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The Crucial Role of Diet in Managing Gestational Diabetes Mellitus: A review

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ABSTRACT:
Gestational Diabetes Mellitus (GDM) is the type of diabetes that occurs temporarily during pregnancy when the body is unable to produce enough insulin to control elevated blood sugar levels. Dietary intervention has emerged as a cornerstone in GDM management, focusing on regulating blood sugar levels and promoting a healthy pregnancy. Diet management of GDM is based on several fundamental principles. The first and most important step is managing carbohydrates focusing on the composition, type, and amount of carbohydrate intake. Consuming complex carbohydrates with lots of fiber is preferred to maintain stable blood sugar levels. To achieve all nutritional requirements, lean proteins and healthy fats should be included in meal planning. GDM dietary recommendations emphasize portion control and knowledge of the glycemic index of foods, which encourage more precise blood sugar regulation. A holistic lifestyle approach to GDM, which combines dietary changes with regular physical activity, stress management, and other factors, is also highlighted by recent studies. Food orders and split meal plans are essential in GDM management and should be followed by GDM patients even after delivery. The interconnection of many lifestyle factors in achieving the best blood sugar control and maternal well-being is acknowledged comprehensively. GDM patients who practice healthier dietary and lifestyle choices are less prone to have type 2 diabetes after delivery. In conclusion, the importance of diet in ensuring a favourable pregnancy outcome for mothers with GDM is emphasized in this review, along with the necessity of continued research and multidisciplinary cooperation for improving GDM care. Healthcare professionals and patients can work towards better results in managing GDM by becoming aware of the most recent advancements in dietary management.

1. Introduction

Gestational Diabetes Mellitus (GDM) is the type of diabetes that occurs temporarily during pregnancy when the body is unable to produce enough insulin to control elevated blood sugar levels also can be characterized as glucose intolerance noticed in the beginning or during pregnancy [1,2]. During pregnancy, pregnant women gradually develop insulin resistance, maintaining sufficient nutrients for the developing fetus [3]. Hyperglycaemia is caused by insulin resistance in pregnant women with gestational diabetes mellitus [3,4]. The fetus receives glucose through the placenta, which boosts fetal insulin production and encourages fetal development, leading to macrosomia and children who are Large for Gestational Age (LGA) [5]. GDM has long-

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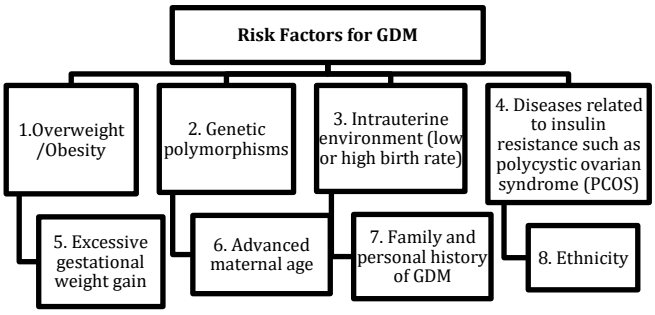
term effects, including an increased risk of type 2 diabetes in both mother and child and childhood obesity. Short-term effects of GDM include an increased likelihood of unfavourable pregnancy outcomes [6]. GDM is becoming more common, which increases the requirement for therapy. To effectively control gestational diabetes, lifestyle modifications are crucial. Medical nutrition therapy, along with weight management (maintaining a healthy weight or losing weight) and exercise, is the initiative treatment measure for GDM to follow[5,7,8]. It has been suggested that lifestyle modifications alone are sufficient to control blood sugar in between 70 and 85 percent of women with GDM [8]. Blood sugar control is the main objective of dietary treatment in GDM. In managing GDM making the right food decisions is crucial for maintaining blood sugar levels under control and protecting the health of the mother and fetus. Insulin resistance is a condition in which the body's cells do not respond to insulin properly and may be brought on by hormonal changes during pregnancy. An important organized diet aids in regulating these variations and avoiding high blood sugar rises. The developing fetus may suffer consequences from uncontrolled GDM. Microsomal growth that is out of control (macrosomia) in the mother can increase the chance of problems during delivery. The baby receives vital nutrients without being overly exposed to increased blood sugar levels with a properly maintained diet and management[6]. GDM can bring risk to the mother's health by the chance of developing preeclampsia, high blood pressure, and type 2 diabetes in the future. These risks can be prevented with proper diet and food composition.

2. Gestational diabetes mellitus (GDM)

GDM is defined as intolerance of carbohydrates resulting in hyperglycemia of variable severity with onset or first recognition during pregnancy (This does not rule out the chance that there was undiagnosed glucose intolerance before the onset of pregnancy.)[9] Gestational diabetes mellitus (GDM) has emerged as a global public health problem. Globally, the prevalence of GDM ranges from 1-28% depending on the screening method used and the population studied. The incidence of gestational diabetes is high among Asian populations. In India, the prevalence ranges from 3.8% in Kashmir to 17.9% in Tamil Nadu [9,10] The woman's body goes through several physiological changes in a healthy pregnancy to meet the expanding needs of the developing fetus. A significant metabolic adaptation takes place in insulin sensitivity. Insulin sensitivity rises in the early stages of pregnancy, encouraging the body to absorb glucose into adipose storage in preparation for the increased energy requirements of a later pregnancy[11]. However, a rise in hormones including cortisol, leptin, estrogen, progesterone, placental lactogen, and placental growth hormone occurs later in gestation and contributes to the development of insulin resistance [9]. Human placental lactogen affects carbohydrate, protein, and fat metabolism, increasing the free fatty acids by lipolysis. Blood glucose is consequently slightly raised, and this glucose is easily transferred through the placenta to support the fetus's growth[12]. Further increases in blood glucose and free fatty acid (FFA) concentrations are caused by this mild form of insulin resistance, which also encourages the body to produce glucose by itself and breaks down fat reserves. During pregnancy, there is fasting hypoglycemia and postprandial hyperglycemia. In the fasting state, as there is hypoglycemia, triglycerides are broken down into fatty acids and ketones [13]. So, in pregnancy, there is a shift in the source of fuel from glucose to lipids. If starvation is prolonged, it leads to ketosis. In short, pregnancy induces a diabetogenic state in the individual. This diabetogenic response is linked to the synthesis of placental insulinase by the placenta, which accelerates the breakdown of insulin, and an increase in insulin-antagonizing hormones such as progesterone, cortisol, and human placental lactogen [9].

Fig 1: Risk Factors for GDM [9]



3. Diagnosis of GDM

For the diagnosis of GDM, the Diabetes in Pregnancy Study Group, India (DIPSI) and the World Health Organization (WHO) do not advise a screening test [14]. Instead, they suggest a direct diagnostic test oral glucose challenge test (OGCT), which was used as a screening

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test in the past but is now considered both a screening and a diagnostic test. The ideal time to perform the diagnostic test for GDM is at 12-16 weeks of gestation or the first visit to the antenatal (AN) clinic. If a woman's test results are normal at the first visit, the test is repeated between 24 and 28 weeks of gestation and later at 32-34 weeks. Different screening methods are used in different parts of the world. Either a single-step method or a two-step method is used to diagnose GDM [15].

- **Single-step methods**

The International Association of Diabetes and Pregnancy Study Group (IADPSG), the WHO, and the Government of India recommend a single-step method for the diagnosis of GDM as this is convenient for the woman, is economical, and does not require the woman to be fasting.

(i) Diabetes in Pregnancy Study Group India (DIPSI) method [16]

The antenatal woman is given 75 g of glucose in 300 mL of water irrespective of the time of her last meal and whether she is in the fasting or the non-fasting state (the glucose water can be consumed slowly for about 5 minutes to avoid nausea and vomiting). Oral glucose does not cause nausea and vomiting if administered in the non-fasting state.[16] Two hours after the woman has consumed the glucose solution, venous blood is drawn and tested for plasma glucose. The plasma glucose can be tested by an autoanalyzer/semi-autoanalyzer. If these machines are not available, capillary blood may be tested by glucometers that are calibrated to plasma glucose. The test result is considered normal if the plasma glucose at 2 hours post-glucose load is <140 mg/dL. If the 2-hour post-glucose load is > 140 mg/dL, the woman is considered positive for GDM. Women who test normal at the first visit should undergo repeat testing at 24-28 weeks and if found normal, should be tested once again between 32 and 34 weeks [9,16].

(ii) The International Association of Diabetes and Pregnancy Study Group (IADPSG) criteria [17]

The woman comes after overnight fasting and her fasting plasma glucose level is checked. Then, the woman is given 75 g of glucose in 150 mL of water. The plasma glucose is checked at 1 and 2 hours. GDM is diagnosed if any one value is equal to or more than the cut-off values listed (Table 1).

Table 1: The International Association of Diabetes and Pregnancy Study Group (IADPSG) criteria for GDM diagnosis [9,17]

Plasma Glucose test	Normal value
Fasting plasma glucose	92 mg/dL
1-hour plasma glucose	180 mg/dL
2-hour plasma glucose	153 mg/dL

(iii) The WHO method

The 75 g 2-hour glucose tolerance test is recommended by the WHO for universal GDM screening between weeks 24 and 28 of pregnancy (GTT). For this test, the woman comes fasting and is given a 75 g glucose load. A 2-hour plasma glucose value of ≥140 mg/dL is diagnostic of GDM[9,16].

- **Two-step method**

In the two-step method, first, a screening test is carried out and if it is positive, the second step is a diagnostic test. The first step is a 50 g glucose challenge test irrespective of the woman's last meal. It is performed at 24-28 weeks of gestation in women who do not have pre-existing diabetes. If the 1-hour plasma glucose is ≥140 mg/dL, then the second step is carried out. Step two involves a 100 g glucose OGTT, in which the fasting plasma glucose level is checked, following which, 100 g of glucose is given orally, and the plasma glucose level is checked at 1, 2, and 3 hours. A diagnosis of GDM is made if any two of the following values are abnormal (Table 2)

Table 2: Two-step method for GDM diagnosis [9]

Plasma Glucose test	Normal value
Fasting plasma glucose	95 mg/dL
1-hour plasma glucose	180 mg/dL
2-hour plasma glucose	155 mg/dL
3-hour plasma glucose	140 mg/dL

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GDM is associated with adverse maternal and fetal outcomes (Table 3)

Table 3: The maternal and fetal effects of GDM [9,18]

Maternal effects	Fetal effects	Neonatal effects
Preterm labour Pre-eclampsia Infections Hydramnios Operative delivery	Second-and third-trimester fetal loss Macrosomia Fetal death Hypertrophic cardiopathy	Hypoglycemia Hypocalcemia RDS Hypomagnesemia Hyperbilirubinemia Polycythemia Unexplained neonatal death

4. Lifestyle factors that can impact GDM

Lifestyle factors that can impact GDM are firstly healthy eating which is a balanced and nutritious diet essential for managing GDM [2] focusing on the consumption of complex carbohydrates, such as whole grains, fruits, vegetables, and legumes. These foods have a lower impact on blood glucose levels. It's important to monitor the correct portion sizes and avoid consuming sugary and processed foods. Regular physical activity or exercise can help increase insulin sensitivity and management of blood glucose levels. Activities like walking, swimming, and prenatal yoga can be beneficial [3,8]. Monitoring blood sugar, and knowing how various foods affect blood sugar levels can be done through regular monitoring of blood sugar levels. Weight control management is essential to maintain a healthy weight during pregnancy. Excess weight gain can contribute to insulin resistance [2]. Healthcare providers can guide proper weight gain goals depending on weight before pregnancy. High stress levels can impact blood sugar control. Stress management and practicing relaxation techniques like deep breathing, meditation, or prenatal massage can help manage stress [8]. Lastly, sleep and hydration, prioritize adequate sleep, as sleep deprivation can affect blood sugar levels and overall well-being, staying well-hydrated is essential for overall health. Regular prenatal appointments with healthcare providers are essential. They will monitor blood sugar levels, overall health, and the well-being of both mother and baby. Medication or insulin is needed in some cases; lifestyle changes alone might not be enough to manage GDM [4].

5. Importance of Nutritional recommendations in pregnancy

Nutritional advice aims to improve the state of well-being of the mother and the growing fetus together by controlling blood sugar levels and ensuring a sufficient diet. The critical aspects of recommendations include monitoring carbohydrate intake, choosing nutrient-dense foods, portion control, and regular blood sugar monitoring, all under the guidance of healthcare professionals and registered dietitians to plan individual needs [7]. Proper nutrition management can help prevent complications associated with GDM and support favorable pregnancy outcomes. Optimal weight gain when compared to normal glucose tolerance pregnancies (NGTP), for women with GDM, the required weight gain during pregnancy remains the same as for NGTP [2]. The fetus's growth and development should be maintained throughout gestational weight gain [19]. It is advised that the woman engages in a daily 30-minute walk or another exercise regimen during this time. A 2-hour Post-Prandial Blood Sugar (PPBS) test should be performed after two weeks of following MNT (Medical Nutrition Therapy) and exercising. Only 10% of GDM patients need insulin, while 90% of patients only need MNT [20]. Adapt a standard diet for two weeks before adding insulin in the case of a small rise. If the Blood Sugar increases more than 200mg/dl advise MNT and Insulin[21]. It's crucial to adjust the strategy based on the demands of those with GDM when calculating their calorie needs. Because weight patterns fluctuate over time, adjustments should be made. A diet that focuses on carbohydrates that encourage adequate nutrition, healthy weight gain, normoglycemia, and the absence of ketosis is important [2,19]. According to research, women who gain weight above or below the recommended levels face the risk of adverse maternal and neonatal outcomes, such as pregnancy-related problems, postpartum weight retention, and child obesity[19,22]. The desired amount of maternal weight gain can differ depending on pre-pregnancy and current weight; however, due to insulin resistance, smaller, more frequent meals and snacks will be beneficial. Since the patient is in 1st trimester normal Body Mass Index can be provided up to @30kcal/kg/IBW (Ideal Body Weight) [23]. Pregnant women can benefit from guidance on the recommended rate of weight gain throughout the second and third trimesters[19]. In addition to being a significant dietary

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energy source, foods high in carbohydrates should also contain vitamins, minerals, and fiber [24].

(i) Carbohydrates

Carbohydrates (CHO) are the most significant macronutrient in GDM patients. The consumption of carbohydrates has a direct impact on postprandial hyperglycemia because they increase blood glucose levels during digestion and absorption [25,26]. The type and amount of carbohydrates will affect blood glucose levels [3]. As a result, hyperglycemia can occur when a meal contains a lot of carbohydrates[25]. However, glucose serves as the fetus' major source of energy and is necessary for optimal fetal growth and metabolism [27]. The Institute of Medicine (IOM) recommends consuming at least 175 grams of carbohydrates daily and between 46 and 65 energy percent (E%) from carbohydrates to support healthy fetal growth, development, and function [19,28,29] A minimum of 175 grams of carbs per day is required. Carbohydrates should account for 35–45% of total calories [23]. Spread carbohydrate-containing foods throughout the day. IDF MENA guideline recommends 35% -45% of total calories should be from carbohydrates [30], To avoid nutritional ketosis, it's crucial to consume 175 g of CHO or more per day [31]. The 2014 guidelines issued by the Government of India suggest that the diet of a mother with GDM should consist of 50–60% carbohydrates, 10–20% protein, and 25–30% fat [32]. Consequently, carbohydrate is suggested as 50-55% of Total Energy Intake (TEI). wholesome food choices with 40–50% of calories coming from fiber-rich, complex carbohydrates [26,33].

(ii) Protein

Protein requirements increase during pregnancy and are associated with the synthesis of maternal that is blood, breast and uterus, and fetal (fetus, placenta, and other tissues) [34]. Similar to the standard nutrition recommendations for healthy pregnancies, protein intake is advised for treating GDM with diet. When pregnant, the IOM recommends ingesting protein in amounts ranging from 10 to 35 percent of daily calories, with a regular minimum of 71 grams and an average requirement of 0.88 grams per kg [19]. NNR (Nordic Nutrition Recommendations) also recommends that non-pregnant adult women consume 10–20% of their body weight in protein, with a regular minimum of 71 g and an average requirement of 0.88 g/kg. NNR also recommends a safe increase in protein consumption [26,34]. 71 grams of protein per day is the minimum recommended daily requirement index (DRI) for pregnant women [23,30]. At least 20% of the calories should come from proteins, they are the building materials of the body responsible for energy, growth, and maintenance [23]. Lean chicken, freshwater fish, egg white, low/no fat dairy, beans, lentils, and nuts are healthy sources of protein and should be evenly distributed in the meal plan. Protein supplements do not improve pregnancy outcomes and require more clarity concerning addressing intrauterine growth restriction and twin pregnancies, 15-30% calories, from protein [33]

Animal proteins, often known as complete proteins, contain all nine of the essential amino acids (AA). Plant-based proteins, often known as incomplete proteins, may lack one or more AAs. However, the necessary amino acids can be obtained by consuming a variety of plant-based proteins throughout the day [35]. However, vegans should carefully manage their diets because they are more prone than omnivores and vegetarians to not get enough protein [36]. Therefore, appropriate protein intake is necessary for human growth, development, and health. Sufficient consumption of high-quality protein derived from animal products (such as lean meat and milk) is necessary for both adults and children's tissues (such as skeletal muscle, the brain, heart, kidneys, liver, and gut) to be maintained, function, and be in optimal health. Consuming a suitable combination of animal- and plant-based foods is therefore a viable strategy for ensuring balanced dietary AA for both adults and children. To avoid any negative health effects, one should limit daily protein intake to the safe maximum limit [26,37].

(iii) Fat

A total of 25% -35% of calories per day should come from fats. Do not exceed 40% of total calories [23]. IOM recommends 20-35% & DDG recommends 30-35% of Total energy intake from lipids [30]. To reduce the development of trans fats and the end products of advanced glycosylation, use cooking oils with a high smoke point, like rice bran oil, rather than ones with a low smoke point. Because eating eggs, dairy products, and meat every day provides the required daily allowance of saturated fat (<7%), consuming more saturated fat (such as clarified butter, butter, and cream) raises the risk of maternal hypertriglyceridemia and macrosomia. 20-35% calories, from primarily unsaturated fats. It is advised to consume less saturated fat and trans fatty acids (TFAs), which may cause problems and more omega-3

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fatty acids and non-polysaccharides with a low glycaemic index [33]

(iv) Fibre

In general, postprandial excursions from simple carbohydrates are higher than those from complex carbohydrates. NNR advises women to consume 25 g minimum dietary fiber [34], however, women with GDM are advised by the American Diabetes Association to ingest at least 28 g of fiber daily [38], which is similar to the IOM's guidance for pregnant normoglycemic women [19]. Consuming whole-grain bread, pasta, and rice, as well as 600 g of fruit and vegetables each day—at least 300 g of vegetables, with a focus on rough and fibrous veggies—will help you meet these recommendations. Incorporate more fiber into your diet to prevent glycemic spikes (green leafy vegetables, fresh fruits, vegetables & whole grains, etc.), oat bran, legumes (dry beans of all kinds, peas, and lentils), pectin (from fruit, such as apples), and forms in root vegetables (like raw carrots) all contain beneficial amounts of soluble fiber [39] A 26% risk reduction of GDM was linked to a habitual dietary fiber supplementation of 10 g/d, whereas a 23% risk reduction of GDM was linked to an increase of 5 g/d of cereal or fruit fiber. Dietary fiber has been demonstrated to improve glucose homeostasis by slowing glucose absorption, delaying stomach emptying, and reducing appetite and energy intake [26,40,41]. Additionally, soluble fiber supplementation in obese women may reduce inflammation and glycemic regulation while also preventing excessive pregnancy weight gain.

(v) Vitamin B9/ Folic acid

During pregnancy, folates are a crucial vitamin. Since folate is crucial to the creation of nucleic acids and, consequently, cell division, it has a substantial impact on the fetus' development. Low birth weight and neural tube abnormalities are more likely in mothers with low folate levels. A dietary supplement called folic acid, which is a synthetic version of the folate family, has been found to lower the risk of negative outcomes in NGTP during the periconceptional phase [42–44]. Following the Nordic Council of Ministers' 2014 recommendation for pregnant women to consume 500 g/d [34], the IOM recommends consuming 600 g per day when pregnant [19].

Table 4. Nutritional recommendations in pregnancy

Dietary Component	Recommendations	Reference
Energy	Enhance the fetus's growth and development. Depending on pre-pregnancy and current weight, different levels of maternal weight gain are desirable. Pregnant women with hyperglycemia should consume enough calories to gain weight as directed. Weight growth during the first trimester should be between 0.5 and 2 kg. No increase in calorie consumption should be practiced during the first trimester. During the second trimester, it is advisable to consume an additional 340 kcal each day. During the third trimester, it is advised to consume an additional 452 kcal each day. Every two weeks, patients with PCOS should have their weight examined because they may gain excessive weight. PCOS stands for polycystic ovarian disease.	45,46
Carbohydrates	Carbohydrates least 175g every day (35 percent -45 percent of Total Energy Intake)	19,28,29
Fiber	27 g of fiber daily (same as required before pregnancy)	38,47

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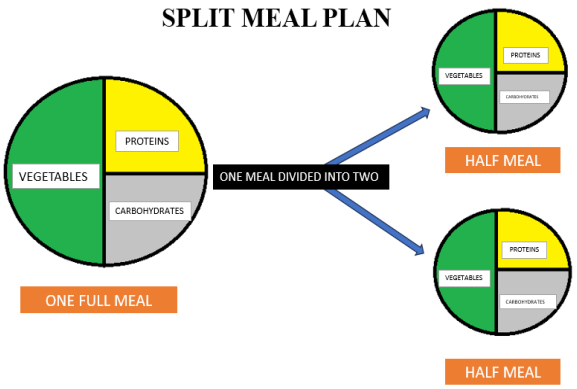
Proteins	Minimum 71g/day of proteins	19,23,30
Sodium	Foods high in sodium should be avoided. 1500–2300 mg of sodium daily (same amount as a non-pregnant individual)	23,48
Fluid	The daily minimum fluid intake is 2.3L	49,50
Vitamins and Minerals	Folic acid is 570 mg/day, ferrous iron 40 mg/day, and zinc 14.5 mg/day Vitamin B, is 2.75g/day, Vitamin C, is 80mg/day, and Magnesium requirements are increased by 385mg/day. An hour should pass between taking iron supplements and consuming calcium-rich foods. prefer to combine vitamin C and a supplement for iron.	34,42–44

6. Smart plate split meal plan

A split meal plan implies splitting a meal into two halves (i.e., eat half the portion, wait for an hour, test glucose levels, and then eat the remaining half portion)[51]. Meal splitting is necessary for GDM because post-prandial hyperglycemia can be reduced by dividing calorie and CHO intake between meals and snacks [52]. In most GDM mothers, 1st phase insulin secretion is deficient and due to the dawn phenomenon, there is more insulin resistance seen at the start of the day. Therefore, breakfast sugars are the most difficult to control [53]. It is advised to have a low carbohydrate, high protein first as a meal to avoid undue spikes in post-breakfast plasma glucose levels. Reducing the glycaemic load of the breakfast reduces the post-prandial peak [25]. Lifestyle modification is essential for the management of GDM. Smart Plate is a simple technique of eating food on a measured plate to avoid overconsumption, it is a principle to make a customized food plate according to dietary habits, occupation, daily workout, and lifestyle[51,54]. The proportion of nutrients to be filled in the plate should be one-half portion and two-quarter portions i.e., half portion of the plate must contain non-starchy vegetables (plant-based fiber-rich diet vegetables, for example, green leafy vegetables and other vegetables (beans & gourd variety, etc.), on the other hand, the one-quarter plate should contain proteins, e.g., lean meat or skinless poultry or fish and food or egg white or peanut butter or soya beans and products [24] while another quarter plate portion must contain grains, vegetables (starchy), beans, and lentils. In addition to the contents in the plate, the following can be used for healthy meal planning, outside plate contents can have dairy (<1% fat) and fruits, and must avoid fruit along with a meal to avoid postprandial glycemic response [55]. GDM patients should be advised to split their single meal into two halves i.e., instead of single meal intake all at once [54]. Patients can split the same single meal into two halves with a time gap be one hour to reduce postprandial glucose level. A split meal plan may have a positive impact on postprandial glucose levels if patients follow the splitting of single meal intake with a time gap and food order [54,56]. Hence split meal plan with a smart plate method follow-up is essential for GDM which can help in maintaining the sugar spikes in blood glucose levels. (Figure 2-. Split meal plan dividing one whole meal into two half meals and consuming each in 1-hour gap)

Figure 2: Split meal plan



7. Food order

For diabetic patients, maintaining adequate metabolic control is crucial to preventing long-term problems [57,58]. However, a significant percentage of diabetes patients continue to have their condition inadequately controlled, primarily due to poor dietary compliance [59,60]. GDM must be encouraged to develop a suitable diet, including lifelong eating habits and meal patterns. Medical experts

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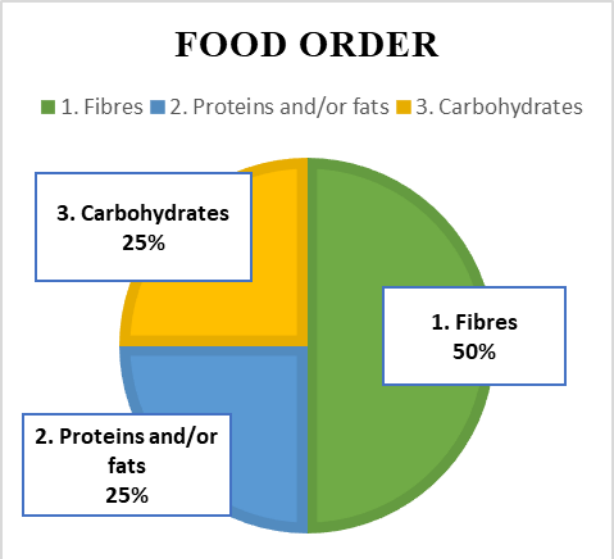
must be trained in diabetes education, especially nutrition education, and must provide clear information. Food order is a simple practice of eating vegetables followed by protein-rich foods and/or fats and finishing off with carbohydrates. The order of food should be vegetables first followed by protein and lastly followed by carbohydrates. Consuming vegetables and proteins before carbohydrates reduces glycemic and insulin levels. Vegetables contain fiber that is almost entirely indigestible and can help reduce the pace at which food is turned to sugar. The gut helps to release glucagon-like peptide-1(GLP-1) once protein and/or fat are consumed before carbohydrates. The fact that GLP-1 promotes glucose-induced insulin secretion while decreasing glucagon secretion makes it essential for preserving glucose homeostasis. GLP-1 may also serve as a satiety hormone. The timing of meals, or eating protein and/or fat before carbohydrates, boosts the stomach's production of the hormone glucagon-like peptide-1 (GLP-1), which slows gastric emptying and improves postprandial glucose excursion.[61] The afferent vagus nerve allows GLP-1 to affect the hypothalamus, where it is known to reduce appetite. So, it stands to reason that increasing GLP-1 secretion through meal schedules should result in weight loss[61 62]

Consuming vegetables first improves glycemic control compared to the reverse regimen, which involves eating carbohydrates before vegetables. Postprandial glucose and insulin levels are much lower when vegetables are consumed before carbohydrates [63]. The dietary fiber content of the vegetables ingested before the carbohydrate can help to partially explain why eating veggies before carbohydrates lower postprandial glucose levels [64,65]. Vegetables rich in dietary fiber reduce the peak postprandial glucose levels, which enhances glucose tolerance [41]. Following the consumption of vegetables, dietary carbohydrates are digested more slowly and require less insulin for later metabolic disposal. Since diabetes patients frequently experience a delay in the release of insulin, these modifications would be beneficial to them [66]. Therefore, the order of food, which puts vegetables first, followed by proteins and/or fats, and carbohydrates last, can help to maintain a reduction in blood sugar levels. (Fig 3- Healthy Eating Plate with Food Order (1. Vegetable 2. Protein 2. Carbohydrate)) [55]

Numerous other variables can affect the glycemic response and carbohydrate digestion in the small intestine among them are the rate of digestion and absorption [67], types of food composition[68], cooking technique, types/varieties of starch, the presence of alpha-amylase inhibitors [69], transit duration [70], amount of protein and fat intake [71], gastric emptying rates [72], intestinal absorption [73], hormonally induced gastrointestinal reaction [74], glucose metabolism in cells and the equilibrium of hepatic glucose. After eating a given number of vegetables, the patients' post-meal satiety improved, and overall hunger levels reduced. This might cause individuals to consume fewer carbohydrates after each meal. To learn more about the precise mechanisms underlying these metabolic alterations, additional research is needed.

Figure 3: Healthy Eating Plate with Food Order (1. Vegetable 2. Protein 2. Carbohydrate)



Vegetables and fruits – ½ of your plate

Whole grains – ¼ of your plate

Protein power – ¼ of your plate

8. **Preventing Future Diabetes**

Women with GDM have a higher chance of getting type 2 diabetes in the future. A well-managed diet during pregnancy and postpartum can help reduce this risk. Educational support healthcare must provide educational sessions about GDM management. These sessions can provide valuable information on meal planning, blood sugar monitoring, and overall self-care. It's essential to work with healthcare providers to maintain personalized plans for specific needs and circumstances[7]. With the

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right lifestyle modifications and medical support, many GDM women can effectively manage their condition and have healthy pregnancies. The proper management of maternal hyperglycemia may reduce the morbidity of mothers and newborns [32], with the first-line approach of MNT for the treatment of GDM [75]. The majority of the time, controlling blood sugar levels with diet alone is sufficient, but up to 50% of women fail to maintain good metabolic control and need to be treated with insulin or hypoglycemic medications [76] Diet is a potent regulator of the gut microbiota, which has a well-known impact on the host's inflammatory response and insulin resistance[77]. Pre-eclampsia, large for gestational age births, and reduced birth weight are all lower in incidence among GDM patients who receive lifestyle therapy[31]. Pre-pregnancy consumption of red and processed meats has been both positive and significantly linked with the risk of developing GDM, Western dietary pattern was significantly associated with a higher risk of developing GDM in pregnant women [24]. Blood glucose level range for fasting blood sugar level should be less than 95mg/dL, while an hour after a meal should be less than 140mg/dL also two hours after a meal should be less than 120mg/dL as a normal level[75]. Stress management is very important for GDM patients, women face stress when GDM is diagnosed during pregnancy, stress over losing control of GDM during the process of dietary management, and anxiety related to the fear of maternal and infant complications.[78] Self-control, supportive surroundings, and avoiding overthinking can prevent GDM women from many complications. Also drinking enough water throughout the day will keep patients properly hydrated, which is essential for any food plan to be effective [79]. MNT, weight control (maintaining a healthy weight or losing weight), and exercise are important first-line treatments for GDM. MNT in GDM aims to prevent hypoglycemia and ketosis, achieve normoglycemia, and contribute to the health of the mother and fetus [7,8]. A healthy diet, avoiding overconsumption of food, proper food order intake, staying hydrated, regular exercise and sleep, also following dietary advice from healthcare workers can help GDM control their sugar level and prevent them from developing diabetes in the future.

Table 5: Recommendations for lifestyle- Guideline

Guideline topic	Lifestyle recommendations	Reference
ADA (American Diabetes Association)	Encourage Breastfeeding A minimum of 7 % of present body weight must be lost to achieve weight loss Advise low fat intake in daily diet Increase fiber at 14g/1000 kcal Increase physical activity up to 150mins/week with moderate activity	80,81
NICE (Nutrition Information Communication and Education)	Weight management Healthy dietary habits and physical activity Breastfeeding encouragement	80
ADIPS (Australasian Diabetes in Pregnancy Society)	Management of weight control healthy food and physical activity	82
RACGP (Royal Australian College of General Practitioners)	General nutritious eating Increase overall physical activity Loss of Weight To encourage breastfeeding	80,83
RSSDI (Research Society for the Study of Diabetes in India)	Postpartum healthy eating habits and lifestyle changes help GDM women from the onset of diabetes in the future.	33

9. Conclusion

GDM women should have a proper dietary choice for the management of blood glucose levels. Maintaining a healthy weight and lowering the need for medication or insulin therapy are both benefits of a balanced diet.

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Managing carbohydrate intake is at the heart of GDM dietary management. Focusing on complex carbohydrates, portion control, and spacing out meals can prevent spikes in blood sugar. Opting for nutrient-dense foods ensures that both the mother and the developing baby receive essential vitamins, minerals, and other nutrients required for a healthy pregnancy. Eliminating added sugars and sugary foods is essential to prevent sudden blood sugar spikes. Food Order and split meal plans are essential in GDM management and should be followed by GDM patients even after delivery. To evaluate the effectiveness of food choices and make necessary adjustments, it is vital to continuously check blood sugar levels. Each woman's dietary needs during pregnancy are unique. Consulting with healthcare providers and registered dietitians for personalized guidance is crucial for effectively managing GDM, further, it ensures a healthier pregnancy and reduces problems that could affect both the mother and the child. Adopting a well-structured and personalized dietary approach is important in managing GDM since it prevents developing type 2 diabetes in the future and supports the baby's long-term health. Diet gives expecting mothers the ability to keep their blood sugar levels steady, promoting a healthier pregnancy and reducing the likelihood of problems. To maintain an appropriate dietary consumption meal plan food composition, food balancing, and food order are important considerations. Collaborating closely with healthcare professionals and adhering to their dietary recommendations is essential for effectively managing GDM and promoting the well-being of both the mother and the baby.

Refrences

1. Sonagra, A. D.; Biradar, S. M.; Dattatreya, K.; DS, J. M. Normal Pregnancy-a State of Insulin Resistance. *J Clin Diagn Res* **2014**, *8* (11), CC01.
2. Rasmussen, L.; Poulsen, C. W.; Kampmann, U.; Smedegaard, S. B.; Ovesen, P. G.; Fuglsang, J. Diet and Healthy Lifestyle in the Management of Gestational Diabetes Mellitus. *Nutrients* **2020**, *12* (10), 3050.
3. Association, A. D. Management of Diabetes in Pregnancy. *Obstet Gynecol Surv* **2017**, *72* (5), 264–266.
4. Moreno-Castilla, C.; Hernandez, M.; Bergua, M.; Alvarez, M. C.; Arce, M. A.; Rodriguez, K.; Martinez-Alonso, M.; Iglesias, M.; Mateu, M.; Santos, M. D. Low-Carbohydrate Diet for the Treatment of Gestational Diabetes Mellitus: A Randomized Controlled Trial. *Diabetes Care* **2013**, *36* (8), 2233–2238.
5. McIntyre, H. D.; Catalano, P.; Zhang, C.; Desoye, G.; Mathiesen, E. R.; Damm, P. Gestational Diabetes Mellitus. *Nat Rev Dis Primers* **2019**, *5* (1), 47.
6. Ovesen, P. G.; Fuglsang, J.; Andersen, M. B.; Wolff, C.; Petersen, O. B.; David McIntyre, H. Temporal Trends in Gestational Diabetes Prevalence, Treatment, and Outcomes at Aarhus University Hospital, Skejby, between 2004 and 2016. *J Diabetes Res* **2018**, *2018*.
7. Kurtzhals, L. L.; Nørgaard, S. K.; Secher, A. L.; Nichum, V. L.; Ronneby, H.; Tabor, A.; McIntyre, H. D.; Damm, P.; Mathiesen, E. R. The Impact of Restricted Gestational Weight Gain by Dietary Intervention on Fetal Growth in Women with Gestational Diabetes Mellitus. *Diabetologia* **2018**, *61*, 2528–2538.
8. Yamamoto, J. M.; Kellett, J. E.; Balsells, M.; Garcia-Patterson, A.; Hadar, E.; Sola, I.; Gich, I.; van der Beek, E. M.; Castaneda-Gutierrez, E.; Heinonen, S. Gestational Diabetes Mellitus and Diet: A Systematic Review and Meta-Analysis of Randomized Controlled Trials Examining the Impact of Modified Dietary Interventions on Maternal Glucose Control and Neonatal Birth Weight. *Diabetes Care* **2018**, *41* (7), 1346–1361.
9. Mudaliar, A. L. *Mudaliar and Menon's Clinical Obstetrics*; Orient Blackswan, 2005.
10. Zhu, Y.; Zhang, C. Prevalence of Gestational Diabetes and Risk of Progression to Type 2 Diabetes: A Global Perspective. *Curr Diab Rep* **2016**, *16*, 1–11.
11. Parrettini, S.; Caroli, A.; Torlone, E. Nutrition, and Metabolic Adaptations in Physiological and Complicated Pregnancy: Focus on Obesity and Gestational Diabetes. *Front Endocrinol (Lausanne)* **2020**, *11*, 611929.
12. Segura Moreno, M. T. Effect of Maternal Obesity and Gestational Diabetes on Placental Fatty Acid Uptake, Metabolism and Transfer to the Fetus. **2019**.
13. Koren, D.; Palladino, A. Hypoglycemia. In *Genetic diagnosis of endocrine disorders*; Elsevier, 2016; pp 31–75.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 3813-3826 | ISSN:2251-6727

14. Tripathi, R.; Verma, D.; Gupta, V. K.; Tyagi, S.; Kalaivani, M.; Ramji, S.; Mala, Y. M. Evaluation of 75 g Glucose Load in Non-Fasting State [Diabetes in Pregnancy Study Group of India (DIPSI) Criteria] as a Diagnostic Test for Gestational Diabetes Mellitus. *Indian Journal of Medical Research* **2017**, *145* (2), 209–214.
15. Rani, P. R.; Begum, J. Screening and Diagnosis of Gestational Diabetes Mellitus, Where Do We Stand. *J Clin Diagn Res* **2016**, *10* (4), QE01.
16. Rani, P. R.; Begum, J. Screening and Diagnosis of Gestational Diabetes Mellitus, Where Do We Stand. *J Clin Diagn Res* **2016**, *10* (4), QE01.
17. Tripathi, R.; Verma, D.; Gupta, V. K.; Tyagi, S.; Kalaivani, M.; Ramji, S.; Mala, Y. M. Evaluation of 75 g Glucose Load in Non-Fasting State [Diabetes in Pregnancy Study Group of India (DIPSI) Criteria] as a Diagnostic Test for Gestational Diabetes Mellitus. *Indian Journal of Medical Research* **2017**, *145* (2), 209–214.
18. Reece, E. A. The Fetal and Maternal Consequences of Gestational Diabetes Mellitus. *The Journal of maternal-fetal & neonatal medicine* **2010**, *23* (3), 199–203.
19. Rasmussen, K. M.; Yaktine, A. L. Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines. Weight Gain during Pregnancy: Reexamining the Guidelines. *Washington, DC: National Academies Press (US).[Google Scholar]* **2009**.
20. Brzozowska, M.; Bieniek, E.; Szosland, K.; Lewiński, A. Gestational Diabetes-Is Diet and Insulin the Only Solution? *Neuroendocrinology Letters* **2017**, *38* (5).
21. Vedantam, D.; Poman, D. S.; Motwani, L.; Asif, N.; Patel, A.; Anne, K. K. Stress-Induced Hyperglycemia: Consequences and Management. *Cureus* **2022**, *14* (7).
22. Voerman, E.; Santos, S.; Inskip, H.; Amiano, P.; Barros, H.; Charles, M. A.; Chatzi, L.; Chrousos, G. P.; Corpeleijn, E.; Crozier, S. LifeCycle Project-Maternal Obesity and Childhood Outcomes Study Group. Association of Gestational Weight Gain with Adverse Maternal and Infant Outcomes. *JAMA* **2019**, *321* (17), 1702–1715.
23. Masood, S. N.; Shegem, N.; Baqai, S.; Suliman, M.; Alromaihi, D.; Sultan, M.; Salih, B. T.; Ram, U.; Ahmad, Z.; Aljufairi, Z. IDF-MENA Region Guidelines for Management of Hyperglycemia in Pregnancy. *Journal of Diabetology* **2021**, *12* (Suppl 1), S3–S42.
24. Ferrie, J. E. Evidence and Policy: Mind the Gap. *Int J Epidemiol* **2015**, *44* (1), 1–7.
25. Peterson, C. M.; Jovanovic-Peterson, L. Percentage of Carbohydrate and Glycemic Response to Breakfast, Lunch, and Dinner in Women with Gestational Diabetes. *Diabetes* **1991**, *40* (Supplement_2), 172–174.
26. Sachdev, M.; Misra, A. Heterogeneity of Dietary Practices in India: Current Status and Implications for the Prevention and Control of Type 2 Diabetes. *Eur J Clin Nutr* **2023**, *77* (2), 145–155.
27. Hay Jr, W. W. Placental-Fetal Glucose Exchange and Fetal Glucose Metabolism. *Trans Am Clin Climatol Assoc* **2006**, *117*, 321.
28. McIntyre, H. D.; Catalano, P.; Zhang, C.; Desoye, G.; Mathiesen, E. R.; Damm, P. Gestational Diabetes Mellitus. *Nat Rev Dis Primers* **2019**, *5* (1), 47.
29. K, N. S. of the D. C. A. C. of D. U. The Implementation of Nutritional Advice for People with Diabetes. *Diabetic Medicine* **2003**, *20* (10), 786–807.
30. Vasile, F. C.; Preda, A.; Ștefan, A. G.; Vladu, M. I.; Forțofoiu, M.-C.; Clenciu, D.; Gheorghe, I. O.; Forțofoiu, M.; Moța, M. An Update of Medical Nutrition Therapy in Gestational Diabetes Mellitus. *J Diabetes Res* **2021**, *2021*, 1–10.
31. Blumer, I.; Hadar, E.; Hadden, D. R.; Jovanovič, L.; Mestman, J. H.; Murad, M. H.; Yogev, Y. Diabetes and Pregnancy: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab* **2013**, *98* (11), 4227–4249.
32. Nguyen, T. H. L.; Yang, J. W.; Mahone, M.; Godbout, A. Are There Benefits for Gestational Diabetes Mellitus in Treating Lower Levels of Hyperglycemia than Standard Recommendations? *Can J Diabetes* **2016**, *40* (6), 548–554.
33. Kumar, V.; Agarwal, S.; Saboo, B.; Makkar, B. RSSDI Guidelines for the Management of Hypertension in Patients with Diabetes Mellitus. *Int J Diabetes Dev Ctries* **2022**, *42* (4), 576–605.
34. Ministerråd, N. *Nordic Nutrition Recommendations 2012. Part 1: Summary, Principles and Use*; Nordic Council of Ministers, 2013.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 3813-3826 | ISSN:2251-6727

35. Melina, V.; Craig, W.; Levin, S. Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. *J Acad Nutr Diet* **2016**, *116* (12), 1970–1980.
36. Sebastiani, G.; Herranz Barbero, A.; Borrás-Novell, C.; Alsina Casanova, M.; Aldecoa-Bilbao, V.; Andreu-Fernández, V.; Pascual Tutusaus, M.; Ferrero Martínez, S.; Gómez Roig, M. D.; García-Algar, O. The Effects of Vegetarian and Vegan Diet during Pregnancy on the Health of Mothers and Offspring. *Nutrients* **2019**, *11* (3), 557.
37. Wu, G. Dietary Protein Intake and Human Health. *Food Funct* **2016**, *7* (3), 1251–1265.
38. Association, A. D. 14. Management of Diabetes in Pregnancy: Standards of Medical Care in Diabetes—2020. *Diabetes Care* **2020**, *43* (Supplement_1), S183–S192.
39. Zhang, C.; Liu, S.; Solomon, C. G.; Hu, F. B. Dietary Fiber Intake, Dietary Glycemic Load, and the Risk for Gestational Diabetes Mellitus. *Diabetes Care* **2006**, *29* (10), 2223–2230.
40. Liese, A. D.; Schulz, M.; Fang, F.; Wolever, T. M. S.; D'Agostino Jr, R. B.; Sparks, K. C.; Mayer-Davis, E. J. Dietary Glycemic Index and Glycemic Load, Carbohydrate and Fiber Intake, and Measures of Insulin Sensitivity, Secretion, and Adiposity in the Insulin Resistance Atherosclerosis Study. *Diabetes Care* **2005**, *28* (12), 2832–2838.
41. Mcintosh, M.; Miller, C. A Diet Containing Food Rich in Soluble and Insoluble Fiber Improves Glycemic Control and Reduces Hyperlipidemia among Patients with Type 2 Diabetes Mellitus. *Nutr Rev* **2001**, *59* (2), 52–55.
42. Lucock, M. Folic Acid: Nutritional Biochemistry, Molecular Biology, and Role in Disease Processes. *Mol Genet Metab* **2000**, *71* (1–2), 121–138.
43. Burdge, G. C.; Lillycrop, K. A. Nutrition, Epigenetics, and Developmental Plasticity: Implications for Understanding Human Disease. *Annu Rev Nutr* **2010**, *30*, 315–339.
44. Farkas, S. A.; Böttiger, A. K.; Isaksson, H. S.; Finnell, R. H.; Ren, A.; Nilsson, T. K.; Nilsson, T. K. Epigenetic Alterations in Folate Transport Genes in Placental Tissue from Fetuses with Neural Tube Defects and in Leukocytes from Subjects with Hyperhomocysteinemia. *Epigenetics* **2013**, *8* (3), 303–316.
45. Most, J.; Dervis, S.; Haman, F.; Adamo, K. B.; Redman, L. M. Energy Intake Requirements in Pregnancy. *Nutrients* **2019**, *11* (8), 1812.
46. Sheehan, M. T. Polycystic Ovarian Syndrome: Diagnosis and Management. *Clin Med Res* **2004**, *2* (1), 13–27.
47. Qiu, C.; Coughlin, K. B.; Frederick, I. O.; Sorensen, T. K.; Williams, M. A. Dietary Fiber Intake in Early Pregnancy and Risk of Subsequent Preeclampsia. *Am J Hypertens* **2008**, *21* (8), 903–909.
48. Strohm, D.; Bechthold, A.; Ellinger, S.; Leschik-Bonnet, E.; Stehle, P.; Heseker, H.; (DGE, G. N. S. Revised Reference Values for the Intake of Sodium and Chloride. *Ann Nutr Metab* **2018**, *72* (1), 12–17.
49. Tattari, S.; Gavaravarapu, S. M.; Pullakhandam, R.; Bhatia, N.; Kaur, S.; Sarwal, R.; Rajkumar, H.; Reddy, G. B. Nutritional Requirements for the Elderly in India: A Status Paper. *Indian J Med Res* **2022**, *156* (3), 411.
50. Bardosono, S.; Prasmusinto, D.; Hadiati, D. R.; Purwaka, B. T.; Morin, C.; Pohan, R.; Sunardi, D.; Chandra, D. N.; Guelinckx, I. Fluid Intake of Pregnant and Breastfeeding Women in Indonesia: A Cross-Sectional Survey with a Seven-Day Fluid Specific Record. *Nutrients* **2016**, *8* (11), 651.
51. Yates, L.; Warde, A. Eating Together and Eating Alone: Meal Arrangements in British Households. *Br J Sociol* **2017**, *68* (1), 97–118.
52. Seshadri, R. American Diabetes Association Gestational Diabetes Mellitus. *Diabetes Care* **2002**, *25*, S94–S96.
53. Seshiah, V.; Balaji, V. Prevention and Management of Diabetes in Pregnancy. *ECAB Clinical Update: Diabetology* 35.
54. Jia, S. S.; Liu, Q.; Allman-Farinelli, M.; Partridge, S. R.; Pratten, A.; Yates, L.; Stevens, M.; McGill, B. The Use of Portion Control Plates to Promote Healthy Eating and Diet-Related Outcomes: A Scoping Review. *Nutrients* **2022**, *14* (4), 892.
55. Plate, H. E. The Nutrition Source. *Harvard TH Chan School of Public Health https://www. hsph. Harvard. edu/nutrition source/healthy. Accessed* **2021**, *22*.
56. Mustafa, S. T.; Hofer, O. J.; Harding, J. E.; Wall, C. R.; Crowther, C. A. Dietary Recommendations for Women with Gestational Diabetes Mellitus: A Systematic Review of Clinical Practice Guidelines. *Nutr Rev* **2021**, *79* (9), 988–1021.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 3813-3826 | ISSN:2251-6727

57. Nathan, D. M. Long-Term Complications of Diabetes Mellitus. *New England journal of medicine* **1993**, *328* (23), 1676–1685.
58. Group, U. K. P. D. S. (UKPDS). Effect of Intensive Blood-Glucose Control with Metformin on Complications in Overweight Patients with Type 2 Diabetes (UKPDS 34). *The Lancet* **1998**, *352* (9131), 854–865.
59. Bloomgarden, Z. T.; Karmally, W.; Metzger, M. J.; Brothers, M.; Nechemias, C.; Bookman, J.; Faierman, D.; Ginsberg-Fellner, F.; Rayfield, E.; Brown, W. V. Randomized, Controlled Trial of Diabetic Patient Education: Improved Knowledge without Improved Metabolic Status. *Diabetes Care* **1987**, *10* (3), 263–272.
60. Peyrot, M.; Rubin, R. R.; Lauritzen, T.; Snoek, F. J.; Matthews, D. R.; Skovlund, S. Psychosocial Problems and Barriers to Improved Diabetes Management: Results of the Cross-National Diabetes Attitudes, Wishes and Needs (DAWN) Study. *Diabetic medicine* **2005**, *22* (10), 1379–1385.
61. Giezenaar, C.; Lange, K.; Hausken, T.; Jones, K. L.; Horowitz, M.; Chapman, I.; Soenen, S. Acute Effects of Substitution, and Addition, of Carbohydrates and Fat to Protein on Gastric Emptying, Blood Glucose, Gut Hormones, Appetite, and Energy Intake. *Nutrients* **2018**, *10* (10), 1451.
62. Kubota, S.; Liu, Y.; Iizuka, K.; Kuwata, H.; Seino, Y.; Yabe, D. A Review of Recent Findings on Meal Sequence: An Attractive Dietary Approach to Prevention and Management of Type 2 Diabetes. *Nutrients* **2020**, *12* (9), 2502.
63. Imai, S.; Fukui, M.; Kajiyama, S. Effect of Eating Vegetables before Carbohydrates on Glucose Excursions in Patients with Type 2 Diabetes. *J Clin Biochem Nutr* **2014**, *54* (1), 7–11.
64. Howarth, N. C.; Saltzman, E.; Roberts, S. B. Dietary Fiber and Weight Regulation. *Nutr Rev* **2001**, *59* (5), 129–139.
65. Wong, J. M. W.; Jenkins, D. J. A. Carbohydrate Digestibility and Metabolic Effects. *J Nutr* **2007**, *137* (11), 2539S-2546S.
66. Snoek, F. J. Barriers to Good Glycaemic Control: The Patient's Perspective. *Int J Obes* **2000**, *24* (3), S12–S20.
67. Anderson, I. H.; Levine, A. S.; Levitt, M. D. Incomplete Absorption of the Carbohydrate in All-Purpose Wheat Flour. *New England Journal of Medicine* **1981**, *304* (15), 891–892.
68. Jenkins, D. J.; Wolever, T. M.; Taylor, R. H.; Barker, H.; Fielden, H.; Baldwin, J. M.; Bowling, A. C.; Newman, H. C.; Jenkins, A. L.; Goff, D. V. Glycemic Index of Foods: A Physiological Basis for Carbohydrate Exchange. *Am J Clin Nutr* **1981**, *34* (3), 362–366.
69. Yoon, J. H.; Thompson, L. U.; Jenkins, D. J. The Effect of Phytic Acid on in Vitro Rate of Starch Digestibility and Blood Glucose Response. *Am J Clin Nutr* **1983**, *38* (6), 835–842.
70. Englyst, H. N.; Kingman, S. M.; Cummings, J. H. Classification and Measurement of Nutritionally Important Starch Fractions. *Eur J Clin Nutr* **1992**, *46*, S33-50.
71. Thorne, M. J.; Thompson, L. U.; Jenkins, D. J. Factors Affecting Starch Digestibility and the Glycemic Response with Special Reference to Legumes. *Am J Clin Nutr* **1983**, *38* (3), 481–488.
72. Holt, S.; Carter, D.; Tothill, P.; Heading, R.; Prescott, L. Effect of Gel Fibre on Gastric Emptying and Absorption of Glucose and Paracetamol. *The Lancet* **1979**, *313* (8117), 636–639.
73. Schwartz, S. E.; Levine, G. D. Effects of Dietary Fiber on Intestinal Glucose Absorption and Glucose Tolerance in Rats. *Gastroenterology* **1980**, *79* (5), 833–836.
74. Amori, R. E.; Lau, J.; Pittas, A. G. Efficacy and Safety of Incretin Therapy in Type 2 Diabetes: Systematic Review and Meta-Analysis. *JAMA* **2007**, *298* (2), 194–206.
75. Committee, A. D. A. P. P.; Committee: A. D. A. P. P. 15. Management of Diabetes in Pregnancy: Standards of Medical Care in Diabetes—2022. *Diabetes Care* **2022**, *45* (Supplement_1), S232–S243.
76. Wong, V. W.; Jalaludin, B. Gestational Diabetes Mellitus: Who Requires Insulin Therapy? *Australian and New Zealand Journal of Obstetrics and Gynaecology* **2011**, *51* (5), 432–436.
77. Ponzo, V.; Fedele, D.; Goitre, I.; Leone, F.; Lezo, A.; Monzeglio, C.; Finocchiaro, C.; Ghigo, E.; Bo, S. Diet-Gut Microbiota Interactions and Gestational Diabetes Mellitus (GDM). *Nutrients* **2019**, *11* (2), 330.
78. Hui, A. L.; Sevenhuysen, G.; Harvey, D.; Salamon, E. Stress and Anxiety in Women with Gestational

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 3813-3826 | ISSN:2251-6727

Diabetes during Dietary Management. *Diabetes Educ* **2014**, *40* (5), 668–677.

79. Benelam, B.; Wyness, L. Hydration and Health: A Review. *Nutr Bull* **2010**, *35* (1), 3–25.
80. O'Reilly, S. L. Prevention of Diabetes after Gestational Diabetes: Better Translation of Nutrition and Lifestyle Messages Needed. In *Healthcare*; MDPI, 2014; Vol. 2, pp 468–491.
81. Association, A. D. Standards of Medical Care in Diabetes—2014. *Diabetes Care* **2014**, *37* (Supplement_1), S14–S80.
82. Nankervis, A.; McIntyre, H. D.; Moses, R. G.; Ross, G. P.; Callaway, L. K. Testing for Gestational Diabetes Mellitus in Australia. *Diabetes Care* **2013**, *36* (5), e64–e64.
83. Practitioners, R. A. C. of G. *Guidelines for Preventive Activities in General Practice*; Royal Australian College of General Practitioners, 2012.