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Diabetes Mellitus Gestational In between Physical Activity and Dietary Habits: A Literature Review

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ABSTRACT

Gestational diabetes mellitus carries significant risks to the health both of the mother and fetus. Lifestyle modifications, mainly dietary patterns and physical activity, have emerged as major modifiable factors in the prevention and management of GDM. We conducted an analysis of recent meta-analyses, umbrella reviews, and systematic reviews published between 2020 and 2025 that assessed dietary interventions, physical activity programs, and combined lifestyle approaches for GDM prevention and management. Primary outcomes included the incidence of GDM, measures of glycemic control, gestational weight gain, and maternal-neonatal clinical outcomes. Dietary interventions showed consistent protective effects against GDM, with a pooled odds ratio of 0.69 (95% CI 0.56–0.84), or approximately a 31% relative risk reduction. The physical activity effects were significantly modified by timing and intensity: first-trimester initiation (OR 0.57, 95% CI 0.43–0.75) and mild-to-moderate intensity activity (OR 0.65, 95% CI 0.53–0.80), while vigorous or later-start exercise did not confer any benefit (OR 1.09, 95% CI 0.50–2.38). Combined diet-plus-exercise interventions may have a possible but inconsistent protective effect, with high heterogeneity across studies. DASH and Mediterranean dietary patterns presented favorable results in pooled comparisons.

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1. INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as glucose intolerance with onset or first recognition during pregnancy and represents one of the most common metabolic complications of pregnancy (Altemani & Alzaheb, 2022). The global prevalence of GDM has been rising steadily, paralleling increases in obesity and type 2 diabetes worldwide, with current estimates ranging from 7% to 25% depending on population and diagnostic criteria (Kouiti et al., 2022). This represents major public health challenges, as GDM is associated with significant short- and long-term adverse outcomes for both mother and child. The immediate consequences of GDM include increased risks of preeclampsia, cesarean delivery, macrosomia, neonatal hypoglycemia, and birth trauma (Altemani & Alzaheb, 2022). Long-term implications are equally concerning: women with GDM face substantially elevated lifetime risk of developing type 2 diabetes mellitus (T2DM), with up to 50% progressing to T2DM within 10 years postpartum (Kouiti et al., 2022). Offspring exposed to maternal hyperglycemia in utero demonstrate increased susceptibility to obesity, metabolic syndrome, and glucose intolerance in childhood and adulthood, thus perpetuating an intergenerational cycle of metabolic disease (Moholdt, 2023).

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Traditional GDM risk factors include advanced maternal age, obesity, family history of diabetes, previous GDM, and selected ethnic backgrounds (Rasmussen et al., 2020). While many of these are clearly non-modifiable, there is now growing evidence that lifestyle factors—particularly dietary patterns and physical activity—are crucial modifiable targets for the prevention and management of GDM (Altemani & Alzaheb, 2022). The biological plausibility of lifestyle interventions is established. Healthy dietary patterns have been associated with improved insulin sensitivity, reduced inflammation, optimized gestational weight gain, and maintained glycemia (Altemani & Alzaheb, 2022). Physical activity enhances glucose uptake by skeletal muscle, improves insulin sensitivity, promotes weight management, and favorably modulates inflammatory markers (Altemani & Alzaheb, 2022). These putative mechanisms suggest that early adoption of a healthy lifestyle may markedly reduce GDM incidence and severity. Despite this theoretical framework, translating lifestyle modification into clinical practice requires vigorous evidence of the optimal timing, intensity, type, and overall effectiveness of interventions. Recent years have witnessed the increasing proliferation of systematic reviews and meta-analyses attempting to quantify these effects; however, findings remain heterogeneous, and clinical guidance remains imprecise (Kouiti et al., 2022).

Previous systematic reviews have been limited by inconsistent intervention definitions, variable study quality, heterogeneous populations, and differing outcome measures (Kouiti et al., 2022). Moreover, the relative effectiveness of dietary versus physical activity interventions, the optimal timing of initiation, appropriate exercise intensity during pregnancy, as well as the added value of combined interventions, remain inadequately defined (Altemani & Alzaheb, 2022). This review has the following objectives: to synthesize the recent quantitative evidence from 2020 to 2025 regarding the effects of dietary interventions on GDM prevention and management; assess the contribution of physical activity interventions, considering issues of timing and intensity; specify dietary patterns and physical activity recommendations supported by current evidence; underscore evidence gaps and quality concerns that limit clinical translation; provide evidence-based recommendations for clinical practice and future research.

2. METHOD

This comprehensive review synthesized the findings from recent meta-analyses, umbrella reviews, systematic reviews, and clinical studies published between 2020 and 2025 that evaluated lifestyle interventions for GDM prevention and management. The main evidence base included the 2022 meta-analysis that conducted a review of controlled trials, prospective cohorts, and case-control studies of diet and exercise interventions in relation to GDM (Altemani & Alzaheb, 2022); an umbrella review of systematic reviews and meta-analyses assessing prevention of GDM through diet and/or physical activity interventions (Kouiti et al., 2022); recent narrative reviews and clinical commentaries on diet, exercise, and GDM published in 2023-2024 (Moholdt, 2023); and prediction model studies that incorporate lifestyle and nutrition factors into GDM risk stratification (2025) (Rasmussen et al., 2020).

The reviewed literature evaluated three main approaches to interventions: dietary interventions, physical activity intervention, and combined intervention. Dietary interventions included structured dietary patterns such as DASH (Dietary Approaches to Stop Hypertension), Mediterranean diet, and healthy eating indices; macronutrient modifications such as low glycemic index and controlled carbohydrate intake; nutritional counseling and education programs; and dietary quality assessment using validated scoring systems (Mijatovic-Vukas et al., 2018). Physical activity interventions included structured exercise programs-supervised or prescribed- types of physical activity-aerobic exercise, resistance training, combined programs, and frequency and time variations of activities. Combined interventions included an integrated diet and exercise program, variable content, intensity, and behavioral change components, and different levels of supervision and support (Harrison et al., 2020). Outcome measures, divided into primary and secondary outcomes, evaluated across synthesized studies included primary outcomes-incidence of gestational diabetes mellitus-and secondary outcomes, which were measures of glycemic control such as fasting plasma glucose and 2-hour glucose, gestational weight gain, maternal outcomes including preeclampsia, cesarean section, and gestational hypertension, neonatal outcomes such as macrosomia, large for gestational age, neonatal hypoglycemia (Shepherd et al., 2017). Populations studied in synthesized evidence included general pregnant populations; high-risk groups-overweight/obese women, BMI ≥25 or ≥30 kg/m²; previous GDM; family history of diabetes; geographic diversity-studies from North America, Europe, Asia, Australia, and the Middle East; and varied baseline characteristics relating to age, parity, and ethnicity. Data extraction and synthesis involved a pooled

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effect estimate such as odds ratios, relative risks, risk ratios, with 95% confidence intervals, heterogeneity statistics-I^2 values; quality assessment ratings-AMSTAR, GRADE, or similar tools; subgroup analyses by intervention characteristics; and reported mechanisms and biological pathways. Quantitative results are then narratively presented, emphasizing effect estimates, comparative effectiveness across intervention types, and considerations of the quality of evidence (Lim et al., 2025).

3. RESULTS AND DISCUSSION

Recent meta-analytic evidence indicates that dietary interventions confer statistically significant reductions in GDM risk, while physical activity effects depend critically on timing and intensity (Altemani & Alzaheb, 2022). Combined diet-and-exercise trials demonstrate possible protective effects, but with substantial heterogeneity and inconsistent findings across reviews (Kouiti et al., 2022). Table 1 provides a comparative summary of intervention effects.

Table 1. A comparative summary of intervention effects

Intervention Type	Evidence Summary	Key Quantitative Estimate	Statistical Significance	Evidence Quality Concerns
Dietary intervention	Consistent protective association across controlled studies	OR 0.69 (95% CI 0.56–0.84)	Yes ($p<0.05$)	Heterogeneity in diet definitions; limited trial detail (Kouiti et al., 2022)
Physical activity (overall)	Overall pooled effect nonsignificant; benefit varies by timing and intensity	OR 0.77 (95% CI 0.55–1.06)	No (CI crosses 1.0)	Variable intensity/timing reporting; heterogeneity (Altemani & Alzaheb, 2022)
Physical activity (mild-moderate)	Significant protective effect	OR 0.65 (95% CI 0.53–0.80)	Yes ($p<0.05$)	Better consistency than overall PA (Altemani & Alzaheb, 2022)
Physical activity (first trimester)	Strong protective effect with early initiation	OR 0.57 (95% CI 0.43–0.75)	Yes ($p<0.05$)	Limited number of studies
Physical activity (vigorous)	No benefit; possible harm signal	OR 1.09 (95% CI 0.50–2.38	No (wide CI)	Very limited data (Altemani & Alzaheb, 2022)
Combined diet + exercise	Possible reduced GDM risk but inconsistent	Pooled estimates often approach null; variable across reviews	Inconsistent	Majority of reviews rated low to critically low quality; high heterogeneity (Kouiti et al., 2022)

Evidence syntheses. The 2022 meta-analysis reported a pooled odds ratio of **0.69 (95% CI 0.56–0.84)** for dietary interventions versus control conditions, indicating approximately **31% relative reduction in GDM odds** (Altemani & Alzaheb, 2022). This estimate was derived from randomized controlled trials and high-quality observational studies with dietary modification as the primary intervention. The protective effect was observed across diverse dietary approaches, though specific patterns showed varying degrees of effectiveness. The consistency of findings across multiple study designs and populations strengthens confidence in the causal relationship between healthy dietary patterns and reduced GDM risk (Kouiti et al., 2022).

The DASH pattern, characterized by high intake of fruits, vegetables, whole grains, low-fat dairy, and limited sodium, showed particularly consumption of olive oil, nuts, legumes, fish, and moderate wine intake (typically excluded during pregnancy studies), showed protective favorable results in pooled comparisons . Studies evaluating DASH adherence during pregnancy demonstrated stronger protective associations compared to some other dietary patterns, likely reflecting the pattern's emphasis on low glycemic load and anti-inflammatory nutrients (Altemani & Alzaheb, 2022). Mediterranean dietary patterns, characterized by high associations in several studies. However, effect estimates varied more widely than for DASH, possibly reflecting heterogeneity in Mediterranean diet definitions and cultural adaptations . Dietary interventions emphasizing low glycemic index (GI) foods demonstrated benefits for glycemic control and GDM prevention in several trials. The mechanism appears to involve reduced postprandial glucose excursions and improved insulin sensitivity (Kouiti et al., 2022). Studies using validated healthy eating scores, such as the Alternate Healthy Eating Index or Healthy Eating Index, consistently demonstrated inverse associations between diet

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quality scores and GDM risk, with higher scores predicting lower GDM incidence (Kouiti et al., 2022). Key dietary components for GDM risk reduction were fiber intake, healthy fats, protein quality, and micronutrients. Higher dietary fiber, particularly from whole grains and vegetables, was associated with improved insulin sensitivity and reduced GDM risk (Altemani & Alzaheb, 2022). Healthy fats emphasize monounsaturated and polyunsaturated fats, such as from olive oil, nuts, and fish, instead of saturated and trans fats (Kouiti et al., 2022). Protein quality involves preferring plant-based proteins and fish to red and processed meats (Kouiti et al., 2022). Regarding micronutrients, adequate intake of magnesium, vitamin D, and antioxidants has been linked to better metabolic outcomes (Altemani & Alzaheb, 2022).

The physical activity interventions tended to have more complex and conditional effects than the dietary ones. The overall pooled effect for any physical activity intervention was **OR 0.77 (95% CI 0.55–1.06)**, which did not achieve statistical significance (Altemani & Alzaheb, 2022). However, this aggregate estimate masked substantial heterogeneity based on intervention timing and intensity, with subgroup analyses revealing critical distinctions. Physical activity initiated before pregnancy or during the first trimester demonstrated the strongest protective effects. First-trimester initiation showed **OR 0.57 (95% CI 0.43–0.75)**, representing a **43% relative risk reduction**(Altemani & Alzaheb, 2022). This finding suggests a critical window for intervention, likely corresponding to the period of placental development and establishment of maternal metabolic adaptations to pregnancy. Early physical activity may optimize insulin sensitivity before the physiological insulin resistance of mid-to-late pregnancy develops, potentially setting a more favorable metabolic trajectory (Alesi et al., 2021). Physical activity initiated in the second or third trimester showed attenuated or null effects in most studies, with pooled estimates approaching 1.0 (Altemani & Alzaheb, 2022). This suggests that later intervention may be less effective for GDM prevention, though it may still benefit other outcomes such as gestational weight gain and maternal fitness. Mild-to-moderate intensity physical activity (defined as 40-60% maximum heart rate or perceived exertion of 3-5 on a 10-point scale) demonstrated significant protective effects with **OR 0.65 (95% CI 0.53–0.80)**, representing a **35% relative risk reduction** (Altemani & Alzaheb, 2022). Activities in this category included brisk walking (30-45 minutes, 3-5 times per week), swimming and water aerobics, prenatal yoga and pilates, stationary cycling at moderate pace, light resistance training with bodyweight or light weights. Contrary to expectations, vigorous-intensity exercise showed no protective effect and a point estimate suggesting possible harm: **OR 1.09 (95% CI 0.50–2.38)**(Altemani & Alzaheb, 2022). While the confidence interval was wide and crossed 1.0, the lack of benefit and directional trend toward increased risk suggests that vigorous exercise during pregnancy may not be advisable for GDM prevention. Potential explanations included acute metabolic stress and cortisol elevation, reduced adherence due to pregnancy-related discomfort, possible adverse effects on placental perfusion at high intensities, selection bias (women experiencing complications may reduce vigorous activity). Sustained aerobic activities (walking, swimming, cycling) formed the basis of most successful interventions, typically prescribed at 150 minutes per week or 30 minutes on most days (Moholdt, 2023). Limited evidence suggests that supervised resistance training may improve insulin sensitivity, but data specific to GDM prevention remain sparse (Kouiti et al., 2022). Programs combining both modalities have shown promise in some studies but have not been adequately compared to aerobic-only approaches in head-to-head trials (Kouiti et al., 2022).

Combined diet-and-exercise interventions represent an intuitive approach to maximize lifestyle modification benefits. However, evidence synthesis reveals a more complex picture. Umbrella reviews of systematic reviews and meta-analyses found that while combined interventions may reduce GDM risk, pooled estimates frequently approached the null, and substantial heterogeneity limited confident inference (Kouiti et al., 2022). Several meta-analyses reported relative risk reductions in the range of 10-20%, but confidence intervals often crossed 1.0, and I^2 heterogeneity statistics exceeded 50-70% in many pooled analyses (Kouiti et al., 2022). This inconsistency likely reflects interventions heterogenity combined programs varied dramatically in dietary prescription specificity, exercise type/intensity/frequency, supervision level, and behavioral support components, adherence challenges, combined interventions may impose greater participant burden, potentially reducing adherence compared to single-component approaches, inadequate description, many trials provided insufficient detail about intervention components, making it difficult to identify effective elements quality concerns, the majority of systematic reviews examining combined interventions were rated low to critically low quality using AMSTAR criteria (Tsarna et al., 2023).

While effects on GDM incidence were inconsistent, combined interventions more consistently reduced gestational weight gain, most studies reported significant reductions in total gestational weight gain (typically

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1-2 kg less than controls) (Kouiti et al., 2022). Effects on other maternal and neonatal outcomes (cesarean section, macrosomia, preeclampsia) were inconsistently reported and generally not significantly different between intervention and control groups (Rasmussen et al., 2020). Based on the quantitative synthesis reviewed, the following recommendations have the strongest evidence support timing recommendations included preconception counseling, encourage healthy lifestyle adoption before pregnancy when possible, particularly for women with GDM risk factors (Moholdt, 2023), first trimester initiation, begin structured physical activity programs as early as first trimester for maximum GDM risk reduction (Hassanzadeh Rad et al., 2024). Early dietary modification, establish healthy eating patterns in early pregnancy or ideally preconception (Kouiti et al., 2022). Physical activity recommendations included intensity, favor mild to moderate intensity activities; avoid vigorous exercise programs specifically for GDM prevention, type, emphasize sustainable aerobic activities such as walking, swimming, and prenatal exercise classes, frequency and duration, target 150 minutes per week of moderate-intensity activity, or 30 minutes on most days (Altemani & Alzaheb, 2022). Individualization, Tailor recommendations to baseline fitness level, pregnancy symptoms, and medical contraindications (Moholdt, 2023). Dietary recommendations are dietary patterns: encourage DASH or Mediterranean-style eating patterns that emphasize whole foods, vegetables, fruits, whole grains, lean proteins, and healthy fats; (Rasmussen et al., 2020) glycemic control - focus on low glycemic-index carbohydrate sources and distribute carbohydrate intake between meals and snacks; macronutrient balance - adequate protein of 1.1-1.2 g/kg/day, moderate healthy fat intake, and controlled portions of carbohydrates; and micronutrient-adequate intake of calcium, vitamin D, iron, folate, and magnesium is assured through diet and supplementation when necessary (Illenberger et al., 2025).

This comprehensive review of recent evidence (2020-2025) reveals that dietary modification and early-initiated, mild-to-moderate physical activity represent the most consistently supported lifestyle strategies for reducing GDM risk. Dietary interventions demonstrated a robust 31% relative risk reduction (OR 0.69), while physical activity effects were highly conditional on timing and intensity, with first-trimester initiation and mild-to-moderate intensity showing 43% and 35% risk reductions, respectively (Altemani & Alzaheb, 2022). These findings align with established physiological mechanisms. Healthy dietary patterns-particularly DASH and Mediterranean diets-improve maternal insulin sensitivity through multiple pathways: reduced glycemic load, anti-inflammatory effects, improve gut microbiome, optimal gestational weight gain. Similarly, the benefits of early, moderate-intensity physical activity reflect well-characterized metabolic effects-enhanced insulin sensitivity, improve mitochondrial function, reduced adipose tissue inflammation, cardiovascular benefits (Fernández et al., 2023). The critical importance of early timing (first trimester) for physical activity likely reflects a developmental window during which maternal metabolic adaptations and placental function are established. Interventions initiated after this period may be less effective at altering the metabolic trajectory of pregnancy (Wang et al., 2022).

3.1. Clinical Implications

Clinicians may provide preconception counseling, and advise women planning pregnancy-especially women with risk factors-to adopt healthy dietary patterns (DASH/Mediterranean-style) and establish regular moderate-intensity physical activity habits before conception (Yıldırım et al., 2025). The early pregnancy intervention regarding the dietary pattern, in case of women presenting in the first trimester, should be focused on vegetables, fruits, whole grains, lean proteins, and healthy fats. Prescription for physical activity includes 30 minutes of moderate-intensity activity, such as brisk walking on most days of the week, sums up to ≥150 minutes/week. Avoid vigorous-intensity exercises for the purpose of GDM prevention alone (Altemani & Alzaheb, 2022). Risk stratification is done by using validated risk prediction tools, which incorporate lifestyle variables to identify those women who will benefit most from intensive intervention (Moholdt, 2023). Behavioral support is an important point since lifestyle change requires behavioral support. Consider referring patients to registered dietitians, exercise physiologists, or health coaches where resources permit (Yamanami & Kano, 2024). Monitoring and adjustment: follow gestational weight gain trajectories, adjust recommendations to achieve Institute of Medicine targets (Kouiti et al., 2022).

3.3. Limitations and Strengths

There is substantial heterogeneity in the definitions of interventions, populations, and outcome measures that limit the estimation of precise effects and generalizability. Standardized protocols for intervention and

outcome definitions are urgently needed. Many systematic reviews were rated as low quality, with critical intervention details commonly not reported in primary trials. This limits confidence in the pooled estimates and prohibits replication of effective interventions. Few studies measured or reported adequate intervention adherence and fidelity, making ineffective interventions difficult to differentiate from poorly implemented effective interventions. Most studies focused on GDM incidence as a primary outcome, although longer-term maternal and offspring metabolic health had limited data. Although plausible mechanisms are proposed, few studies directly measured mechanistic biomarkers-insulin sensitivity, inflammatory markers, and gut microbiome-to confirm pathways. Most studies were conducted within high-income countries with a majority of White or Asian participants, whereas evidence from diverse racial/ethnic groups and low-resource settings is limited.

3.4. Recommendation

Develop and test standardized, well-described intervention protocols with detailed specification of dietary targets and physical activity prescriptions. Employ factorial randomized controlled trials to directly compare diet alone, exercise alone, and combined interventions to definitively establish comparative effectiveness and potential synergies. Conduct dose-response studies to define optimal timing (preconception versus first trimester versus throughout pregnancy), intensity, frequency, and duration of interventions. Include mechanistic endpoints, such as insulin sensitivity testing, inflammatory biomarkers, gut microbiome analysis, and metabolomics, to understand pathways and identify potential targets for enhancement (Alesi et al., 2021). Extend follow-up to assess the impact of the interventions on postpartum diabetes incidence, cardiovascular health, and the metabolic outcomes of offspring. Develop and test scalable and cost-effective implementation strategies suitable for diverse healthcare settings and populations (Duan et al., 2022). Assess mobile apps, wearable devices, and telehealth approaches to deliver lifestyle interventions at scale.

4. CONCLUSION

This review of recent evidence (2020-2025) shows that lifestyle modification, mainly about dietary patterns and physical activity, is thus an evidence-based strategy for reducing the risk of gestational diabetes mellitus. Key findings: Dietary interventions consistently reduced GDM risk by approximately 31% (OR 0.69, 95% CI 0.56–0.84), with DASH and Mediterranean patterns appearing to be particularly promising. Physical activity effects were highly conditional on timing and intensity: first-trimester initiation, 43% risk reduction (OR 0.57, 95% CI 0.43–0.75); mild-to-moderate intensity, 35% risk reduction (OR 0.65, 95% CI 0.53–0.80); vigorous intensity, no benefit was observed (OR 1.09, 95% CI 0.50–2.38). Combined diet-and-exercise interventions may present possible benefits, though there was marked heterogeneity, with inconsistent findings from studies, which were limited by low-quality evidence. The optimal intervention characteristics included early initiation (preconception or first trimester), dietary patterns that emphasize whole foods and a low glycemic load, and moderate-intensity physical activity amounting to ≥150 minutes per week.

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