countries. Diabetes is a major cause of blindness, kidney failure, heart attacks, stroke and lower limb amputation. Between 2000 and 2016, there was a 5% increase in premature mortality from diabetes. In 2019, an estimated 1.5 million deaths were directly caused by diabetes. Another 2.2 million deaths were attributable to high blood glucose in 2012. A healthy diet, regular physical activity, maintaining a normal body weight and avoiding tobacco use are ways to prevent or delay the onset of type 2 diabetes. Diabetes can be treated and its consequences avoided or delayed with diet, physical activity, medication and regular screening and treatment for complications.

Dietary studies on type 2 diabetes

In one of the dietary studies, the role of vitamin D status, calcium intake, and the risk of developing type 2 diabetes was examined. According to the authors, the role of vitamin D in glucose homeostasis appears to be its association with insulin secretion, insulin resistance, and systemic inflammation and this is one of its important non-skeletal functions²⁵. In addition, there seems to be a link between the consumption of dairy products and a lower risk of type 2 diabetes and this has been demonstrated in many observational studies although the mechanism and the role of calcium intake in the risk of developing this condition have not been well established²⁵. Therefore, a randomized controlled trial on the role of vitamin D and calcium in the development of type 2 diabetes will further elucidate our understanding of the mechanisms of action of these micronutrients²⁵. In a related study cardiovascular risk factors and their association with vitamin D deficiency based on a nationally representative sample of 3260 young Mexican women was explored. The authors found that the prevalence of vitamin D deficiency among the women aged 20 to 49 years old was a public health problem and that obesity, type 2 diabetes, and high total cholesterol were found to be associated with vitamin D deficiency⁸.

On the other hand, an author conducted a systematic review and meta-analysis in order to evaluate the effect of dietary, supplementary, and total zinc intake and status on the risk of developing type 2 diabetes. This was based on the understanding that zinc may have a protective role against type 2 diabetes¹⁶. The results showed that a moderately high dietary zinc intake based on the 'Dietary Reference Intake' may reduce the risk of type 2 diabetes by 13% and up to 41% in rural settings¹⁶. In contrast, elevated serum/plasma zinc concentration was found to be associated with an increased risk of type 2 diabetes in the general population, although no relationship was established between total or supplementary zinc intake and type 2 diabetes¹⁶. The relationship between the dietary intake of zinc, potassium, calcium, and magnesium and glycemic control in patients with diabetes was explored⁶. Apart from evaluating the association between micronutrients and the risk of type 2 diabetes, the role of macronutrients and other metabolites in the development of this condition have been studied extensively. *Song* and *Lee* sought to examine whether dietary patterns that explain the variation of the triglyceride (TG) to high-density lipoprotein cholesterol (HDL-C) ratio were associated with the incidence of type 2 diabetes in Korean men and women³². The authors found evidence that suggests that dietary patterns associated with low levels of TG/HDL-C ratio may have the potential to reduce the risk of type 2 diabetes³².

Based on the above, it is essential that dietary management approaches that are tailored to meet the needs of people with type 2 diabetes reflect these elements that are aimed at reducing the risk of acute and chronic complications. In this regard, it was noted in a narrative review that there is evidence that suggests the possible reversal of this condition through interventions and these have been incorporated into guidelines¹⁸. These approaches may involve the use of bariatric surgery, low-calorie diets, or carbohydrate restriction¹⁸. In particular, the American Diabetes Association and the European Association for the Study of Diabetes have recommended a low carbohydrate diet and support the use of short-term low-calorie diets for weight loss.

A protocol was developed for a longitudinal study on evaluating how diet changes with the diagnosis of diabetes. It has been observed that the quality of diets plays a significant role in assisting people with type 2 diabetes to manage their condition and thus reduce the risk of developing diabetes-related complications⁷. This is because diet quality is the extent to which food intake complies with national or international dietary guidelines or a prior diet quality score and it influences glycemic control in people with type 2 diabetes and has a significant impact on the risk of complications¹⁶. It often includes the macronutrient components of the diet. Thus, researchers summarized the research evidence on randomized controlled trials of the effect of dietary polyunsaturated fatty acids (PUFAs) on glycemic control in people with type 2 diabetes: This study was based on the fact that replacing saturated fatty acids (SFAs) with PUFAs decreases blood cholesterol levels and prevents cardiovascular diseases and that fat quality may also affect insulin sensitivity and increase the risk of type 2 diabetes³³. Evidence from prospective studies have also shown that a high intake of SFAs can increase the risk of type 2 diabetes, while a high intake of PUFAs reduces the risk of the condition³³. Based on this review, while about half of the studies that examined the effect of fish, fish oils, vegetable oils, or nuts found changes related to glycemic control in people with type 2 diabetes, the other half found no effects³³. In addition, it remains unclear whether PUFAs from marine or vegetable sources affect glycemic regulation differently and this is a potential area for future research³³.

What is clear, however, is that a low glycemic index (GI) diet is more effective in controlling glycated hemoglobin and fasting blood glucose than a high GI diet in patients with type 2 diabetes²⁷. In a further systematic review and meta-analysis, a study sought to evaluate the effects of a low GI diet on the cardio-metabolic and inflammatory parameters in patients with type 2 diabetes and in women with gestational diabetes mellitus (GDM) and examine whether the effects are different in these conditions²⁷. While 10 randomized controlled studies were included in the systematic review, only 9 were selected for the meta-analysis²⁷. The results of the meta-analysis found no significant differences ($p > 0.05$) between the low GI and higher GI diets with respect to total cholesterol, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol in patients with type 2 diabetes²⁷.

Nutritional approaches employed in managing patients with type 2 diabetes may also involve the use of enteral nutrition, including oral nutritional supplements (ONS)⁴. The effectiveness of these diabetes-specific formula (DSF) and standard formulas on glycemic control and lipid profile in patients with type 2 diabetes continues to generate interest. Based on this, a study used a systematic review and meta-analysis of randomized controlled trials to evaluate the effect of diabetes-specific enteral nutrition formula on cardio-metabolic parameters in patients with type 2 diabetes²⁹.

American Diabetes Association for the Study of Diabetes have recommended a low carbohydrate diet and support the use of short-term low-calorie diets for weight loss¹³.

A low carbohydrate diet (LCD), replacing some staple foods with nuts such as tree nuts and groundnuts, has been shown to reduce weight, improve blood glucose, and regulate blood lipid in type 2 diabetes²⁰. The management of type 2 diabetes may also include the administration of insulin. But questions remain whether the dose of insulin before a meal should be based on glycemia or meal content²⁰. A study reviewed existing guidelines and

scientific evidence on insulin dosage in people with type 1 and type 2 diabetes and explored the effect of the meal composition such as carbohydrate, protein and fat on postprandial glucose²³. The authors found that in most current guidelines aimed at establishing prandial insulin doses in type 1 diabetes, only carbohydrates are counted, whereas in type 2 diabetes the meal content is often not taken into consideration. Therefore, it was concluded that prandial insulin doses in managing people with diabetes should take into account the pre-meal glycemia, as well as the size and composition of the meals²³.

According to the American Diabetes Association (ADA), a Mediterranean-style diet, a plant-based diet, and a diet known as Dietary Approaches to Stop Hypertension (DASH) are all good for the reduction in the incidence of type 2 diabetes¹³.

General guidance on healthy eating

General guidance on healthy eating from the NHS will generally be based upon the following set of guidelines: Increasing intake of low GI carbohydrate foods, Increasing fruit and vegetable intake, Reducing saturated fat intake, Reducing sugar intake, Reducing salt, Safe and sensible alcohol consumption

Low fat diet

A low-fat diet is typically not a low-carbohydrate diet. Whilst low-calorie, low fat diets can lead to weight loss, they are not very effective at improving blood glucose levels. Low fat diet consists of vegetables, fruit, starches, protein and low fat dairy products³⁴. When compared against low-carbohydrate diets, low-fat diets typically perform poorly in terms of blood glucose control and are ineffective at helping people to reduce their dependence on diabetes medication. Long-term studies have also showed that low-fat diets perform poorly in terms of preventing heart disease. For these reasons, the low-fat diet advised by the NHS is currently facing scrutiny from prominent doctors and health campaigners²¹.

The Mediterranean Diet

The Mediterranean diet refers to diets that are based around fresh foods, a strong intake of vegetables and natural sources of fat. Mediterranean diet includes plant foods, minimally processed, locally grown food, fresh fruits, olive oil as main source of dietary lipid¹⁹

According to one meta-analysis, Mediterranean diet compared to other diet improved glycemic control by reducing hemoglobin A1c of about -0.47%². The diet has varied quite substantially in research trials, with some trials testing low-carbohydrate Mediterranean diets and other trials using a higher-carbohydrate, whole grain version of the diet.

Very-low calorie diets

A very-low-calorie diet was studied in 2011, in Newcastle University where researchers stated its positive effects on type 2 diabetes in a small study of 11 participants. The diet used involved meal replacement shakes which provided 600 kcal, plus participants were able to have up to 200 kcal from non-starchy vegetables. The shakes used provide around 20g of carbohydrate per serving and the diet was therefore low in carbohydrate as well as being very low in calories. In a larger trial, that is currently running, initial findings show that the average weight loss was 14kg and diet had helped 40 per cent of participants to reverse their type 2 diabetes 6 months after the diet period had been completed¹⁷

Raw food diet

A raw food diet is based around foods that are eaten raw such as vegetables, fruit and nuts. The diet is typically relatively low in carbohydrate as starchy foods usually need to be cooked. The raw food diet has seen some impressive anecdotal results, with people reporting that they have lost significant weight and reduced their medication requirements²². Studies that are not diabetes-specific indicated that long-term adherence to raw food diets can lower total cholesterol but also lowers levels of HDL cholesterol which is needed to protect against heart disease²¹. So far, there is a lack of clinical trials to investigate how effective the diet may be in treating diabetes in the general population.

High Protein Diet and Type 2 Diabetes

The American Diabetes Association (ADA) recommends lean proteins low in saturated fat for people with diabetes¹⁷. Getting enough and the right balance of protein may be more challenging for a vegan or vegetarian, but foods like beans (dried or canned beans, and bean products like hummus and falafel), nuts and nut spreads, is a good source of protein for vegans¹⁷. It is essential to keep portion size in mind when snacking on nuts, as they are also high in fat and calories. The American Heart Association (AHA) counts a small handful (roughly 1.5 ounces) of whole nuts as one serving. If you opt for unsalted almonds, 1.5 ounces will provide 258 calories and nearly 23g of fat, per estimates¹³

Meanwhile, processed or packaged foods should be avoided or limited in your diabetes diet because, in addition to added sugars and processed carbohydrates, these foods are often high in sodium. Getting too much sodium in your diet can increase your blood pressure and, in turn, the risk of heart disease or stroke¹³. It is important to keep your blood pressure in check when managing diabetes. In addition to getting enough fiber,

incorporating protein-rich foods in your diet can help keep you satiated and promote weight loss according to a study. Losing just 5 percent of body weight has been shown to improve blood sugar control in overweight and obese individuals with type 2 diabetes¹

Best Diabetic Diet according to the ADA¹²:

Fish high in omega-3 fatty acids, such as salmon, sardines, Albacore tuna, mackerel, and rainbow trout. Shellfish, including clams, crab, imitation shellfish, lobster, scallops, shrimps, and oysters, Skinless turkey, skinless chicken, Beans and legumes, Cottage cheese, Nuts like almonds, cashews, pecans, walnuts, and peanuts. Nut spreads, like almond butter, Nut butters (in moderation), Avocados, Olives, Plant-based oils, like soybean oil, corn oil, olive oil, and sunflower oil, Seeds, like flaxseed and chia seed, Brown rice, Barley, Whole-grain breads, such as 100 percent whole-wheat bread, Whole-grain cereal, such as oats, Whole eggs and Tofu.

Worst Diabetic Diet according to the ADA¹²:

Beef (turkey is an acceptable option), hot dogs, sausages and pepperoni, bacon and salt pork, Sweetened or flavored nuts, like honey-roasted or spicy, sweetened protein shakes or smoothies, Fast food, Full-fat dairy products, Coconut and palm oil, Packaged snacks, like crackers, corn chips, and potato chips, Processed sweets, like doughnuts, cakes, cookies, and muffins, Stick margarine and butter, White bread, white rice, white pasta, Pastries, Sugary breakfast cereals, Sodas, refined sugars, processed carbohydrates, trans fats, high-fat animal products, high-fat dairy products, high fructose corn syrup, artificial sweeteners, and any highly processed foods, Contrary to popular belief, not all carbohydrates should be avoided in managing diabetes. In fact, the ADA recommends vitamin-rich whole grains in a healthy diabetes diet¹² These foods contain fiber, which are beneficial for digestive health. Fiber can also promote feelings of fullness and can help slow the rise of blood sugar¹².

On the other hand, grains such as white bread, as well as sugary, processed, or packaged grains, should be avoided or limited to help prevent increase in blood sugar level. Dietary fiber slows the breakdown of starch into glucose (sugar), which helps keep blood sugar levels steady.

Importance of Diet in type 2 diabetes

Diet help to control blood sugar (glucose) level, manage weight and control heart disease risk factors, such as high blood pressure and high blood fats¹⁷ High calories and fat, creates an undesirable rise in blood glucose level²². Therefore, in order to reduce the problems of diabetes, management strategies usually include dietary interventions and lifestyle changes such as increased physical activities. Sometimes, diabetes may co-exist with other conditions such as stroke and these may present unique challenges in relation to nutritional interventions⁴. Good glycemic control can help in preventing long-term complications of type 2 diabetes after eating.

A guideline for a good eating habit for diabetic people; Fill one-half your plate with nonstarchy vegetables. One-fourth of your plate should feature your protein (such as meat or a plant-based source), and the final fourth should include a grain or other starch, such as starchy vegetables, a piece of fruit, or a small glass of milk. Processed and sugary foods such as soda, candy are unhealthy for diabetes patients and should be limited in the diet¹³.

Healthy diabetes meal plans include plenty of vegetables, and limited processed sugars and red meat. Diet recommendations for people with type 2 diabetes include a vegetarian or vegan diet, the American Diabetes Association diet (which also emphasizes exercise), the Paleo Diet, and the Mediterranean diet¹⁷

Oral Medications for Type 2 Diabetes

Currently, there are nine drug classes of oral diabetes medications approved for the treatment of type 2 diabetes²⁰; Sulfonylureas, for example, glimepiride (Amaryl) and glipizide (Glucotrol, Glucotrol XL) Meglitinides, for example, nateglinide (Starlix) and repaglinide (Prandin) Thiazolidinediones, for example, pioglitazone (Actos), DPP-4 inhibitors, for example, sitagliptin (Januvia) and linagliptin (Tradjenta).

Glycemic index

Glycemic index are used to measure the impact of a carbohydrate on blood sugar. High glycemic index foods induce postprandial hyperinsulinemia which is associated with type 2 diabetes.²¹ Carbohydrates are the primary food that raises blood sugar level. Foods with low glycemic index raise blood sugar modestly and thus are better choices for people with diabetes. The main factors that determine a food's glycemic load are the amount of [fiber](#), fat, and protein it contains²¹

Carbohydrates

Carbohydrate can be classified as either Complex carbohydrates, or Simple sugars.

Complex carbohydrates (low glycemic foods); known as Polysaccharides. They are in their whole form and include additional nutrients such as: Fiber, Vitamins, Smaller amounts of proteins and fats. These additional nutrients slow down the absorption of the glucose and keep blood sugar levels more

stable. Examples of complex carbohydrates, or low glycemic index foods include: Brown rice, Whole wheat, Oatmeal, Vegetables, Fruits and Beans. Digestion of complex carbohydrates could take more time because digestive enzymes have to work harder to breakdown the chains into individual sugars³⁵ A diabetes meal plan can follow a number of different patterns and have a variable ratio of fats, proteins, and carbohydrates.

Grains and starchy vegetables

Whole grains, such as brown rice, quinoa, and oatmeal are good sources of fiber and nutrients; and have a low glycemic load making them good food choices. Whole grains have less of an impact on blood sugar because of the lower glycemic load. Starchy vegetables that are good sources of nutrients like vitamin C, and that are higher in carbohydrates than green vegetables, but lower in carbohydrate than refined grains, can be eaten in moderation. Starchy vegetables include: Potatoes, Corn and other root vegetables¹³

Non-starchy vegetables

Non-starchy vegetables, such as green vegetables, can be eaten in abundance. These foods have limited impact on blood sugar, and also have many health benefits.

Simple carbohydrates (high glycemic load foods); known as Monosaccharides. These are processed foods, and don't contain other nutrients to slow down sugar absorption and thus these foods can raise blood sugar dangerously fast. Many simple carbohydrates that should be avoided are easily recognized as "white foods" which include; Sugar, White bread, Cookies, White potatoes, sweets, Fruit juice.

Healthy fats for Type 2 diabetic

Fats have little direct effect on blood sugar; but, as part of a meal, they are useful in slowing down the absorption of carbohydrates. Fats also have effects on health that are not related to blood sugar. For example: Animal meat fats increase the risk of cardiovascular disease. However, dairy, and specifically fermented dairy such as yogurt, appears to decrease this risk. Plant-based fats such as olive oil, nuts, seeds, and avocado are associated with lower cardiovascular disease risk¹⁷

Factors that lead to hyperglycemia

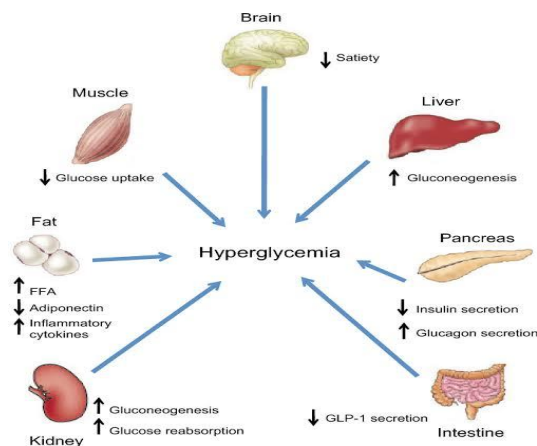


Figure 2; Pictorial representation of the factors that can lead to hyperglycemia (DeFronzo et al., 2015)

CONCLUSION AND RECOMMENDATION

In order to reduce the problems of diabetes, management strategies should include lifestyle changes such as increased physical activities and diet improvement. A diabetes meal plan can follow a number of different patterns and have a variable ratio of fats, proteins, and carbohydrates. The carbohydrates consumed should be low glycemic load and come primarily from vegetables. The fat and proteins consumed should primarily come from plant source.

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