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A Narrative Review of a Low Glycemic Index Dietary Intervention During and after Gestational Diabetes Mellitus

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Abstract
Gestational diabetes mellitus (GDM) causes short- and long-term adverse health consequences, including postnatal DM among women post-GDM. This review synthesised the recent evidence about low glycemic index (GI) dietary intervention during and after GDM. Literature searches were conducted for articles published in English through two electronic databases, MEDLINE (for PubMed) and Science Direct, for studies that investigated the effects of a low GI during and after GDM. Eight studies met the criteria. Six studies were conducted among women with GDM during pregnancy, and two studies in women post GDM. In women with GDM, all studies had an intervention with a control group. Five studies reported at least one positive outcome in glucose levels, obstetric and fetal outcomes, or dietary intake compared to the control group. In women post GDM, one study had an intervention with a different control group, while another study was conducted within the same group but with a washout interval. Both studies reported at least one positive outcome in glucose levels, insulin sensitivity, or body weight reduction. The low GI diet intervention featured strategies to avoid and eliminate moderate to high GI foods and substitute high GI with low GI foods. The use of low GI diets during and after GDM provides some favourable outcomes. Further studies on diet GI in women post GDM are warranted to improve the quality of evidence tailored to a specific population.

Introduction
Gestational diabetes mellitus (GDM) is characterised as the degree of glucose intolerance with onset or first recognition during pregnancy (American Diabetes Association, 2003). GDM is amongst the most common pregnancy complications, and the prevalence was more than 30% in several countries, including developing countries (Zhu & Zhang, 2016). In Malaysia, two studies showed that the prevalence of GDM ranged from 18.3% and 24.9% (Idris et al., 2009; Shamsuddin et al., 2001).

GDM has been associated with significant short- and long-term unfavourable health effects for the mother and fetus. One of the worrying implications is type 2 diabetes mellitus (T2DM) development. A retrospective cohort study in Sri Lanka found that GDM is a crucial factor in developing T2DM. They discovered that contrary to women without GDM, women with GDM had a ten-fold greater risk of developing T2DM during a ten year follow up (Herath et al., 2017). This finding is greater than the seven-fold risk documented in a systematic review (Bellamy et al., 2009). In Malaysia, a cross-sectional study conducted among antenatal mothers showed that the prevalence of T2DM among women post GDM was 12.1%. Moreover, there is an established relationship between GDM with the commencement of diabetes in childhood and youth (Blotsky et al., 2019).

Lifestyle advice, including Medical Nutrition Therapy (MNT), is the principal intervention component in GDM. The purpose of MNT is to keep blood glucose levels within the normal range by optimising the carbohydrate composition of the diet while avoiding hypoglycemia or ketosis as a result of an excessive carbohydrate intake reduction (American Diabetes Association, 2008). Maternal diet, particularly dietary carbohydrates, is essential for fluctuating blood glucose after a meal (Catalano et al., 1995). Different types of carbohydrates give different glycemic effects, and it is advised to choose appropriate types of carbohydrates which reduce glucose excursion after meal instead of reducing the amount of carbohydrate altogether.

The glycemic index (GI) is a measure of blood glucose reaction after consuming carbohydrate food. GI values are categorised into low (<55), intermediate (55-69), and high (≥70). Foods with high GI resulted in a quick rise of blood glucose and insulin responses. Meanwhile, foods with low GI cause gradual rises in glucose response due to the slower digestion and absorption rate (Figure 1).

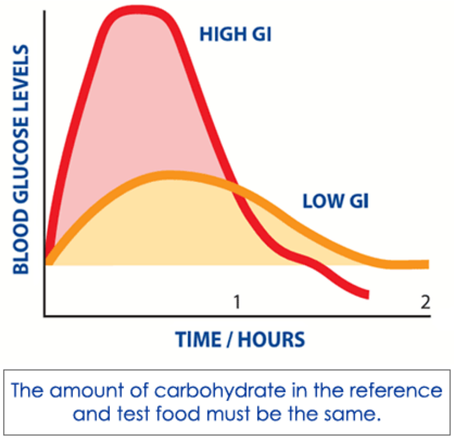

Figure 1. GI as a percentage of area under the curve
(Source: University of Sydney, 2014)

Past studies have tried to encapsulate the existing data on GI and pregnancy (Yusof et al., 2014). However, it is focused on clinical outcomes without specifying the changes in dietary quality and adequacy. Moreover, Yusof et al (2014) did none attempt to study low GI and women post-GDM. The topic is relevant as post-GDM increases the risk of developing T2DM, contributing to the worldwide diabetes epidemic. A low GI diet improved HbA1c in men and women already diagnosed with T2DM (Brand-Miller et al., 2003). Therefore, this narrative review determines the effect of a low GI diet for women of reproductive age during and after GDM. The data would aid healthcare experts to take appropriate and practical interventions regarding GDM, particularly on the dietary aspect.

Methods

Literature Search

Literature searches through two databases, MEDLINE (for PubMed) and Science Direct (for Elsevier), were conducted without time restrictions. Some of the search terms and their combinations include "gestational diabetes" AND "glucose" OR "weight" OR "dietary intake" AND "low glycemic index". The search was restricted to English papers, and the lists of references of review articles and original publications were reviewed for other possibly related studies.

Study Selection

Studies giving dietary intervention which covered the aspect of low GI diets for women with GDM or with a history of GDM and determined a minimum of one of the routinely measured clinical outcomes during pregnancy were included. The outcomes comprise obstetric and fetal outcomes, blood glucose, blood pressure, dietary intake, induction of labour, method of delivery, maternal weight gain, and risk of prematurity. Studies conducted in healthy women and did not specify any nutrition plan component were excluded. At first, a total of 21 relevant studies were discovered (Figure 2). We excluded four studies after a detailed screening of the title and abstract. Of these, nine studies were excluded further as they did not meet the study criteria. Reason of study exclusion included not relevant to the research question, review articles, unpublished articles and duplicate publications.

Data Extraction

Data extraction of related study information for articles meeting inclusion criteria was conducted. The extracted data included study location, study design, participant characteristics, number of participants, study duration, study visits, features of diets, other components of nutritional education, outcome measures, and main findings.

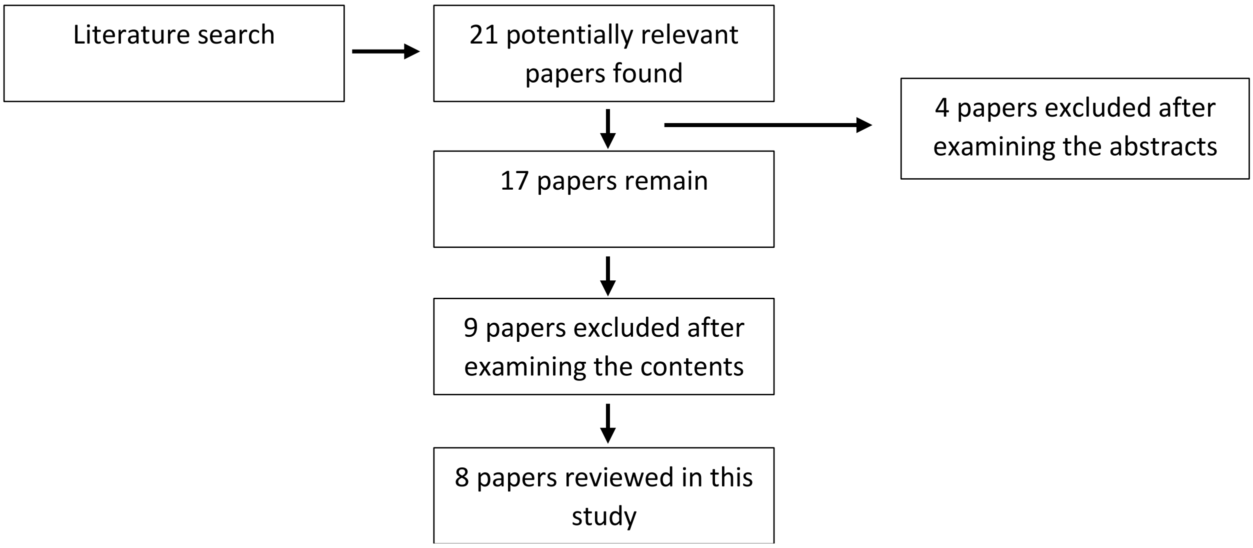

Figure 2: Process of paper selection through literature search

Results

The search strategy identified 21 articles published on the low GI diet and GDM. After excluding duplicates, screening the title and abstract, and analysing the context, 13 articles were excluded. Finally, after the exclusion, a total of 8 studies were included in this narrative review.

Description of Studies

Most studies except one had an interventional study design with a control group. The study without a comparison group had a three-week washout interval (Östman et al., 2006). All of the studies were randomised trials (Farhanah et al., 2017; Hu et al., 2014; Shyam et al., 2013; Perichart-Perera et al., 2012; Grant et al., 2011; Louie et al., 2011; Moses et al., 2009; Östman et al., 2006). Women were randomly assigned to an intervention or control group. The intervention group were given low GI dietary advice. The control group was given either a standard or conventional diet, continued current regimen with physicians, or was not adequately mentioned in the study. On the contrary, the interventional group was provided with low GI diets.

Participants ranged from 40 to 140, with most of them in their 30s. The studies were generally carried out in English speaking countries (n = 8), including one from Mexico, one from Canada, one from Sweden, and two from Australia. Three studies were conducted in Asia, including two from Malaysia and one from China.

Low GI diet in Women with GDM

Study Characteristics

Six studies were carried out among women with GDM. The number of participants varied from 40 to 140, with a total of 486 participants (Table 1). Two of them were carried out in Asia (Malaysia and China) (Farhanah et al., 2017; Hu et al., 2014), two in Australia (Louie et al., 2011; Moses et al., 2009), one each in Canada and Mexico (Perichart-Perera et al., 2012; Grant et al., 2011), respectively.

Five studies included adult patients with GDM (Farhanah et al., 2017; Grant et al., 2011; Hu et al., 2014; Louie et al., 2011; Moses et al., 2009), while one study combined patients with GDM and diabetes in pregnancy (Perichart-Perera et al., 2012). Ages ranging from 18 to 45 years old, with most of them in their 30s. The participants had a confirmed diagnosis of GDM mainly in their second trimesters ranging from 18 – 35 weeks of gestations (Table 1). Study duration varied between 5 days and ten weeks. Outcome measures included blood glucose, dietary intake, blood pressure, anthropometric data (maternal weight gain, infant birth weight), and obstetric (induction of labour, method of delivery). These studies included outcomes on blood glucose except for one study (Farhanah et al., 2017), which only reported outcomes on dietary intake.

Outcomes Measures

(i) Blood Glucose Outcomes

The low GI diet group improved blood glucose outcomes (Hu et al., 2014; Perichart-Perera et al., 2012; Grant et al., 2011; Moses et al., 2009), maternal weight gain (Moses et al., 2009), and dietary intake (Farhanah et al., 2017; Grant et al., 2011; Moses et al., 2009). Five studies assessed blood glucose outcomes (Hu et al., 2014; Perichart-Perera et al., 2012; Grant et al., 2011; Louie et al., 2011; Moses et al., 2009). Out of the five studies, blood glucose outcomes improved significantly in three studies (Hu et al., 2014; Perichart-Perera et al., 2012; Moses et al., 2009). Nonetheless, one study did not show a significant reduction in blood glucose values but reported significant improvement in the percentage of postprandial glucose values in the target range (Grant et al., 2011). Two studies conducted in Australia reported contrast results in which one study reported that both intervention and control diets produced comparable maternal metabolic profile outcomes (Louie et al., 2011). Another study reported that the low GI diet effectively halved the number of participants requiring to use insulin (Moses et al., 2009), and some women from the control group could avoid insulin use when they were asked to follow a low GI diet.

(ii) Obstetric and Fetal Outcomes

Three studies assessed obstetric and fetal outcomes (Perichart-Perera et al., 2012; Louie et al., 2011; Moses et al., 2009). Two studies showed comparable outcomes in all obstetric and fetal outcomes (Louie et al., 2011; Moses et al., 2009), with no significant difference in labour induction and delivery method (Moses et al., 2009). Average infant birth weight and birth weight centile were also in healthy ranges in both intervention and control groups (Louie et al., 2011). Two of the studies reported no significant difference, but lesser women in the low GI diet had excessive weight gain (Louie et al., 2011), while another study reported a significant difference in women who had excessive weight gain (Perichart-Perera et al., 2012), in which the percentage was higher in a group which was not advised on low GI diet. One study reported a higher percentage of risk of prematurity in the low GI diet (Perichart-Perera et al., 2012), although the difference was not significant.

(iii) Dietary Intake

Despite providing dietary intervention, only four studies evaluated modifications in dietary intake. With the low GI diet, participants were able to reduce the total energy consumed (Moses et al., 2009). A low GI diet also helped participants increase fibre intake (Farhanah et al., 2017; Grant et al., 2011; Moses et al., 2009), although the improvement was not significant in one study (Farhanah et al., 2017). GI and GL were reduced in the low GI diet (Farhanah et al., 2017; Grant et al., 2011), although the reduction was not significant in one study (Farhanah et al., 2017). The low GI diet also improved dietary calcium intake (Farhanah et al., 2017) compared to the participants receiving standard nutrition therapy.

Low GI diet among Women post GDM

Study Characteristics

The current literature could only identify two studies conducted among women with a history of GDM (Table 2). One study was conducted in Malaysia for 6 months among 62 participants (Shyam et al., 2013), and another study was conducted in Sweden (n=7) for 9 weeks (Östman et al., 2006). One study was conducted with a control group (Shyam et al., 2013), while another was conducted among the same group, but with a three-week washout period before the dietary intervention (Östman et al., 2006).

Outcome Measures

Glucose outcomes (fasting blood glucose, 2-hour postprandial), obstetric outcomes (weight loss, BMI changes), and dietary intake were assessed in the study, which was conducted in Malaysia (Shyam et al., 2013). The study reported no significant changes in fasting blood glucose between both groups. However, changes in 2-hour postprandial were significantly different between low GI diet and conventional healthy dietary recommendation (CHDR) groups. After six months, the study reported significant reductions in body weight, BMI, waist circumference, and waist-to-hip ratio in the low GI group, while another group only reported a significant reduction in waist circumference. In terms of weight loss, a more significant number of subjects attained a percentage weight loss of ≥5% in the low GI group compared to the CHDR group. After six months, the study also reported that the group with low GI diets reported significantly lower GI, GL, and higher fibre content.

The study conducted in Sweden assessed blood lipids, glucose tolerance and insulin sensitivity (Östman et al., 2006). Dietary modification characterised by reducing the diet GI and add cereal fibre of the bread products enhanced insulin economy. All women in this study had substantially reduced their insulin reactions to the intravenous glucose challenge on average by 35% (0–60 min). On the other hand, the insulin response after the high-GI intervention periods was not significantly affected. However, the fasting HDL cholesterol and triglycerides levels were within the normal range and did not change significantly during the high-GI or low-GI periods. Besides, no changes were found between fasting glucose or insulin at the starting and end of each dietary period.

Key Features of the Intervention

The basis of the low GI depends on the classification of food; low (<55), intermediate (55-69), and high (≥70). In these reviewed studies among women with GDM, dietary intervention on GI mainly included advice to avoid the intake of high GI foods such as white bread, potatoes, and some rice varieties (Moses et al., 2009), elimination of moderate and high GI foods, including tropical fruits, refined bread, breakfast cereals, white rice, refined cookies and pastries, and refined sugars (Perichart-Perera et al., 2012), and replacement of high GI foods to low GI foods (Farhanah et al., 2017; Hu et al., 2014; Perichart-Perera; 2012; Moses et al., 2009). The low GI diet for the study conducted in Australia (Moses et al., 2009) was based on earlier verified low GI food (Atkinson et al., 2008), and the nutritional recommendation was personalised with the particular indication of the energy and nutrient balance to reach expected weight gain. Apart from achieving the desired dietary intervention, some considerations were also made to consider the population's intakes. For instance, despite eliminating moderate and high GI foods in the study (Perichart-Perera et al., 2012), papaya was the only moderate GI fruit allowed since it is one of the most commonly consumed high-fibre foods among this group.

Additionally, most of these studies reported providing nutrition education to participants from intervention and control groups (Farhanah et al., 2017; Hu et al., 2014; Perichart-Perera et al., 2012; Louie et al., 2011; Moses et al., 2009). This included advice on the eating patterns (Farhanah et al., 2017) comprising small frequent meals and even distribution throughout the day, portion size control using the plate method, and a set of meal plans based on the energy requirement. In particular, participants were administered with a booklet outlining the options of carbohydrates and the carbohydrates food amounts constituting one serving based on 15-g portions (Moses et al., 2009). To achieve optimal blood glucose levels, they were also recommended to take three small meals and two to three snacks with a specified number of servings of carbohydrates (Moses et al., 2009). One study provided education on GDM (Hu et al., 2014), which primarily focuses on the causes of GDM, effects on both mother and fetus, principles of diet management and other treatments. However, one study reported providing dietary advice without detailing other nutrition therapy aspects (Grant et al., 2011).

A study in Mexico provided dietary advice on a low GI diet and the nutrition practice guidelines for gestational diabetes by the American Diabetes Association (Perichart-Perera et al., 2012). According to the guidelines, women obtained an individual food plan based on carbohydrate restriction (40– 45% of total energy intake), using a carbohydrate counting method, and moderate energy restriction was suggested only for overweight and obese women. Breakfast carbohydrate intake was limited to 15–30 g, and adequate fibre intake of 20-35 g/day was recommended. Furthermore, women in this group were advised to choose any type of CHO, except added refined sugars.

In the reviewed studies among women post GDM, both studies reported providing advice on the low GI diet incorporating the usual dietary advice (Shyam et al., 2013; Östman et al., 2006). In addition, one study reported providing nutrition education to participants from intervention and control groups which included advice on the consumption of foods low in fat and refined sugars and high in fibre (Shyam et al., 2013). The study also provided dietary advice on the low GI diet and the conventional recommended dietary recommendation. The Malaysian Ministry of Health suggested a recommended diet using the 5M framework to improve Malaysians' living standards, especially on healthy food intake. The approach minimises salt, sugar, and oil and consumes more fruit and vegetables (Ministry of Health Malaysia, n.d.). Moreover, were advised to perform moderate physical activity for thirty minutes and at least five times a week.

Contrary to the other study, one study was conducted with a three-week washout interval (Östman et al., 2006). The participants were provided two bread products with low or high GI during two continuous three-week periods. In the control diet, two commercial bread products (one light and one dark) with GIs of approximately 100 were selected from the market, and both products were low in dietary fibre. On the other hand, two low GI bread products were developed (one light and one dark) from information by past studies which stated that aspects including botanical structure, viscous dietary fibre and organic acids play a major role in the GI of bread (Liljeberg et al., 1992, 1995, 1996).

Analyses of the Key Features

Out of the six studies among women with GDM comparing intervention to the control group (Table 1), five reported at least one positive outcome in glucose levels, obstetric and fetal outcomes, and dietary intake (Farhanah et al., 2017; Hu et al., 2014; Perichart-Perera et al., 2012; Grant et al., 2011; Moses et al., 2009). Only one study reported comparable outcomes in the aspects assessed (Louie et al., 2011). The particular study reported that in exclusively monitored women with GDM, a LGI diet and a conventional high fibre diet resulted in comparable pregnancy results.

In studies among women post GDM (Table 2), both studies reported at least one positive outcome in glucose levels, insulin sensitivity, or body weight reduction (Shyam et al., 2013; Östman et al., 2006).

Discussion

The narrative review offers evidence of the efficacy of a low GI diet in enhancing no less than one clinical outcome, inclusive of glycemic control, obstetric and fetal outcomes such as maternal weight gain and infant birth weight, and dietary intake in people with GDM or a history of GDM. The key features of the diet included dietary advice on avoiding high GI foods, eliminating all moderate and high GI foods, and substituting foods with high GI to foods with low GI. On top of that, most of these studies reported providing nutrition education to participants for intervention and control groups. This included eating pattern advice and dietary advice on consuming foods low in fat and refined sugars and high in fibre.

During pregnancy, optimal growth and the health of both the mother and fetus are of utmost importance. In women with GDM, optimal glucose control is as important as appropriate weight gain and sufficient nutrient intake (Reader, 2007). Elevated glucose values, particularly increased postprandial glucose, are related to unfavourable consequences in GDM. According to a study in Canada, the incidence of diabetes in children and youth born to mothers with GDM was more significant than in mothers without GDM (Blotsky et al., 2019). The study reported that the chances of those born to mothers with GDM to develop diabetes by 22 years were doubled. Hence, it is essential for healthcare providers, parents, children and youth to acknowledge the risk of developing diabetes to take preventive measures to halt this issue.

Nutrition acts as an essential element in the health outcomes of all pregnant women. Carbohydrate is the primary nutrient that influences postprandial glucose levels. Carbohydrate intake can be influenced by regulating the total amount, distribution, and type of carbohydrates. Apart from the total amount of carbohydrates, the carbohydrate type may also influence, and the GI has garnered attention as a nutrition intervention to provide additional benefit to total carbohydrate control.

A low GI diet improved blood glucose outcomes in six studies for women during and post GDM (Hu et al., 2014; Shyam et al., 2013; Perichart-Perera et al., 2012; Grant et al., 2011; Moses et al., 2009; Östman et al., 2006). On the other hand, one study showed that both diets (low GI and high fibre, moderate GI) produce comparable outcomes (Louie et al., 2011). However, this may be because all women had been provided early nutrition counselling in a group session regardless of the dietary assignment. As a result, both groups were taking a lower GI diet compared to the population norms upon recruitment. In other words, both groups attained a comparatively low GI diet, with only a modest five-point difference between groups. Hence, these findings suggest that low GI diets could produce optimal blood glucose results among women with GDM or a history of GDM along with extensive medical management of GDM.

Women with GDM are known to be at a higher risk to develop. What stays beyond our understanding is how to interpret the data of prevention into practice effectively. A review paper summarises the results of past studies regarding the incidence and risk factors of postpartum diabetes and looks into current lifestyle interventional trials which aimed to prevent postpartum diabetes (Moon et al., 2017).

The Diet, Exercise, and Breastfeeding Intervention (DEBI) is a randomised controlled feasibility trial among women with previous GDM (Ferrara et al., 2011). Some dietary intervention components include advice to follow the ADA diet and written materials on portion size, foods with low GI or low fat and food labels. The results showed that the intervention reduced the intake of dietary fat and increased breastfeeding with borderline significance. However, the levels of physical activity did not vary. As a result, more women in the intervention group achieved their postpartum weight goal. The results also showed that women in the intervention group achieved lower glucose than the control group, although statistically insignificant. They have also reported that women who reduced greater than 2 kg achieved significantly lower fasting glucose, 2-hour insulin, glucose after the meal at 12 months postpartum (Ehrlich et al., 2014). Another randomised interventional trial was carried out in Asia among Chinese women post-GDM with impaired glucose tolerance on postpartum OGTT (Shek et al., 2014). Women in the intervention group were referred to the dietitian for advice on diet and exercise. This study found that contrary to the control group, fewer women who were given lifestyle intervention developed postpartum T2DM during a three-year follow-up period, although this was statistically insignificant.

Clinical trials showed that the incidence of T2DM reduced by up to 58% for high-risk groups succeeding lifestyle change (Qiao et al., 2010; Saaristo et al., 2010). The United States DPP demonstrated that lifestyle modification works for women post GDM, their risk of T2DM decreased by 50% (Ratner et al., 2008), and the results of diabetes prevention sustained ten years after the intervention within the whole DPP cohort (Knowler et al., 2009). Although there is a consistent consensus that lifestyle modification is assured to prevent diabetes, conveying that information differs between recommendations, resulting in differences in interpretation (O'Reilly, 2014). In this regard, the difference is more apparent in nutrition than the recommendations for physical activity that are comparatively consistent. Furthermore, to our knowledge, although the risk factors of the progression of future diabetes are acknowledged, studies on the contribution of dietary GI towards the incidence of T2DM among women post GDM are scanty. Hence, the competence to evaluate the findings of the interventions within this context will offer healthcare providers essential information on effective and practical approaches to manage and work with women with a history of GDM to make lifestyle changes and reduce their chances of postpartum diabetes.

This review has some limitations. First, we did not perform meta-analyses of the study findings; thus, we could not quantify the outcome measures such as the changes in body weight. Next, another limitation could be the different diagnostic criteria for GDM used in the included studies. Furthermore, the evaluated outcomes were not always the same in the included studies, were not uniformly standardised, or were unavailable. Finally, the compliance to dietary interventions provided was not investigated or documented in all trials except one. Hence, all these features strengthen the necessity to conduct well-constructed RCTs on the effects of dietary interventions in patients with GDM or a history of GDM.

Dietary intervention is crucial in lowering the risk of further complications for patients with GDM or a history of GDM. The studies included in this review have discussed dietary interventions on low GI diets and several other essential nutrition educations. However, it is crucial to provide individually tailored nutrition plans and consider their health status and risk stratification. Moreover, it is also equally important to assess patients' acceptance and adherence to the dietary interventions provided. Our findings target to assist health care professionals in identifying ideal nutrition intervention approaches for people with GDM or a history of GDM.

Conclusion

When incorporated as part of nutrition intervention approaches in people with GDM or post GDM, low GI diets may have clinical benefits, including glycemic control, body weight, and fetal outcomes. In this regard, public health interventions focusing on high-risk populations must also emphasise long-term follow-up of subjects and prioritise better blood glucose control during and after a GDM pregnancy. Subsequently, more data on dietary quality and adherence during the intervention may be included. Further studies on diet GI in women with a history of GDM are needed to enhance the quality of evidence and further tailor dietary interventions to this specific setting.

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Table 1: Characteristics of studies with a comparison group among women with GDM

No	Author, Year (Country) Objectives	Study Characteristics			Intervention vs Comparison Group	Findings		Summary
			Intervention Group	Comparison Group		Intervention Group	Comparison Group	
1	Moses et al. 2009 (Australia) Determine whether prescribing LGI diet for women with GDM could reduce the **number of women requiring insulin** without compromise of **pregnancy outcomes**	**Design:** Randomised trial **Duration:** 10 weeks **Study visits:** 4 • Between 28 and 32 weeks of gestation • ~1-2 weeks after initial visit • ~3-4 weeks after initial visit • 35-37 weeks of gestation **N:** 63 **Age:** 30s	N= 31 **Dietary advice:** -Low GI diet -Avoid white bread, processed commercial breakfast cereals, potatoes, some rice varieties **Nutrition education:** • Yes -Booklet: CHO choices, amounts - 3 small meals, 2-3 snacks with a specified number	N=32 **Dietary advice:** - Conventional high-fiber (and higher GI) diet - Recommend potatoes, whole wheat bread, specific high-fiber, moderate-to-high–GI breakfast cereals **Nutrition education:** • Yes	**Glycemic index:** • LGI group: significant reduction • HGI group (didn't start insulin): (NS) • HGI group (start insulin): significant reduction **Dietary intake:** • Total energy consumed in both groups: significant reduction • Reduction in total energy consumed between groups (NS) **Obstetric and fetal outcomes:**	**Insulin treatment:** 29% (9 women) required insulin **Glycemic index:** • (-8.4 ± 1.0 kcal, *p*<0.001) **Dietary intake:** • Energy intake (-281 ± 79 kcal, *p*=0.001)	**Insulin treatment:** 59% (19 women) met the criteria to commence insulin treatment (*p* < 0.023) 9 of 19 women were able to avoid insulin use by changing to a LGI diet **Glycemic index:** HGI, no insulin • (-1.5 ± 1.6 kcal, *p*=0.38) HGI to LGI • (-7.9 ± 1.1 kcal, *p*<0.001) **Dietary intake:** HGI, no insulin	LGI diet for women with GDM effectively halved the number needing to use insulin No compromise of obstetric or fetal outcomes

			CHOs servings	-Booklet: CHO choices, amounts - 3 small meals, 2-3 snacks with a specified number CHOs servings	• Weight gain (NS) • Induction of labour (NS) • Method of delivery (NS) • Gestational age at delivery (NS)		• Energy intake (-251 ± 140 kcal, *p*=0.10) HGI to LGI • Energy intake (-262 ± 119 kcal, *p*=0.042)	
2	Hu et al. 2014 (China) Determine the influence of a LGI diet on **postprandial glucose levels** in women with GDM	**Design:** Randomised trial **Duration:** 5 days **Study visits:** Diet management started on day 2, finished on day 5 **N:** 140 **Age:** 30s	N= 66 **Dietary advice:** Received low GI staple food - Low GI staple food to replace general staple food (white rice) for lunch and dinner meals - Breakfast: same as control group	N= 74 **Dietary advice:** Received routine staple food (white rice) diet to the same as a normal diabetic control diet for patients with GDM - Breakfast: same as intervention group	**Blood glucose outcomes:** • Post-intervention: significantly reduced in LGI group ($p<0.05$) • Percentage changes from baseline: significantly greater in LGI group ($p<0.05$)	**Blood glucose outcomes:** • Fasting (-3.7%) • After breakfast (-18.7%) • After lunch (-20.3%) • After dinner (-22.1%) • Significant decrease in all measurement ($p<0.01$)	**Blood glucose outcomes:** • Fasting (-1.2%) • After breakfast (-11.9%) • After lunch (-8.0%) • After dinner (-7.3%) • Significant decrease after breakfast ($p<0.001$), lunch ($p<0.001$),	LGI staple diet significantly reduces postprandial glucose levels in women with GDM

			GDM Education: • Yes - Cause of GDM - Effects (mother and fetus) - Principles of diet management - Other treatments	**GDM Education:** • Yes - Cause of GDM - Effects (mother and fetus) - Principles of diet management - Other treatments			dinner (*p*=0.008)	
3	Louie et al. 2011 (Australia) Determine the effect of LGI versus conventional high-fiber diet on **pregnancy outcomes, neonatal anthropometr**	**Design:** Two-arm parallel randomised controlled trial **Study visits:** ≥ 3 face-to-face visits with dietitians **N:** 99 **Age:** 30s (26-42)	N= 50 **Dietary advice:** -Low GI (LGI) diet **Nutrition counselling:** • Yes	N= 49 **Dietary advice:** -High fiber, moderate GI (HF) diet **Nutrition counselling:** • Yes	**Blood glucose outcomes:** • Post-intervention (NS, *p*=0.464) **Obstetric and fetal outcomes:** • Maternal weight gain (NS, *p*=0.095) • Fetal outcomes (NS)	**Blood glucose outcomes:** • Post-intervention: (4.3 ± 0.1 mmol/L) **Obstetric and fetal outcomes:** • Excessive maternal weight gain (25%)	**Blood glucose outcomes:** • Post-intervention: (4.4 ± 0.1 mmol/L) **Obstetric and fetal outcomes:** • Excessive maternal weight gain (42%)	Both diets produced comparable pregnancy outcomes in women with GDM

	y, maternal metabolic profile in GDM				- Average infant birth weight, birth weight centile were within healthy norms in both groups	• Infant birth weight (3.3 ± 0.1 kg) • Birth weight centile (52.5 ± 4.3 kg)	• Infant birth weight (3.3 ± 0.1 kg) • Birth weight centile (52.2 ± 4.0 kg)	
4	Shuhaimi et al. 2017 (Malaysia) Determine the effect of LGI intervention to improve **dietary intake** among women with GDM	**Design:** Randomised controlled study **Duration:** 4 weeks **Study visits:** **N:** 40 **Age:** 30s (18-45)	N= 20 **Dietary advice:** -Low GI (LGI) intervention - Received education to substitute high GI to low GI foods **Eating pattern advice:** • Yes - Small frequent meals - Even daily distribution - Portion size control	N= 20 **Dietary advice:** -Standard nutrition therapy (SNT) - Instructed to eat high fibre carbohydrate containing foods without referring to GI concept **Eating pattern advice:** • Yes	• **Dietary intake:** -Dietary GI ($p<0.05$) -Dietary GL (NS, $p=0.4$) -Dietary CHO ($p<0.05$) -Dietary fiber (NS, $p=0.09$) -Dietary Ca ($p<0.05$)	• **Dietary intake:** -Dietary GI: (50 ± 9) -Dietary GL: (24 ± 7) -Dietary CHO: (290 ± 154 g) -Dietary fiber: (17 ± 16 g) -Dietary Ca: (702 ± 309 mg)	• **Dietary intake:** -Dietary GI: (57 ± 6) -Dietary GL: (26 ± 5) -Dietary CHO: (243 ± 85 g) -Dietary fiber: (11 ± 5 g) -Dietary Ca: (500 ± 278 mg)	LGI dietary intervention improved dietary intake of women with GDM

			(plate method) - Set of meal plan based on energy requirement - Food basket (basmati rice, pasta)	- Small frequent meals - Even daily distribution - Portion size control (plate method) - Set of meal plan based on energy requirement - Food basket (white rice, instant oats)				
5	Grant et al. 2011 (Canada) Determine the feasibility and effect on **glycaemic control** of LGI diet in women with GDM or	**Design:** Randomised, open-label, active-control **Duration:** 4 weeks **Study visits:** **N:** 47	N= 24 **Dietary advice:** -Low GI (LGI) diet -Asked to select starch choices; given a list of low GI foods	N= 23 **Dietary advice:** -Control diet -Asked to select starch choices; given a list of intermediate and high GI foods	**Blood glucose outcomes:** • SMBG -Post-intervention (NS) • SMBG; On target: - During treatment; fasting (S), postprandial (S) • HbA1c (NS) • Insulin (NS)	**Blood glucose outcomes:** • SMBG - Fasting: (-0.48 ± 0.11 mmol/L) - Postprandial: (-0.58 ± 0.19 mmol/L) • SMBG; on target:	**Blood glucose outcomes:** • SMBG - Fasting: (-0.35 ± 0.19 mmol/L) - Postprandial: (-0.44 ± 0.21 mmol/L) • SMBG; on target:	LGI diet did not have a statistically significant effect on mean glycaemic control LGI diet significantly increase

	impaired glucose tolerance of pregnancy	**Age:** 30s (18-45)			**Dietary intake:** -Dietary fiber (p=0.001) -Dietary GI (p=0.001) -Dietary GL (p=0.014)	- % postprandial increase 13% (p<0.001) • SMBG; above target: - % postprandial 25.9% **Dietary intake:** **-**Dietary fiber: (30 ± 1.6 g) -Dietary GI: (49 ± 0.8) -Dietary GL: (98.2 ± 5.1)	- % postprandial increase 6% (p<0.05) • SMBG; above target: - % postprandial 30.3% **Dietary intake:** **-**Dietary fiber: (23 ± 1.0 g) -Dietary GI: (58 ± 0.5) -Dietary GL: (125 ± 8.8)	percentage of postprandial glucose values within target range LGI diet improved dietary intake (higher fiber, lower GI, GL)
6	Perichart-Perera et al. 2012 (Mexico) Compare the effect of including only LGI CHO against all types of CHO on **maternal**	**Design:** Randomised clinical trial **Duration:** 4 years **Study visits:** 3 **N:** 97 **Age:** 30s (20-42)	N= 42 **Dietary advice:** -Received intervention followed the ADA nutrition practice guidelines for GDM	N= 55 **Dietary advice:** -Received intervention followed the ADA nutrition practice guidelines for GDM	**Blood glucose outcomes:** • Fasting plasma and capillary glucose in both groups (S) • Fasting plasma and capillary glucose between groups (NS) • Glycemic goals: Higher in LGI group	**Blood glucose outcomes:** • Fasting plasma and capillary glucose decreased significantly (p=0.004, 0.001) • Achieved glycemic goals 2HPP	**Blood glucose outcomes:** • Fasting plasma and capillary glucose decreased significantly (p=0.003, 0.001) • Achieved glycemic goals 2HPP	Inclusion of LGI CHO as part of a comprehensive nutrition intervention is equally effective in improving glycemic control as compared

	glycemic control and on the **maternal and newborn's nutritional status** of women with T2DM and GDM		-Counselled to eliminate all moderate and high GI foods **Nutrition education:** • Yes	**Nutrition education:** • Yes	**Obstetric and fetal outcomes:** • Excessive weight gain (p=0.002) • Prematurity risk (NS, p=0.237) -Higher in LGI group	glucose at lunch, pre-prandial, 2HPP glucose at dinner (p<0.05) **Obstetric and fetal outcomes:** • Excessive weight gain (9.8%) • Risk of prematurity (19%)	glucose at lunch only (p=0.03) **Obstetric and fetal outcomes:** • Excessive weight gain (34.8%) • Risk of prematurity (11.3%)	to all types of CHO Positive effect in preventing excessive maternal weight gain but increased risk of prematurity

Table 2: Characteristics of studies with a comparison group among women with history of GDM

No	Author, Year (Country) Objectives	Study Characteristics			Intervention vs Comparison Group	Findings		Summary
			Intervention Group	Comparison Group		Intervention Group	Comparison Group	
1	Shyam et al. 2013 (Malaysia) Determine the effects of	**Design:** Randomised trial **Duration:** 6 months	N= 33 **Dietary advice:** - Conventional healthy	N=29 **Dietary advice:** - Conventional healthy	**Glucose outcomes:** • FBG (NS) • Changes in 2HPP between groups (p=0.025)	**Glucose outcomes:** • Changes in 2HPP: (-0.2(2.8))	**Glucose outcomes:** • Changes in 2HPP: (-0.8(2.0))	Lowering GI of healthy diets resulted in significant improvement in glucose

	conventional dietary improvement on administered with and without additional LGI education, in management of **glucose tolerance** and **body weight** in Asian women with previous GDM	**N:** 62 **Age:** 30s (20-40)	dietary recommendation CHDR + low GI (LGI) **Nutrition education:** • Yes - Low in fat, refined sugars, high in fibre **GI education:** • Yes - Substitute high GI foods with LGI foods - List of GI foods classification	dietary recommendation (CHDR) **Nutrition education:** • Yes - Low in fat, refined sugars, high in fibre **GI education:** • No	**Obstetric outcomes:** • **Weight loss** -5% weight loss (p<0.01) -10% weight loss (NS) • **Mean BMI changes** (p=0.03) **Dietary intake:** -Dietary fiber (p<0.001) -Dietary GI (p<0.001) -Dietary GL (p=0.04)	**Obstetric outcomes:** • **Weight loss** -Percentage achieving 5% weight loss (33.3%) • **Mean BMI changes** (-0.6 kg/m^2) **Dietary intake:** -Dietary fiber (17 ± 4 g) -Dietary GI (57 ± 5) -Dietary GL (122 ± 33)	**Obstetric outcomes:** • **Weight loss** -Percentage achieving 5% weight loss (7.9%) • **Mean BMI changes** (0 kg/m^2) **Dietary intake:** -Dietary fiber (13 ± 4 g) -Dietary GI (64± 6) -Dietary GL (142 ± 35)	tolerance and body weight reduction compared to conventional low-fat diets with similar energy prescription
2	Ostman et al. 2006 (Sweden) Study the possibility of	**Design:** Randomised controlled trial **Duration:** 9 weeks	**Same group** N= 7 **Dietary intervention:** -Bread with low GI (LGI)	N= 7 **Dietary intervention:** -Bread with high GI and	**Glucose tolerance:** • FBG (NS) • Insulin (NS) **Blood lipids:** • HDL-cholesterol (NS)	**Same group** <u>Low GI</u> **Glucose outcomes:** • Insulin AUC after IV glucose	<u>High GI</u> **Glucose outcomes:** • Insulin AUC after IV glucose	Combination of LGI and high DF has a beneficial effect on insulin economy in

improving **blood lipids**, **glucose tolerance** and **insulin sensitivity** in women with impaired glucose tolerance and a history of GDM by merely changing the GI and dietary fibre content of bread	**Study visits:** **N:** 7 **Age:** 30s (27-41)	and high dietary fibre **Nutrition education:** • No **GI education:** • No	low dietary fibre **Nutrition education:** • No **GI education:** • No	• Triglycerides (NS)	challenge reduced significantly - 0-60 min (35%) - 10-30 min (39%) - 10-40 min (43%) - 10-60 min (44%)	challenge not significantly affected	women at risk of developing T2DM.