Review

Preventive Methods to Reduce The Risk of Gestational Diabetes Onset: A Narrative Literature Review

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Preventive Methods to Reduce the Risk of Gestational Diabetes Onset: A Narrative Literature Review

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Abstract: *Background/Objectives:* Gestational diabetes (GD), affecting approximately 15% of pregnancies globally, presents significant risks to both maternal and fetal health. This highlights the urgent need for effective prevention and management strategies. This review aims to synthesize existing literature to identify and evaluate effective interventions for GD prevention. *Methods*: A narrative review was conducted in September 2024, searching four biomedical databases: PubMed-Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE, and the Cochrane Library. *Results*: Eleven studies were included, encompassing systematic reviews, meta-analyses, and narrative reviews. Key findings indicate that dietary interventions, especially the Mediterranean diet (risk reduction of 15%-38%), and physical activity (28%-36% risk reduction) are among the most effective strategies for preventing GD. Supplementation with probiotics and myo-inositol has also demonstrated significant reductions in GD risk, with up to 60% risk reduction for probiotics and 50%-70% for myo-inositol. Pharmacological interventions, such as metformin, show promise but require further evaluation for safety and efficacy in pregnancy. *Conclusions*: Interventions such as dietary modifications, physical activity, and supplementation with probiotics and myo-inositol are effective in preventing GD. However, further research is needed to establish standardized protocols, especially regarding pharmacological treatments and long-term outcomes for both mothers and infants.

Keywords: gestational diabetes; prevention; diet; physical activity; nutritional supplements; narrative review

1. Introduction

Gestational Diabetes (GD) is defined as any degree of glucose intolerance that occurs during pregnancy or is first recognized during pregnancy. The optimal blood glucose concentration values for diagnosing GD remain controversial [1–7]. The prevalence of GD varies globally and affects approximately 15% of pregnant women [7–13]. Typically, GD is detected between the 13th and 26th week of gestation or early in the third trimester of pregnancy [14]. With the implementation of screening programs, GD is often diagnosed before symptoms appear. Although many women remain asymptomatic, signs and symptoms of hyperglycemia, such as polyuria, polydipsia, blurred vision, and fatigue, may be observed when GD is either undetected or poorly controlled [15].

Universal screening for GD is recommended between the 24th and 28th week of gestation, typically involving an oral glucose tolerance test (OGTT) with 75 grams of glucose, assessing fasting, 1-hour, and 2-hour blood glucose levels. A single value above the threshold during any point of the

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OGTT is sufficient to establish a diagnosis [16]. Maintaining normal blood glucose levels during pregnancy is essential to prevent both short- and long-term adverse pregnancy outcomes [17].

The presence of GD during pregnancy increases the risk of premature labor, cesarean section, hypertensive disorders, preeclampsia, and recurrence of GD in subsequent pregnancies [18]. Fetal consequences include macrosomia (birth weight greater than 4000g or 4500g), which can lead to adverse maternal outcomes such as uterine rupture and perineal trauma [19]. Additionally, macrosomia may cause birth-related trauma, including shoulder dystocia, nerve paralysis, and fractures. GD is also associated with neonatal hypoglycemia (blood glucose levels <45mg/dL), hyperbilirubinemia (elevated bilirubin levels around 2-3mg/dL), polycythemia (elevated hemoglobin levels >16g/dL), hypocalcemia (blood calcium levels <8.8mg/dL), and respiratory distress syndrome [17].

In the years following pregnancy, women with GD are at increased risk for developing type 2 diabetes mellitus (T2D), cardiovascular disease, and metabolic syndrome, while offspring are more likely to experience childhood obesity, cardiovascular diseases, developmental disorders, neurological distress, and diabetes [20]. In the neonatal period, the risks of respiratory distress syndrome, jaundice, and hypoglycemia are elevated [21–26]. Long-term health consequences for children include obesity, diabetes, metabolic syndrome [27,28], and adverse neurodevelopmental outcomes [29–31]. Several factors increase the risk of GD, with advanced maternal age and maternal overweight (BMI ≥ 25 kg/m^2) or obesity (BMI ≥ 30 kg/m^2) being the most common [32]. Other risk factors [14] include non-modifiable ones such as ethnicity (Hispanic or Asian), a history of GD in previous pregnancies, a history of delivering a macrosomal infant, family history of T2D, and conditions linked to insulin resistance, such as polycystic ovary syndrome. Modifiable factors, often related to lifestyle, include physical inactivity, poor diet quality, and excessive weight gain during pregnancy (gestational weight gain).

Poor diet quality, including low dietary fiber intake, high glycemic index foods, and increased consumption of sugar-sweetened beverages, has been implicated in the risk of GD [20]. A higher risk of GD is also associated with lower levels of physical activity and sedentary behavior, particularly in early pregnancy [20]. Interventions to prevent GD have been implemented before conception, during pregnancy, and between pregnancies (inter-conceptional). These interventions include dietary modifications, physical activity, dietary supplementation, and pharmacological approaches.

This narrative review aims to synthesize the existing literature to understand effective interventions for the prevention of GD and possible complications.

2. Methods

2.1. Narrative Review Methodology and Search Strategy

A narrative review was conducted following the reporting guideline of Green [33]. This literature review was driven by the following research question: *What are the effective interventions for preventing GD and possible complications?*

The bibliographical search was carried out in September 2024, interviewing four biomedical databases MEDLINE (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE and Cochrane Library, using the keywords “Diabetes, Gestational”, “Primary Prevention”, “Diet, Exercise”, “Risk Factors”, “Life Style”, opportunely combined by Boolean operators (Annex 1).

Studies published from 2014 to 2024, and full text articles were considered. The studies included were those that addressed the research question and had the following characteristics: full-text available, and belonging to the secondary literature (meta-analyses, systematic reviews).

2.2. Formulation of the Research Question

The research question for this study was developed using the PICO tool [34]. Three main aspects of PICO strategy were included in this review:

P = pregnant women and GD;
I = probiotics;
O = prevention of GD and possible complications.

2.3. Inclusion and Exclusion Criteria

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The selection of studies was conducted based on several inclusion criteria. Specifically, studies had to address the research question, focus on identifying effective interventions for the prevention of gestational diabetes, and include only systematic reviews and meta-analyses as secondary literature. Additionally, documents written in languages other than English were considered, with no geographical limitations imposed on the studies. Conversely, the exclusion criteria ruled out studies that did not answer the research question. Studies involving obese women or women already diagnosed with diabetes or gestational diabetes were also excluded.

2.4. Data Extraction and Synthesis

The data extraction process was conducted by two researchers utilizing EndNote 20 software [35]. The following information was systematically extracted: Author, Year, Objective, Study Design, Main Interventions, and Main Outcomes. The results were presented as a narrative synthesis, supported by tables for enhanced clarity and detail.

3. Results

Through a comprehensive search across the Medline/PubMed, Embase, Cochrane Library, and CINAHL Complete databases, a total of 45 studies were identified as potentially relevant to the research question. Following an initial screening, 31 duplicate records were removed, leaving 14 studies that appeared relevant based on title and abstract. After a full-text review, eight systematic literature reviews (two with meta-analysis) two narrative literature reviews included [36–45].

The results of the narrative reviews on interventions for preventing GD are summarized in Table 1. This table outlines the key studies included in the narrative review on GD prevention, detailing the objectives, study designs, interventions, and main outcomes, along with the essential statistical data.

Table 1. Summary of Studies Evaluating the Effects of Interventions for Preventing GDM and Related Outcomes.

Author, Year	Objective	Study Design	Main Interventions	Main Outcomes
Kouiti et al [42], 2022	To assess diet and physical activity for preventing GD	SR	MedDiet, aerobic and resistance exercises, combinations	MedDiet: OR = 0.66. Physical activity: significant reduction in GD risk. Combinations less effective.
Tang et al [43], 2022	To analyze five types of interventions for preventing GD	SR with Meta-analysis	Probiotics, diet, physical activity, myo-inositol, combinations	Probiotics: OR = 0.57; Physical activity: OR = 0.64. Less certainty for diet (OR = 0.82) and myo-inositol (OR = 0.77).
Mierzyński et al [44], 2021	To examine dietary strategies and supplements	NR	MedDiet, probiotics, myo-inositol, vitamin D	Mediterranean diet: 17.1% reduction in GD risk (p = 0.012). Probiotics: GD incidence reduced from 36% to 13% (p = 0.003). Myo-inositol: RR = 0.127 (p = 0.001).
Popova et al [36], 2021	To explore the role of the Mediterranean diet	SR	MedDiet with olive oil and nuts	Reduction in GD risk by 15% to 38%. Overweight

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Griffith et al [45], 2020	Synthesis of reviews to analyze five types of interventions for preventing GD	SR	Diet, physical activity, myo-inositol, vitamin D	women: RR = 0.39 ($p < 0.05$). Myo-inositol: RR = 0.43. Vitamin D: RR = 0.50. No benefit for omega-3 (RR = 1.00).
Mijatovic-Vukas et al [39], 2018	To study diet and physical activity interventions	SR with Meta-analysis	MedDiet, plant-based proteins, physical exercise	Mediterranean diet: 15%-38% reduced risk. Moderate physical activity: 21% reduced risk ($p = 0.03$).
Donazar-Ezcurra et al [37], 2017	To investigate the role of nutritional factors	SR	Probiotics, myo-inositol, MedDiet	Probiotics: GD incidence reduced to 13% ($p = 0.003$). Myo-inositol: RR = 0.127 ($p = 0.001$).
Rogozińska et al [38], 2015	To evaluate dietary and combined approaches	SR with Meta-analysis	Low GI diet, probiotics, myo-inositol	Low GI diet: 33% risk reduction (RR = 0.67). Probiotics and myo-inositol: RR = 0.40 ($p < 0.01$).
Russo et al [41], 2015	To examine the effects of physical activity	SR and Meta-analysis	Aerobic, resistance, combined exercises	28% reduced risk of GD (RR = 0.72; $p = 0.005$). Low heterogeneity ($p = 0.33$).
Simmons [40], 2015	To analyze lifestyle interventions	NR	Diet, physical activity, probiotics, metformin	Probiotics: 60% reduced GD risk. Myo-inositol: significant benefit (2-4 g/day).

Legend. GD = Gestational Diabetes; OR = Odds Ratio; RCTs = Randomized Controlled Trials; RR = Relative Risk; GI = Glycemic Index. MedDiet = Mediterranean Diet, SR = Systematic Review; NR = Narrative Review.

3.1. Diet

Dietary modifications represent a cornerstone intervention in the prevention of GD. Among these, the Mediterranean Diet (MedDiet)—which emphasizes high consumption of extra virgin olive oil, nuts, legumes, fruits, vegetables, and whole grains, with moderate intake of fish and limited consumption of meat and refined sugars—has emerged as one of the most promising strategies. Systematic studies consistently indicate that adherence to the MedDiet reduces the risk of GD by 15% to 38% [36,37]. Similarly, low glycemic index (GI) diets have demonstrated significant efficacy in reducing GD risk by lowering insulin resistance [38]. Moreover, replacing animal proteins with plant-based proteins has been associated with a 51% reduction in GD risk, whereas increased intake of saturated fats and cholesterol correlates with a higher risk of GD [39]. Additionally, moderate consumption of fruit juices and low-fat milk has been linked to a decreased risk of developing GD [39]. However, it is important to note that some studies highlight the heterogeneity of the evidence. Differences in dietary protocols, intervention durations, and the characteristics of study populations complicate the identification of a standardized dietary approach [40].

 doi:10.20944/preprints202412.0555.v1

3.2. Physical Activity

Physical activity during pregnancy has been shown to offer significant benefits in preventing GD. Specifically, aerobic exercises, such as walking, cycling, and aquatic aerobics, performed at moderate intensity, are associated with a 28%-36% reduction in GD risk compared to the control group [41,42]. According to guidelines, a regular exercise regimen of at least 150 minutes per week appears sufficient to achieve a protective effect [39]. Furthermore, exercise programs that incorporate muscle training, stretching, and balance exercises have been found to further improve outcomes. Physical activity contributes not only to energy expenditure but also to better glucose utilization and enhanced insulin sensitivity [43]. Despite these well-documented benefits, uncertainty remains regarding the optimal intensity and duration of interventions [40].

3.3. Combination of Diet and Physical Activity

The combination of dietary modifications and physical activity interventions has yielded mixed results in terms of effectiveness. Some studies have reported a significant reduction in GD risk (up to 39%) when compared to standard care [44]. However, other analyses suggest that the combined approach does not offer greater benefits than separate dietary or physical activity interventions [42]. These discrepancies may be explained by challenges in adherence to combined protocols and variability in the characteristics of the populations studied [38].

3.4. Nutritional Supplements

The use of nutritional supplements, particularly probiotics, has shown promise in preventing GD. Strains such as Lactobacillus rhamnosus GG and Bifidobacterium lactis Bb12 have been found to reduce GDM risk by up to 60%, particularly when combined with intensive dietary counseling [37,38]. Probiotics appear to improve insulin sensitivity by modulating the gut microbiota, which plays a crucial role in metabolic health [43]. Additionally, myo-inositol supplementation, often in combination with 200–400 μg of folic acid, has been shown to significantly reduce the risk of GD by 50%-70% [37,45]. Myo-inositol enhances insulin sensitivity and reduces insulin resistance, contributing to improved glucose metabolism. Furthermore, observational and randomized controlled trials have suggested that vitamin D, administered in weekly doses ranging from 1,400 to 30,000 IU, may reduce the risk of GD by 20%-29% [45]. However, the evidence remains inconclusive, and further studies are needed to clarify the long-term effects of these supplements.

3.5. Pharmacological Strategies

Among pharmacological agents, metformin has been studied as a potential intervention to prevent GD, yielding moderately positive results. At doses of 2–3 g per day, metformin has demonstrated beneficial effects, particularly in obese or overweight women; however, these effects did not reach statistical significance [40,45]. It is essential to note that pharmacological agents are not without risks, and their safety profile, especially with respect to maternal and fetal health, warrants careful consideration. This includes potential concerns regarding the possibility of placental transfer of medications.

4. Discussion

The aim of this review was to synthesize the existing literature to understand effective interventions for the prevention of GD. The results underscore the importance of various preventive strategies, including dietary modifications, physical activity, probiotics, myo-inositol supplementation, vitamin D, and pharmacological approaches such as the use of metformin. Specifically, the MedDiet has been linked to a reduction in the risk of GD by 15% to 38% [36,37], and similar benefits have been observed in other chronic diseases. For example, adopting a diet rich in fiber and low in saturated fats is associated with a reduced risk of cardiovascular diseases [46], while omega-3 fatty acids, found in foods such as fatty fish and nuts, help reduce systemic inflammation, contributing to the prevention of metabolic diseases [47]. Additionally, a low GI diet has been suggested to improve insulin sensitivity, even in non-diabetic individuals, which could benefit the management of T2D [48]. Furthermore, replacing animal proteins with plant-based ones has shown potential in reducing the risk of developing GD [49,50].

 doi:10.20944/preprints202412.0555.v1

In addition to dietary interventions, moderate physical activity has proven effective in reducing the risk of GD by 28% to 36% [41,42], with similar benefits documented for other chronic conditions. Regular exercise helps control body weight, enhances insulin sensitivity, and reduces the risk of developing T2D [51–53]. It also positively impacts cardiovascular health by lowering blood pressure and improving the lipid profile [47]. Moreover, moderate physical activity can significantly reduce the risk of developing cardiovascular diseases, contributing to long-term heart health [54]. Studies have also indicated that physical activity helps lower the risk of certain cancers, such as breast and colon cancer, while improving the overall quality of life in pregnant women [51].

Probiotic supplementation has also shown positive effects in GD prevention, reducing the risk by up to 60% when combined with intensive dietary counseling [37], 38]. Probiotics have similarly benefited other chronic diseases, with research showing that they can reduce intestinal inflammation in chronic inflammatory bowel diseases [55]. Furthermore, probiotics help modulate immune responses, which leads to a lower incidence of respiratory infections. Specific strains, such as Lactobacillus Rhamnosus and Bifidobacterium lactis, have demonstrated effectiveness in treating allergic rhinitis by reducing symptoms and nasal inflammation [56]. In addition to these benefits, probiotics have been studied for their potential in improving the management of T2D, by helping to lower blood glucose levels and enhancing gut function [57]. Myo-inositol supplementation has also shown a significant reduction in GD risk, ranging from 50% to 70% [37,45], with similar effects observed in other metabolic conditions. Myo-inositol intake is known to improve insulin sensitivity and reduce the risk of polycystic ovary syndrome [58]. Similarly, vitamin D supplementation, administered in varying doses, has been shown to reduce the risk of GD by 20% to 29% [45]. Research has also highlighted the benefits of vitamin D in other chronic conditions, including osteoporosis and bone fractures [59]. Furthermore, vitamin D plays a role in modulating the immune system, which contributes to a lower incidence of autoimmune diseases [60], and some studies suggest the potential to reduce cancer risk and response to treatments by enhancing immune responses and reducing systemic inflammation [61–63]. The use of metformin for GD prevention has also shown promising results, particularly in obese or overweight women [40,45]. Metformin has similar benefits in other metabolic conditions, as it improves insulin sensitivity and reduces hepatic glucose production in the treatment of T2D [64]. Additionally, metformin positively impacts the lipid profile, lowering total cholesterol and Low Density Lipoproteins (LDL) levels [65]. Research has also indicated that metformin may provide protective effects against cardiovascular diseases, reducing the incidence of heart attacks strokes and Covid-19 complications in patients with T2D [66,67]. Current evidence suggests that the use of metformin during pregnancy, particularly for the prevention of GD, is generally considered safe but requires caution and monitoring. Several studies have indicated that metformin is not associated with a significant increase in congenital malformations or adverse effects on fetal development [68,69]. Metformin has been successfully used in the management of T2D during pregnancy, but its safety during pregnancy for GD prevention is still a subject of discussion [69]. However, it is important to note that metformin can cross the placenta, and therefore careful evaluation of the risks and benefits is necessary [70].

4.1. Future Developments and Applications in Clinical Practice

Future developments in the prevention of GD should focus on the personalization of interventions. For instance, combining nutritional approaches with genetic analysis could help identify women who are more susceptible to GD and prescribe more targeted treatment plans. A personalized nutritional approach, based on variables such as genetics, metabolic profile, and gut microbiome, could optimize preventive outcomes, significantly reducing the incidence of GD [71]. Several studies have suggested that an individualized approach, considering both genetic and nutritional factors, may improve clinical outcomes in various medical fields, including diabetes management [71,72].

Furthermore, the use of modern technologies, such as smartphone apps and wearable devices for glucose monitoring, could enhance patient compliance and facilitate continuous monitoring of risk factors. Mobile technologies have been successfully applied for remote monitoring of health conditions in pregnant women, allowing for timely and personalized interventions. Recent studies have shown that the use of health tracking apps increases adherence to lifestyle and diet changes in many chronic diseases, and provides continuous data that help adjust preventive strategies and social

 doi:10.20944/preprints202412.0555.v1

support [73–77]. The integration of wearable devices, such as glucose sensors, could allow patients to monitor their glucose levels in real time, improving the effectiveness of preventive measures and facilitating the management of GD risk and other form of diabetes [78,79].

Public health policies should also be adapted to promote healthy lifestyles among women of reproductive age. Awareness campaigns on GD risk, accompanied by practical guidelines on diet, physical activity, and health monitoring, could significantly reduce the incidence of GD. Promoting targeted nutritional policies that encourage healthy eating and increased physical activity in vulnerable populations is essential to address the rising incidence of GD. The dissemination of educational programs on GD prevention could be an important step in reducing the prevalence of the condition in the future [80].

4.2. Limitations of the Review

This review has several limitations. First, the variability in the study designs included, as well as the differences in intervention protocols, may influence the interpretation of the results. Another limitation concerns the variable quality of the studies on probiotics, where the selection of bacterial strains and dosages used are not always homogeneous. Finally, most of the studies did not explore the long-term effects of the interventions, limiting our ability to assess the sustainability of the results over time.

5. Conclusions

The interventions examined in this review, including dietary modifications, physical activity, probiotics, myo-inositol supplementation, vitamin D, and pharmacological approaches such as metformin, all show promise in the prevention of GD. These strategies have demonstrated varying degrees of effectiveness, with dietary changes, especially the Mediterranean diet, and physical activity emerging as particularly beneficial in reducing GD risk. The integration of probiotics and myo-inositol supplementation also presents a potential avenue for preventing GD, although further research is needed to standardize treatment protocols and optimize their use.

While pharmacological interventions like metformin may offer benefits, particularly for high-risk populations, their use must be carefully considered due to potential side effects and the need for long-term safety data. The importance of a personalized, multi-disciplinary approach cannot be overstated, as tailoring interventions to individual needs based on genetic, metabolic, and lifestyle factors may further enhance their effectiveness.

Future research should focus on standardizing intervention protocols, examining the long-term sustainability of these preventive measures, and exploring new technologies, such as mobile health apps and wearable devices, to improve adherence and real-time monitoring of risk factors. Public health initiatives should also be adapted to emphasize prevention and early intervention in high-risk populations, further reducing the incidence of GD.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Search Strategy

Database	Search Strategy	Documents Found	Documents Selected

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Medline PubMed	Search Strategy #1: ("Diabetes, Gestational"[Mesh]) AND "Primary Prevention"[Mesh]	26	1
Medline PubMed	Search Strategy #2: ("Diabetes, Gestational"[Mesh]) AND "Diet, Healthy"[Mesh]	57	3
Medline PubMed	Search Strategy #3: (("Diabetes, Gestational"[Mesh]) AND "Diet"[Mesh]) AND "Exercise"[Mesh]	117	5
Medline PubMed	Search Strategy #4: (("Diabetes, Gestational"[Mesh]) AND "Risk Factors"[Mesh]) AND "Life Style"[Mesh]	98	2
Medline PubMed	Search Strategy #5: (("Diabetes, Gestational"[Mesh]) AND "Diet"[Mesh]) AND "Life Style"[Mesh]	133	4
Embase	Search Strategy #1: 'Gestational diabetes': ti,ab,kw AND 'Primary prevention': ti,ab,kw	109	2
Embase	Search Strategy #2: 'Gestational diabetes': ti,ab,kw AND 'Nutrition': ti,ab,kw AND 'Prevention': ti,ab,kw	193	4
The Cochrane Library	Search Strategy #1: "Gestational diabetes" in Title Abstract Keyword AND "Prevention" in Title Abstract Keyword	13	1
Cinhal Complete	Search Strategy #1: TI Gestational diabetes AND TI Prevention	128	4
UpToDate	Search Strategy #1: Gestational diabetes AND prevention	150	0

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