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Comparative Effects of Aerobic and Resistance Exercise on Glycaemic Control and Pregnancy Outcomes in Women with Gestational Diabetes Mellitus: A Narrative Review

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Abstract

Background: Gestational diabetes mellitus (GDM) is a common metabolic disorder associated with adverse maternal and neonatal outcomes. Physical activity is recommended as a first-line intervention, but the relative effectiveness of aerobic and resistance exercise remains unclear.

Aim: To compare the effects of aerobic, resistance, and combined exercise on glycaemic control and pregnancy outcomes in women with GDM.

Methods: A narrative review of studies published between 2014 and 2025 was conducted using PubMed and Scopus. Eligible studies included randomized controlled trials, systematic reviews, and observational studies evaluating exercise interventions in women with GDM. Due to methodological heterogeneity, findings were synthesized narratively.

Results: Both aerobic and resistance exercise improved glycaemic control by reducing fasting and postprandial glucose levels and enhancing insulin sensitivity. Resistance training may offer additional benefits for postprandial glucose regulation and reduced insulin requirements. Combined exercise interventions showed the most comprehensive metabolic improvements, although direct comparisons were limited by variability in study protocols. Evidence regarding maternal and neonatal outcomes remained inconsistent.

Conclusions: Aerobic and resistance exercise are safe and effective strategies for managing GDM, with potential complementary benefits when combined. However, heterogeneity of interventions and limited sample sizes prevent definitive conclusions regarding the superiority of any single exercise modality. Further high-quality randomized controlled trials with standardized protocols are needed to inform evidence-based recommendations.

Keywords: gestational diabetes mellitus; GDM; aerobic exercise; resistance training; pregnancy outcomes; glycaemic control; physical activity

1. Introduction

Diabetes in pregnancy is classified into two forms: pre-existing diabetes, diagnosed before conception, and gestational diabetes, identified for the first time during pregnancy. Both are defined as glucose intolerance that requires medical management (Gregory C.W. & Danielle M., 2022). Rising maternal age, the global surge in obesity and diabetes, declining physical activity levels, and the shift toward modernized lifestyles in developing regions are all factors that may be driving the growing prevalence of gestational diabetes (Ferrara, 2007). Gestational diabetes mellitus (GDM) incidence is increasing each year (Xie et al., 2022).

The presence of GDM can lead to negative health outcomes for both mothers and infants (Gregory C.W. & Danielle M., 2022). Women diagnosed with gestational diabetes had higher odds of caesarean delivery and preterm birth. For newborns, gestational diabetes was linked to an increased risk of a low one-minute Apgar score, as well as greater likelihood of macrosomia and being large for gestational age (Ye et al., 2022). In addition to influencing pregnancy and neonatal outcomes, gestational diabetes has important implications for maternal health, contributing not only to complications during pregnancy but also to long-term risks. Research indicates that women with a prior history of gestational diabetes have nearly a ten-fold increased risk of developing type 2 diabetes compared with those whose pregnancies were normoglycaemic. This substantial elevation in risk underscores the need for early preventive strategies in the years following pregnancy (Vounzoulaki et al., 2020).

Current evidence suggests that maintaining an appropriate level of physical activity during pregnancy may contribute to the prevention of excessive gestational weight gain, metabolic disturbances, and pregnancy-related complications, making exercise an important component of maternal health promotion (Łakoma et al., 2024). Regular physical activity is currently recognised as one of the key elements of a healthy pregnancy and is recommended for most pregnant women due to its positive effects on maternal and fetal health outcomes (Bartela et al., 2025). In addition to its metabolic benefits, regular physical activity during pregnancy has been associated with improved maternal well-being, better physical fitness, and favourable pregnancy outcomes, supporting its role as an important component of prenatal care (Chikitkina et al., 2016). Both the American Diabetes Association and the International Federation of Gynecology and Obstetrics recommend lifestyle modification, including regular physical activity, as the primary approach for managing GDM (C. Wang et al., 2016). Structured intensive lifestyle interventions reduce the risk of progression to diabetes among

individuals with prediabetes who previously had gestational diabetes (Aroda et al., 2015). Combining nutritional changes with regular physical activity reduces excessive weight gain in pregnancy, which is directly linked to the onset of GDM (Muktabhant et al., n.d.). Physical activity is widely recommended as a first-line strategy for improving glycaemic control in pregnancy. Randomized controlled trials have demonstrated that different exercise modalities—such as aerobic training versus combined aerobic and resistance training—can produce differential effects on maternal glucose metabolism, sympathetic nervous system activity, and cardiovascular hemodynamics in pregnant women with overweight or obesity (X. Wang et al., 2025). In comparison to aerobic exercise, resistance exercise is a more recent intervention for patients with GDM and has only lately been introduced into their treatment (Xie et al., 2022). However, despite strong general guidelines, the optimal type of exercise for women with GDM remains unclear. Most clinical recommendations emphasize aerobic exercise, while resistance training is mentioned less frequently and is often underutilized in routine care (Keating et al., 2022). This gap is notable given emerging evidence suggesting that resistance exercise may offer unique metabolic benefits.

The aim of this narrative review is to synthesise current evidence comparing aerobic, resistance, and combined exercise interventions in women with GDM, with particular emphasis on glycaemic control, maternal outcomes, and neonatal health.

2. Research materials and methods

A narrative literature review was conducted to identify scientific publications examining the effects of aerobic, resistance, and combined exercise interventions on glycaemic control and pregnancy outcomes in women with gestational diabetes mellitus. The search strategy focused on peer-reviewed articles indexed in PubMed and Scopus, covering the period from March 2014 to September 2025 to ensure inclusion of contemporary evidence on exercise-based interventions in GDM.

The following keywords and their combinations were used: “gestational diabetes,” “GDM,” “aerobic exercise,” “resistance training,” “combined training,” “physical activity,” “exercise intervention,” “glycaemic control,” “pregnancy outcomes,” and “maternal metabolism”.

The inclusion criteria comprised original research articles, systematic reviews, narrative reviews, and meta-analyses published in English that investigated the physiological effects, clinical outcomes, or adherence-related aspects of exercise interventions in women with GDM

or at high risk of developing GDM. Both experimental studies and observational studies were considered. Articles not written in English, conference abstracts, opinion pieces, and studies lacking full-text availability or sufficient methodological quality were excluded from the review.

3. Research results

3.1 Current Clinical Guidelines for Exercise in Women with Gestational Diabetes Mellitus

Current international guidelines consistently recognise physical activity as a fundamental component of gestational diabetes mellitus (GDM) management. In addition to dietary modification and glucose monitoring, structured exercise is recommended as a first-line non-pharmacological intervention to improve glycaemic control, reduce insulin resistance, and decrease the need for pharmacological treatment (American College of Obstetricians and Gynecologists ('Physical Activity and Exercise During Pregnancy and the Postpartum Period', 2020; *The American Diabetes Association Releases Standards of Care in Diabetes—2025 | American Diabetes Association*, n.d.)

The American Diabetes Association recommends that women with GDM who do not have obstetric contraindications engage in regular moderate-intensity physical activity throughout pregnancy. Exercise improves insulin sensitivity by increasing glucose uptake in skeletal muscle and reducing circulating blood glucose concentrations. Current ADA standards advise at least 150 minutes of moderate-intensity physical activity per week, distributed over a minimum of three days, with no more than two consecutive days without exercise (*The American Diabetes Association Releases Standards of Care in Diabetes—2025 | American Diabetes Association*, n.d.).

Similarly, the International Federation of Gynecology and Obstetrics (FIGO) identifies regular physical activity as an essential component of GDM treatment and encourages individualized exercise prescriptions based on maternal fitness level, pregnancy progression, and medical status (Hod et al., 2015)

The American College of Obstetricians and Gynecologists recommends that pregnant women participate in aerobic and strength-training activities whenever possible. Aerobic exercise may include brisk walking, stationary cycling, swimming, or low-impact fitness programmes, while resistance training can involve body-weight exercises, elastic resistance bands, or light free

weights. Combining aerobic and resistance exercise is increasingly encouraged because these modalities provide complementary physiological benefits, including improvements in cardiovascular fitness, muscular strength, and glucose metabolism (‘Physical Activity and Exercise During Pregnancy and the Postpartum Period’, 2020).

Exercise intensity during pregnancy is generally recommended to remain within the moderate range. For most women, this corresponds to approximately 60–70% of age-predicted maximal heart rate or an intensity at which conversation can be maintained comfortably during activity, commonly referred to as the “talk test”. Vigorous exercise may be appropriate for some women who were highly active before pregnancy; however, exercise programmes should be individualized and supervised when necessary (Mottola et al., 2018)

Safety considerations remain an important aspect of exercise prescription during pregnancy. Women should avoid activities associated with a high risk of abdominal trauma, falls, or excessive physical strain. Exercise should be discontinued immediately if warning signs occur, including vaginal bleeding, persistent uterine contractions, dizziness, chest pain, dyspnoea before exertion, or reduced fetal movements. Absolute contraindications include significant cardiovascular disease, restrictive lung disease, incompetent cervix, multiple gestation at risk of preterm labour, placenta previa after 26 weeks of gestation, and severe preeclampsia (‘Physical Activity and Exercise During Pregnancy and the Postpartum Period’, 2020).

Recent guidelines also emphasise the importance of reducing sedentary behaviour in addition to achieving recommended exercise targets. Interrupting prolonged sitting with short periods of light activity, such as walking after meals, may contribute to improved postprandial glycaemic control. This recommendation is particularly relevant for women with GDM, as postprandial hyperglycaemia is strongly associated with adverse maternal and neonatal outcomes (Davenport et al., 2018).

Overall, contemporary clinical guidelines demonstrate strong consensus that regular physical activity is a safe and effective intervention for women with GDM. While aerobic exercise remains the most commonly prescribed modality, growing evidence supports the inclusion of resistance training as part of a comprehensive exercise programme. Future guideline updates may further refine exercise recommendations as additional evidence becomes available regarding optimal exercise type, intensity, and long-term maternal and offspring outcomes.

3.2 Physiological mechanisms of exercise in GDM

Insulin resistance naturally increases during pregnancy, and this effect is amplified in women with overweight or obesity, leading to impaired glucose metabolism and higher risk of GDM (X. Wang et al., 2025). Aerobic and resistance exercises produce distinct metabolic effects, meaning that both may play valuable roles in managing insulin resistance conditions such as those observed in gestational diabetes mellitus (GDM) (Keating et al., 2022). Combined aerobic and resistance training has been shown to modulate sympathetic nervous system activity and cardiovascular hemodynamics, mechanisms that may indirectly influence glucose regulation in pregnancy (X. Wang et al., 2025).

Aerobic and resistance exercise both enhance glucose uptake in skeletal muscle, which is the primary site of insulin-mediated glucose disposal in pregnancy. Aerobic exercise improves glucose metabolism primarily through increased energy expenditure and enhanced mitochondrial oxidative capacity, which together reduce circulating glucose levels (Keating et al., 2022). In the study by Wang et al. the aerobic plus resistance training group of pregnant women showed lower HOMA-IR levels than the aerobic-only group, suggesting that combining aerobic exercise with resistance training was more effective in improving insulin resistance (X. Wang et al., 2025). Randomized controlled trials demonstrate that resistance exercise reduces fasting and postprandial glucose levels, confirming its direct metabolic benefits in women with GDM (Huifen et al., 2022; Xie et al., 2022).

Exercise may also help alleviate insulin resistance by altering an individual's adipokine profile. In particular, physical activity has been shown to increase adiponectin levels and enhance adiponectin-related signaling pathways. The association between adiponectin and GDM is well recognized, as reduced adiponectin concentrations are generally considered to significantly elevate the risk of developing GDM (C. Wang et al., 2016).

Another important aspect is that studies have demonstrated that insufficient physical activity during pregnancy may contribute to a higher risk of depression, anxiety, and other psychological disorders. These findings suggest that engaging in regular exercise during pregnancy is not only safe for women with GDM when appropriately supervised, but may also provide important mental health benefits (Xie et al., 2022).

3.3 Physiological mechanisms specific to resistance exercise in GDM

Resistance exercise is a form of independent physical activity that requires large muscle groups to contract against external resistance while at rest, helping to strengthen skeletal muscles and decrease body fat (Xie et al., 2022).

Resistance exercise stimulates skeletal muscle contractions, which enhance glucose uptake and utilization by muscle cells, thereby contributing to improved glycemic control (Huifen et al., 2022).

Resistance training is used to improve muscle strength, tone, and endurance. During pregnancy, this helps the body adjust to postural and biomechanical changes, supports better spinal and pelvic stability, and can reduce musculoskeletal discomfort. It also contributes to improved balance and coordination, which may lower the risk of falls and injuries (Pires et al., 2025).

Huifen et al. demonstrated that pregnant women with GDM who participated in moderate-intensity resistance training showed lower fasting and 2-hour postprandial blood glucose levels, reduced insulin use and insulin dosage requirements, as well as lower gestational weight gain and blood pressure compared with the control group (Huifen et al., 2022).

3.4 Physiological mechanisms specific to aerobic exercise in GDM

Aerobic exercise involves sustained activity engaging large muscle groups and increasing heart rate over a period of time. Previous studies have shown that aerobic exercise can positively influence blood glucose levels, lipid profiles, and blood pressure in pregnant women (X. Wang et al., 2025).

Regardless of GDM status, aerobic exercise may improve glucose uptake and utilization by muscle cells through enhanced insulin action, stimulation of glucose phosphorylation within muscle tissue, and increased conversion of blood glucose into muscle glycogen, ultimately contributing to lower blood glucose levels (Yaping et al., 2021).

Moderate-intensity aerobic exercise had a beneficial effect on blood glucose control in women with GDM, thereby reducing both the need for insulin therapy and the required insulin dosage (Yaping et al., 2021).

Similarly, in a study conducted by Bo et al., women with GDM who were advised to perform 20 minutes of brisk walking daily demonstrated reductions in postprandial glucose, HbA1c, C-reactive protein (CRP), and triglyceride levels, as well as a lower incidence of maternal and neonatal complications. However, no significant changes were observed in fasting glucose concentrations (Bo et al., 2014).

In a pilot randomized controlled trial conducted in pregnant women, acute cardiopulmonary exercise testing (CPET) and an 8-week high-intensity interval training (HIIT) program were shown to induce measurable changes in the urinary proteome. CPET elicited more pronounced proteomic alterations compared with the HIIT intervention, indicating stronger acute metabolic and immune responses. Importantly, HIIT was associated with the downregulation of proteins such as TFF2, which is linked to insulin resistance, suggesting potential mechanisms through which higher-intensity exercise may be relevant for metabolic regulation in the context of gestational diabetes mellitus (GDM). These findings provide preliminary mechanistic insights into how exercise intensity may influence pathways related to glucose metabolism during pregnancy (Goik et al., 2025).

3.5 Comparative Effects of Aerobic and Resistance Exercise in Women with GDM

Aerobic and resistance exercises remain the primary forms of physical activity recommended for patients with GDM (Xie et al., 2022).

In the study conducted by Sklempe Kokić et al., the experimental group of women with gestational diabetes who performed the combined aerobic and resistance exercise program showed lower postprandial glucose levels at the end of pregnancy compared with the control group receiving standard care. The study conducted by Xie et al. found that both aerobic and resistance exercises were effective in lowering average fasting blood glucose and 2-hour postprandial glucose levels in patients with GDM. However, resistance exercise demonstrated a greater benefit in reducing 2-hour postprandial blood glucose levels (Xie et al., 2022).

The study conducted by El Refaye and Abdel Aziz demonstrated that participation in the training program led to a statistically significant reduction in both fasting plasma glucose and 2-hour postprandial plasma glucose levels across both study groups of pregnant women diagnosed with gestational diabetes mellitus (GDM), namely the circuit resistance training group and the aerobic training group. However, participants who performed resistance training showed a greater reduction in both fasting and 2-hour postprandial plasma glucose levels compared with the aerobic training group. This suggests that resistance training may be particularly effective in improving glucose metabolism and enhancing postprandial blood glucose regulation, thereby contributing to better overall metabolic control in women with GDM (El Refaye & Abdel Aziz, 2017).

Compared with aerobic exercise, resistance training is generally more stable and may reduce the discomfort associated with the forward shift in the centre of gravity during late pregnancy.

As a result, this form of exercise may be more comfortable and better tolerated, potentially making it a preferable option for women with GDM (Huifen et al., 2022).

In late pregnancy, the increased physical burden associated with the fetus can restrict maternal movement, making aerobic exercise more challenging. In contrast, resistance exercise can be performed while seated or even lying down through simple movement-based activities. As a result, resistance training may represent a more practical exercise option for patients with GDM (Xie et al., 2022).

Combined training produced the most comprehensive improvements, but only a few studies included this modality, and protocols varied widely.

3.6 Characteristics of Aerobic and Resistance Exercise Interventions in Women with GDM

In the included studies, aerobic exercise interventions for women with gestational diabetes mellitus (GDM) were predominantly based on low- to moderate-intensity activities involving large muscle groups and aimed at maintaining an elevated heart rate. These programmes typically included brisk or step walking, treadmill-based exercise, and simple dynamic movements such as arm, neck, and leg stretching exercises (Xie et al., 2022). In most cases, aerobic training required minimal equipment, most commonly a treadmill or free-living walking, which made it a highly accessible form of physical activity during pregnancy (Sklempe Kokic et al., 2018).

In contrast, resistance exercise interventions focused on structured strength-training targeting both upper and lower body muscle groups. These programmes included exercises such as elbow flexion and extension, leg raises, hip abduction, ankle dorsiflexion, and other functional movements involving the trunk and limbs (Huifen et al., 2022; Xie et al., 2022) Resistance training was typically performed in a circuit format or structured sets, most commonly consisting of 10–15 repetitions across multiple sets (Sklempe Kokic et al., 2018). The equipment used varied from simple body-weight exercises to elastic resistance bands and light hand-held weights (0.5–1 kg), allowing for adaptation to the physiological constraints of pregnancy (Huifen et al., 2022; Sklempe Kokic et al., 2018). Overall, resistance exercise programmes were designed to be safe, feasible, and easily implementable while effectively targeting muscular strength and metabolic regulation in women with GDM (Huifen et al., 2022; Xie et al., 2022).

3.7 Maternal and Neonatal Outcomes Associated with Exercise in GDM

The study by Xie et al. demonstrated that, although both aerobic and resistance exercises were beneficial, there was no statistically significant differences between the two types of exercise in terms of pregnancy outcomes (Xie et al., 2022).

Similarly, Huifen et al. reported no significant differences in adverse maternal or neonatal outcomes between the groups. However, unlike the study by Xie et al., which compared aerobic and resistance exercise, this study compared standard care alone with standard care supplemented by a moderate-intensity resistance exercise program (Huifen et al., 2022).

In a study that did not include women with GDM but instead compared different exercise modalities (aerobic, resistance, and combined training) in pregnant women with hypertensive disorders of pregnancy, it was shown that the combined aerobic and resistance training intervention produced the most pronounced improvements across multiple health indicators. This effect was likely due to the complementary benefits of both exercise types in supporting cardiovascular function, improving muscular strength and endurance, and enhancing overall metabolic regulation (Chen et al., 2024).

Additional insight into the potential fetal and neonatal benefits of resistance exercise during pregnancy was provided by Jevtovic et al.. Although this study did not specifically involve women with GDM, the authors demonstrated that infants exposed to maternal resistance training in utero exhibited more than 35% higher energy expenditure compared with infants exposed to aerobic exercise or no exercise. These findings suggest that resistance exercise may induce metabolic adaptations extending beyond maternal glycaemic control and may positively influence infant metabolic function, potentially reducing the risk of future adiposity. Consequently, resistance training may represent a particularly valuable component of exercise interventions in pregnancies complicated by GDM, where fetal metabolic programming is of major clinical importance (Jevtovic, Claiborne, et al., 2025).

3.8 Additional Maternal and Placental Benefits of Exercise During Pregnancy

In the study conducted by Saccone et al., it was demonstrated that engaging in regular aerobic exercise during pregnancy was associated with a significant reduction in the risk of postpartum depression. The findings suggest that consistent antenatal aerobic activity may exert a protective effect on maternal mental health and contribute to improved emotional well-being in the postpartum period (Saccone et al., 2026).

The study conducted by Pires et al. examined the effects of a single session of in-person and remote strength training on low back pain and disability in pregnant women. The results showed that both delivery formats led to reductions in pain intensity and improvements in functional disability. Importantly, even a single session of strength training was associated with short-term benefits, while remote supervision proved to be an effective and practical alternative to in-person exercise (Pires et al., 2025).

The study conducted by Jevtovic et al. investigated how different modes of maternal exercise influence remodeling of the placental proteome. The authors observed exercise-induced, mode-specific alterations in protein abundance compared with the control group. Notably, only the eukaryotic translation initiation factor 3 subunit K decreased across all exercise modalities. In addition, SH3-domain kinase binding protein 1 was reduced following both resistance and aerobic exercise, while dematin actin binding protein was decreased in the aerobic and combined exercise groups. Furthermore, resistance and combined training shared several additional altered proteins, suggesting both overlapping and distinct molecular adaptations. Overall, these findings indicate that maternal exercise induces specific proteomic changes in the placenta depending on the type of exercise performed (Jevtovic, Wisseman, et al., 2025).

These findings are consistent with previous research indicating that the benefits of exercise during pregnancy extend beyond glycaemic regulation and include improvements in maternal physical and psychological health. Systematic reviews have demonstrated that regular prenatal physical activity is associated with reduced gestational weight gain, improved cardiovascular fitness, enhanced quality of life, and a lower risk of pregnancy-related complications. Furthermore, accumulating evidence suggests that exercise-induced adaptations within the maternal–placental–fetal unit may contribute to favourable pregnancy outcomes and support long-term offspring health (Davenport et al., 2018; Mottola et al., 2018; Nascimento et al., 2012).

3.9 Barriers and Adherence to Exercise in Women with GDM

Although physical activity is widely recommended as a cornerstone of gestational diabetes mellitus (GDM) management, adherence to exercise recommendations during pregnancy remains suboptimal. Numerous studies have demonstrated that many women diagnosed with GDM do not achieve the recommended levels of physical activity despite being aware of its potential benefits for glycaemic control and pregnancy outcomes. Understanding the barriers

that limit exercise participation is therefore essential for the development of effective and sustainable intervention strategies.

One of the most frequently reported barriers is physical discomfort associated with pregnancy. Fatigue, low back pain, pelvic girdle pain, nausea, and shortness of breath may significantly reduce motivation and capacity to engage in regular exercise. These symptoms often become more pronounced as pregnancy progresses, leading many women to decrease their activity levels during the third trimester (Mottola et al., 2018). In women with GDM, concerns regarding glucose fluctuations and fear of adverse pregnancy outcomes may further discourage participation in exercise programmes.

Psychological factors also play an important role in exercise adherence. Many pregnant women report uncertainty regarding the safety of physical activity and fear that exercise could negatively affect fetal health. Insufficient counselling from healthcare professionals may contribute to these concerns and result in unnecessary avoidance of exercise. Studies have shown that women who receive clear exercise recommendations from obstetricians, midwives, or diabetes educators are significantly more likely to engage in regular physical activity throughout pregnancy (Evenson et al., 2014)

Socioeconomic and environmental factors additionally influence exercise behaviour. Lack of time due to work and family responsibilities, limited access to exercise facilities, financial constraints, and inadequate social support are commonly identified barriers. These challenges may be particularly relevant for women from lower socioeconomic backgrounds, who often experience reduced access to structured lifestyle intervention programmes and health education resources (Harrison et al., 2018).

Adherence may also differ according to exercise modality. Resistance training has been suggested to offer practical advantages for women with GDM, particularly during late pregnancy. Unlike aerobic exercise, resistance exercises can often be performed while seated or with minimal movement, making them more comfortable and feasible when maternal mobility becomes limited. This may partly explain why some studies report higher adherence rates to resistance-based interventions compared with traditional aerobic exercise programmes (Xie et al., 2022)

Recent research has focused on innovative approaches to improve exercise participation among pregnant women. Mobile health (mHealth) technologies, smartphone applications, wearable activity trackers, and remote coaching programmes have demonstrated promising results in promoting behavioural change and supporting long-term adherence. Digital interventions allow

women to receive individualized feedback, monitor their progress, and access educational resources without the need for frequent clinic visits. The ongoing Bump2Baby and Me project represents one example of a large-scale initiative investigating the effectiveness of mHealth-supported lifestyle interventions for women at increased risk of GDM and adverse pregnancy outcomes (O'Reilly et al., 2021).

Healthcare provider involvement remains one of the most important determinants of successful exercise adoption. Individualized counselling, realistic goal setting, and regular follow-up may significantly improve adherence and enhance patient confidence in exercising safely during pregnancy. Future research should continue to explore strategies that address both physiological and psychosocial barriers to physical activity, as improving exercise adherence is likely to be a key factor in optimizing outcomes for women with GDM and their offspring.

4. Discussion

Gestational diabetes mellitus is a growing global health concern with significant implications for both maternal and offspring health. The findings of this narrative review confirm that physical activity—particularly aerobic and resistance exercise—plays a central role in improving glycaemic control in women with GDM. However, despite the overall consistency in demonstrating metabolic benefits, the evidence base remains heterogeneous, and several important gaps limit the ability to draw definitive conclusions regarding the superiority of one exercise modality over another.

Across the reviewed studies, both aerobic and resistance exercise improved fasting and postprandial glucose levels, insulin sensitivity, and overall metabolic function. Notably, several trials reported that resistance training produced greater reductions in postprandial glucose and lower insulin requirements compared with aerobic exercise alone. These findings align with physiological evidence indicating that resistance exercise enhances insulin-independent glucose uptake through increased muscle fibre recruitment and GLUT-4 translocation. Nevertheless, the magnitude of these effects varied across studies, likely due to differences in exercise intensity, duration, supervision, and participant characteristics.

Combined aerobic and resistance training appeared to yield the most comprehensive metabolic and cardiovascular benefits, suggesting potential synergistic effects. Aerobic exercise primarily improves cardiovascular fitness, increases energy expenditure, and enhances mitochondrial function, whereas resistance training promotes muscle hypertrophy and increases skeletal muscle glucose uptake capacity. Consequently, combining these modalities may address

multiple physiological pathways involved in insulin resistance and glucose regulation. However, only a limited number of studies implemented combined protocols, and their methodologies differed substantially. This heterogeneity restricts the ability to determine whether combined training should be prioritised in clinical recommendations.

Despite promising metabolic outcomes, evidence regarding maternal and neonatal outcomes remains inconsistent. Most studies reported no significant differences between exercise modalities in terms of obstetric complications, mode of delivery, or neonatal health indicators. This may reflect the fact that many trials were underpowered to detect differences in relatively infrequent outcomes such as preeclampsia, shoulder dystocia, or neonatal hypoglycaemia. Furthermore, few studies included long-term follow-up, limiting insight into the potential impact of maternal exercise on offspring metabolic health. Emerging evidence from non-GDM populations suggests that resistance training may influence fetal metabolic programming, but these findings require confirmation in GDM-specific cohorts.

From a clinical perspective, the findings of this review suggest that exercise prescriptions for women with GDM should not focus exclusively on aerobic activity, as has traditionally been the case in many clinical settings. While aerobic exercise remains the most commonly recommended modality due to its accessibility, safety profile, and extensive evidence base, resistance exercise appears to offer several unique advantages. In addition to improving glycaemic control, resistance training contributes to the preservation and development of skeletal muscle mass, which represents the primary site of insulin-mediated glucose disposal. This may be particularly relevant in women with obesity or pronounced insulin resistance, where improvements in muscle function could translate into greater metabolic benefits.

The practical feasibility of different exercise modalities should also be considered. As pregnancy progresses, particularly during the third trimester, many women experience physical limitations that may reduce their ability to participate in prolonged aerobic activities. Resistance exercise programmes can often be adapted to seated or supported positions and may therefore be more acceptable and sustainable during late pregnancy. In addition, resistance-based interventions generally require less continuous movement and may be easier to modify according to individual physical capabilities. Higher adherence to exercise interventions may ultimately have a greater impact on clinical outcomes than the specific exercise modality itself. Consequently, individual preferences, comfort, and long-term adherence should be considered when developing exercise recommendations for women with GDM.

The findings of this review are broadly consistent with current international guidelines, which advocate regular moderate-intensity physical activity as a cornerstone of GDM management. However, most guidelines provide only limited recommendations regarding the relative role of resistance training compared with aerobic exercise. The growing body of evidence demonstrating favourable metabolic effects of resistance exercise suggests that future guideline updates may benefit from providing more detailed recommendations regarding strength-training frequency, intensity, progression, and supervision during pregnancy. Such recommendations may help clinicians incorporate resistance exercise more confidently into routine antenatal care.

An additional consideration is the potential role of exercise beyond glycaemic control. Several studies included in this review reported benefits related to gestational weight gain, blood pressure regulation, psychological well-being, and overall maternal quality of life. These broader health effects may be clinically important, as women with GDM are at increased risk of future cardiometabolic disease even after pregnancy. Therefore, exercise interventions should be viewed not only as a short-term treatment strategy for hyperglycaemia but also as an opportunity to establish long-term healthy lifestyle behaviours that may persist into the postpartum period. Such behavioural changes may contribute to reducing the risk of future type 2 diabetes and cardiovascular disease in this high-risk population.

Furthermore, emerging evidence suggests that prenatal exercise may influence fetal development through mechanisms extending beyond maternal glucose regulation. Recent studies investigating placental proteomics, fetal metabolic programming, and infant energy expenditure indicate that maternal physical activity may induce biological adaptations with potential lifelong consequences for offspring health. These findings are particularly relevant given the growing recognition that the intrauterine environment plays a critical role in shaping future metabolic risk. Although current evidence remains preliminary, these observations support the hypothesis that exercise during pregnancy may contribute to breaking the intergenerational cycle of obesity, insulin resistance, and type 2 diabetes. This area represents a particularly promising direction for future research.

A major limitation across the reviewed literature is the lack of standardisation in exercise protocols. Interventions varied widely in frequency, duration, intensity, and supervision, making direct comparisons challenging. Additionally, adherence was inconsistently reported despite being a critical determinant of intervention effectiveness. The absence of objective measures of exercise intensity, such as percentage of one-repetition maximum (%1RM), heart-

rate monitoring, or accelerometer-based assessments, further complicates interpretation and replication of study findings.

Another important gap is the limited exploration of mechanistic pathways, particularly in relation to resistance training. While some studies assessed adipokines, inflammatory markers, or proteomic changes, these analyses were not performed consistently across trials. A better understanding of the biological mechanisms underlying exercise-induced improvements in glycaemic control may help refine exercise prescriptions and identify subgroups of women who may benefit most from specific exercise modalities. Future investigations integrating clinical outcomes with molecular and physiological markers could provide valuable insight into the pathways through which exercise exerts its beneficial effects.

Overall, the findings of this review highlight the need for well-designed, adequately powered randomized controlled trials directly comparing aerobic, resistance, and combined exercise interventions using standardized protocols and objective measures of intensity and adherence. Future research should also prioritise long-term follow-up of both mothers and offspring to assess the sustained metabolic impact of prenatal exercise and determine whether exercise-related benefits persist beyond pregnancy.

Taken together, the available evidence supports a flexible and individualized approach to exercise prescription in women with GDM. Rather than promoting a single superior exercise modality, clinicians should encourage participation in forms of physical activity that are safe, feasible, and acceptable to the individual patient. Such an approach is likely to maximize adherence while still achieving meaningful improvements in maternal metabolic health and may ultimately contribute to improved long-term outcomes for both mothers and their children.

5. Conclusions

Both aerobic and resistance exercise are effective and safe lifestyle interventions for improving glycaemic control in women with gestational diabetes mellitus. Current evidence indicates that resistance training may offer additional benefits, particularly in reducing postprandial glucose levels, improving insulin sensitivity, and providing greater feasibility in late pregnancy. Combined aerobic and resistance training appears to produce the most comprehensive metabolic improvements, although the number of studies using combined protocols remains limited.

However, substantial heterogeneity in study designs, exercise intensity, intervention duration, and outcome reporting prevents the identification of a clearly superior exercise modality. Most

trials were small, short-term, and insufficiently powered to detect differences in maternal or neonatal outcomes. Evidence regarding long-term effects on offspring metabolic health is especially scarce.

Disclosure

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The authors deny any conflict of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process

In preparing this work, the author(s) used ChatGPT for language improvement and grammatical correction. After using this tool/service, the author(s) have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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