REVIEW ARTICLE

Effectiveness of Aerobic Exercise in Preventing Gestational Diabetes Mellitus (GDM) Among Pregnant Women: A Systematic Review

Rozlin Abdul Rahman[1,*], Ainon Atikah Ayub[1]

[1]Department of Physical Rehabilitation Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a rising global health issue, affecting both maternal and foetal health. It increases the risk of future type 2 diabetes in mothers and various complications in infants. Aerobic exercise has shown promise in preventing GDM by regulating blood glucose, reducing maternal weight gain, and improving insulin sensitivity. This systematic review evaluates the effectiveness of aerobic exercise in preventing GDM in pregnant women. **Methodology**: Multiple databases, including PubMed, Scopus, and ScienceDirect, were searched for studies published between 2010 and 2020. Randomized controlled trials (RCTs) assessing aerobic exercise as a preventive intervention for GDM were included. After applying the PICOS framework, 1,091 studies were identified, of which six met the inclusion criteria. Study quality was assessed using the revised Cochrane risk-of-bias tool. **Results**: Three studies showed significant improvements in fasting blood glucose and insulin sensitivity with aerobic exercise alone. However, results were mixed when aerobic exercise was combined with other modalities. The variation in findings can be attributed to differences in population risk factors, intervention duration, and study design. **Conclusion**: Aerobic exercise is a promising intervention for reducing GDM risk, particularly in high-risk populations. However, the variability in results highlights the need for standardized exercise guidelines regarding intensity, frequency, and duration. Future research should focus on clarifying these factors and exploring the combined effects of aerobic exercise with other interventions to further enhance GDM prevention.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a pregnancy condition diagnosed in the second or third trimester, affecting 3-5% of pregnancies globally (Petry, 2014). Its prevalence is rising, with rates in Selangor, Malaysia reaching 27.9% (Logakodie et al., 2017), reflecting a broader global trend linked to lifestyle changes and increasing obesity. Studies show that GDM rates are particularly high in urban populations (Amar et al., 2023; Sahota et al., 2022).

Women with GDM face higher risks of complications like preeclampsia, Caesarean deliveries, and long-term type 2 diabetes (T2DM) (Guelfi et al., 2016). GDM also poses risks to infants, such as macrosomia, which can lead to birth complications and long-term health issues. Risk factors include maternal obesity, family history of diabetes, age, and low physical activity (Wang & Luo, 2019). However, fatigue and safety concerns often limit exercise during pregnancy (Gaston & Cramp, 2011).

Aerobic exercise, such as walking and cycling, has emerged as an effective strategy for managing GDM. It improves blood glucose control, boosts insulin sensitivity, and reduces excessive weight gain (Rousseau & Bard, 2016). Recommendations suggest 20-30 minutes of moderate-intensity aerobic exercise most days of the week to improve outcomes for both mother and baby (Chasan-Taber et al., 2021; Hanson et al., 2022). In addition, resistance training and activities like yoga can improve cardiovascular health, muscle strength, and glucose metabolism (Embaby et al., 2016; Sklempe Kokic et al., 2018). These exercises help regulate heart rate, lower blood sugar levels, and reduce GDM-related complications, while promoting better neonatal outcomes (Barakat et al., 2019). Aerobic exercise also enhances glucose uptake in muscles, providing lasting effects on blood sugar regulation (Harrison et al., 2016).

Given the increasing prevalence of GDM and growing evidence supporting exercise as a preventative measure, a systematic review is needed to synthesize recent findings and clarify exercise recommendations, ultimately improving health outcomes for both mothers and infants.

* *Corresponding author.*
E-mail address: rozlin@iium.edu.my

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MATERIALS AND METHODS

Identification

This systematic review aimed to gather studies from 2010 to 2020 assessing the effectiveness of aerobic exercise in preventing GDM among pregnant women. Multiple databases, including PubMed, Scopus, and ScienceDirect, were accessed. Specific keywords such as "aerobic exercise" AND "gestational diabetes mellitus" AND "pregnancy" OR "pregnant women" were used to capture relevant studies. To ensure accuracy, any duplicate articles were consolidated, and studies were excluded if they lacked sufficient details, were incomplete (e.g., non-full-text, non-English articles), involved animal studies, non-randomized controlled trial study design, or were unpublished.

Eligibility

Articles that passed the initial screening underwent an eligibility review, guided by the PICOS (Population, Intervention, Comparison, Outcome, and Study Design) framework. The PICOS criteria were derived from this study's title to ensure relevance to the research question. A summary of these criteria can be found in Table 1 below.

Risk of Bias

The quality and potential bias of each selected study were evaluated using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2), sourced from the University of Bristol (2018). This tool, known for its rigor in assessing methodological quality, ensured that only reliable studies were included in the review.

Study Selection

Initially, 1,091 articles were identified through database searches, with two additional studies located via Google Scholar. After removing duplicates, the remaining articles were screened by title, abstract, and objective relevance, resulting in the exclusion of 898 articles as shown in Figure 1. A total of 16 articles met the PICOS criteria and, after further assessment, 6 articles were ultimately selected for inclusion in this review.

Reporting Results

Data extraction was conducted for each included study. Based on the 2020 Guidelines for Systematic Reviews by the American Occupational Therapy Association, Table 2 captures the study characteristics including author/year, evidence level, study design, risk of bias, participant characteristics, inclusion criteria, study setting, intervention, and key outcomes.

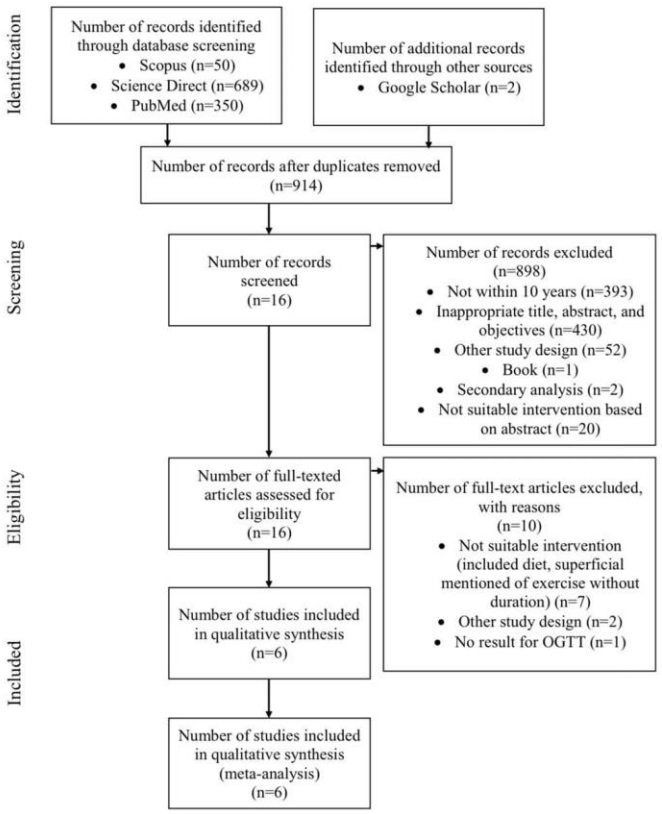

Figure 1: PRISMA flow diagram

Table 1: Details of the PICOS table

P	Healthy pregnant women, pregnant women with GDM, pregnant women with a history of GDM, and pregnant women with a high risk of GDM
I	Aerobic exercise
C	Standard prenatal care or no structured exercise intervention
O	Oral glucose tolerance test (OGTT), fasting blood glucose and insulin level
S	Randomized control trial

RESULTS

Study Characteristics

The studies reviewed involved participants aged 18-40, excluding those with conditions such as hypertension, pre-existing diabetes, or cardiac disease to minimize confounding variables. Participants generally had uncomplicated, sedentary, singleton pregnancies. Most studies provided supervised exercise interventions, although Sklempe Kokic et al. (2018) and Barakat et al. (2019) did not specify whether expert supervision was involved. To ensure consistent intensity levels, some studies used the Borg Rating of Perceived Exertion (RPE) scale, providing a reliable measure of exercise exertion appropriate for pregnant populations. The studies included were well-constructed, randomized controlled trials (RCTs), considered a high level of evidence for evaluating intervention effects. Bias assessment using the RoB 2 tool revealed a generally low risk of bias across studies, although Cordero et al. (2015) showed a higher risk due to unmasked participants, which may have influenced self-reported adherence and perceived outcomes. Summary of the findings is shown in Table 2.

Effects of Aerobic Exercise in GDM

Three studies (Embaby et al., 2016; Guelfi et al., 2016; Wang et al., 2017) examined the effects of aerobic exercise alone on GDM outcomes, while Cordero et al. (2015), Sklempe Kokic et al. (2018), and Barakat et al. (2019) investigated aerobic exercise combined with other modalities. Findings suggest that aerobic exercise alone contributes to significant improvements in fasting glucose and insulin sensitivity (Embaby et al., 2016; Wang et al., 2017). However, in Guelfi et al. (2016), no significant differences were noted in oral glucose tolerance test (OGTT) results, potentially due to variations in population risk factors or exercise adherence.

Interestingly, studies combining aerobic exercise with other modalities (Barakat et al., 2019) found additional benefits, including reduced GDM prevalence and improvements in OGTT outcomes. However, Sklempe Kokic et al. (2018) observed no notable changes in fasting glucose, possibly due to the shorter intervention duration and smaller sample size, emphasizing the importance of study design in determining reliable outcomes. These mixed results highlight that aerobic exercise alone is generally effective but may yield better results when integrated with other forms of physical activity.

This review suggests that aerobic exercise may help prevent GDM in high-risk women. Studies by Embaby et al. (2016) and Wang et al. (2017) showed significant blood glucose reductions through activities like treadmill walking and stationary cycling, supporting broader findings, such as Magro-Malosso et al. (2017), which emphasized the benefits of aerobic exercise in overweight or obese pregnant women. Aerobic exercise enhances glucose uptake in skeletal muscles by activating the GLUT4 transporter, improving glucose absorption without insulin (Bird & Hawley, 2017). However, Guelfi et al. (2016) found that aerobic exercise alone did not significantly improve outcomes for women with a history of GDM, suggesting limited effectiveness for secondary prevention in high-risk populations. This aligns with Muche et al. (2019), which found that exercise is more beneficial for those without prior GDM.

While aerobic exercise holds potential, studies underscore the need for precise guidelines on exercise duration and intensity. For instance, the American Pregnancy Association (2017) suggests stationary cycling as a safer aerobic option due to the shift in the center of gravity during pregnancy, which reduces fall risk. Although cycling is low-impact, further research could examine optimal exercise intensity and modality for maximal benefits.

Aerobic Exercise Combined with Other Exercises in Preventing GDM

Combining aerobic exercise with other activities, such as strength and pelvic floor exercises, shows promise for improving GDM outcomes. Cordero et al. (2015) and Barakat et al. (2019) found that combining land and aquatic exercises led to reduced GDM prevalence and better OGTT results, suggesting that these exercises can enhance fitness and glycaemic control. Aquatic exercises,

for example, aid in weight management, a key factor in GDM prevention (Bacchi et al., 2018). Pelvic floor exercises also improve pregnancy outcomes by reducing labour duration and urinary incontinence (Schreiner et al., 2018). However, Sklempe Kokic et al. (2018) found no significant effects of combined exercises on GDM outcomes. Their six-week intervention and small sample size may explain these results, highlighting the importance of intervention duration and adherence.

Research suggests that early exercise, ideally starting in the first trimester, yields the best results (Padayachee, 2015). Bird and Hawley (2017) emphasize that regular physical activity improves glycaemic control, stressing the benefits of sustained exercise early in pregnancy. Beyond GDM prevention, aerobic exercise offers broader health benefits during pregnancy, improving cardiovascular fitness and lowering chronic disease risk factors (Guelfi et al., 2016). Regular exercise also supports mental well-being, reducing stress and anxiety during pregnancy. Additionally, aerobic activity aids in managing gestational weight gain, which is essential for minimizing GDM risk (Wang et al., 2017). Maintaining weight within BMI-specific guidelines is critical for maternal and foetal health, reinforcing the multifaceted advantages of physical activity in prenatal care.

CONCLUSION

This review emphasizes that regular aerobic exercise is a valuable, non-invasive strategy for reducing the risk of GDM, particularly for women at higher risk. Aerobic activities such as walking, cycling, and low-impact aerobics have been shown to improve blood glucose regulation and insulin sensitivity. However, study results varied due to differences in exercise protocols, sample sizes, and population characteristics, highlighting the need for clear, evidence-based guidelines on exercise intensity, duration, and other specific protocols for GDM prevention.

Future research should focus on standardizing exercise interventions, including defining optimal intensity, frequency, and duration for GDM prevention. Additionally, exploring the combined effects of aerobic exercise with other physical activities, such as resistance and flexibility training, may further enhance maternal health. More diverse studies are also needed to assess the effectiveness of exercise across various demographics and risk profiles.

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Table 2 Study Characteristics

Author/Year	Level of Evidence Study Design Risk of Bias	Participants Inclusion Criteria Study Setting	Intervention and Control Groups	Outcome Measures	Results
Cordero et al. (2015)	Level 1B RCT *Risk of Bias* High	*Final Participants* 257 healthy pregnant women *Inclusion Criteria* - Not previously familiar with exercise or any physical activity *Study Setting* Gym hall Small and large pool tanks (supervised by qualified fitness specialist)	*Intervention (n = 101)* Participants were involved in 50-60 minutes exercise three times per week (two times for land exercise and once for aquatic exercise). They started at 10-14 weeks of pregnancy and ended at 38-39 weeks of pregnancy. The exercise can be divided into; LAND EXERCISE - 10 minutes warming up (locomotion games, light stretch, articular movement) - 20 minutes of low impact aerobic exercise (aerobic dance, Latin dance, cardio boxing) - 12 minutes resistance exercise (15 repetitions for biceps and triceps, quadriceps, and gluteal) - 10 minutes pelvic floor exercise - 8 minutes stretching exercise (relaxation and visualization exercise, self-massage, and pair-massage) # Exercise with 12-14 RPE AQUATIC EXERCISE	*GDM* 1-h, 2-h, and 3-h OGTT at 24-28 weeks of gestation	*Significant Findings* A significant finding in 3-h OGTT level between intervention and control group with p-value < 0.05 (p = 0.021) *Non-significant Findings* The results between intervention and control group showed no significant difference in both 1-h and 2-h OGTT as the p-value > 0.05 (1-h OGTT, p = 0.502, 2-h OGTT, p = 0.097)

			- 10 minutes warming up (swimming except for butterfly style) - 30 minutes of core exercises (strength exercise, lunges) - 10 minutes stretching exercise (flexibility, relaxation, and breathing exercise) *Control Group (n = 156)* Remained inactive		
Embaby et al. (2016)	Level 1B RCT *Risk of Bias* Low	*Final Participants* 40 multigravida pregnant women with a high risk of GDM *Inclusion Criteria* - 24 weeks of pregnancy - BMI > 30kg/m2 - With at least one of the following criteria: i) history of macrosomia baby ii) history of abnormal glucose tolerance during a previous pregnancy iii) Having T2DM *Study Setting* None (no information on supervision)	*Intervention (n = 20)* Pregnant women were assigned to do 45 minutes of aerobic exercise three times per week. They started to exercise at 24 weeks of gestation until 37 weeks. The exercise was divided into three-phase; PHASE 1 - 10 minutes warming up (walking in place) PHASE 2 - 30 minutes active stage (walking on the treadmill without inclination, at speed 0.7km/hour) PHASE 3 - 10 minutes cooling down (walking on the treadmill by decreasing the speed) *Control Group (n = 20)* Traditional care was given to the subjects in the control group including diet intervention	*GDM* Fasting blood glucose and insulin level at 37 weeks of gestation	*Significant Findings* The value for both fasting glucose and insulin level appeared to have significant findings between the intervention and control group with the *p*-value < 0.05 (fasting glucose level, *p* = 0.0001, fasting insulin level, *p* = 0.0001) *Non-significant Findings* None

Guelfi et al. (2016)	Level 1B RCT *Risk of Bias* Low	*Final Participants* 172 pregnant women with a history of GDM *Inclusion Criteria* - less than 14 weeks of gestation - Singleton pregnancy - Not familiar with any exercises - Able to participate for 14 weeks of exercise program *Study Setting* Each participant's home (supervised by exercise physiologist)	*Intervention (n = 85)* Cycling intervention using upright cycle ergometer for up to 60 minutes per session three times per week. The exercise was done within 14 weeks. The exercise can be divided into; - 5 minutes warming up at low intensity pedalling (12-13 RPE) - 20-30 minutes moderate-intensity cycling (14-16 RPE) - 5 minutes cooling down (9-11 RPE) # progressively increase the duration until 45-50 minutes *Control Group (n = 87)* Standard care	*GDM* 2-h OGTT after 14 weeks of exercise program (conclude by recurrence rate of GDM- based on glucose and insulin response to OGTT)	*Significant Findings* None *Non-significant Findings* The OGTT finding illustrated no significant difference between glucose and insulin response in the exercise and control group as the prevalence of getting GDM was the same in both groups (*p*-value = 0.950)
Wang et al. (2017)	Level 1B RCT *Risk of Bias* Low	*Final Participants* 265 pregnant women with a high risk of GDM *Inclusion Criteria* - Singleton pregnancy - BMI 24-28 kg/m2 - Non-smoking *Study Setting* In the hospital with supervision	*Intervention (n = 132)* Cycling program three times per week starting from week 12 of pregnancy until 36-37 weeks of gestation. The exercise lasted for 30 minutes and were classified into; a) 5 minutes warming up with low intensity (9-11 RPE) b) 5 minutes moderate-intensity cycling (12-14 RPE, 30 seconds pedalling with high intensity (15-16 RPE), 5 minutes moderate-low intensity (10-12 RPE), 1-minute pedaling at increase resistance (13-15 RPE).	*GDM* OGTT was observed in 1-h and 2-h during the second trimester	*Significant Findings* A significant difference between exercise group and control group in OGTT level with p-value < 0.05 in both tests (1-h *p*-value = 0.009, 2-h *p*-value = 0.009) *Non-significant Findings* None

			2 minutes interval with 3 repetitions c) 5 minutes cooling down of easy cycling # Progressively increased the duration of exercise until reach 45-60 minutes per session according to individual ability *Control Group (n = 133)* Continue with usual daily activities and were not encouraged to get involved in any physical exercises		
Sklempe Kokic et al. (2018)	Level 1B RCT *Risk of Bias* Low	*Final Participants* 38 pregnant women diagnosed with GDM *Inclusion Criteria* - Aged between 20-40 years old - Upper limit of pregnancy: at least 30 weeks (involved in 6 weeks of exercise intervention) *Study Setting* None with no supervision mentioned	*Intervention (n = 18)* 6 weeks of exercise intervention (two times per week) were introduced to pregnant women with a maximum upper limit for pregnancy was set at 30 weeks. The intervention involved 50-55 minutes exercise which was divided into several parts; a) 20 minutes of aerobic exercise on a treadmill with 13-14 RPE b) 20-25 minutes strengthening exercise (trunk, upper limb, lower limb muscles) c) 10 minutes pelvic floor exercise, stretching, and relaxation *Control Group (n = 20)* Standard prenatal care	*GDM* Fasting glucose level at the end of pregnancy	*Significant Findings* None *Non-significant Findings* At the end of pregnancy, there was no significant difference between fasting glucose level in exercise and control group with the *p*-value > 0.05 (*p*-value = 0.367)

Barakat et al. (2019)	Level 1B RCT *Risk of Bias* Low	*Final Participants* - 456 healthy pregnant women *Inclusion Criteria* - Uncomplicated and singleton pregnancy - No T1DM, T2DM, and GDM at baseline - No history of preterm delivery - Not previously active or involved in other trials *Study Setting* None (supervised by qualified physical activity and sport science professional)	*Intervention (n = 234)* At the beginning of 8-10 weeks of gestation, participants were involved in 55-60 minutes of supervised moderate-intensity exercise for three days per week until 38-39 weeks of gestation. The exercises included; a) 10 minutes warming up (walking and static stretching) b) 30-35 minutes of aerobic exercise (aerobic dance) and strengthening exercise (using 3kg barbells and TheraBand for major muscles) c) 10 minutes cooling down (walking, static stretching, pelvic floor strengthening, and relaxation) # Exercise with 12-14 RPE *Control Group (n = 222)* Received obstetric standard care from health professions including counselling on general nutrition and physical activity	*GDM* 1-h OGTT at week 24-26 gestation	*Significant Findings* The OGTT results showed a significant finding between exercise group and control group with *p*-value < 0.05 (*p* = 0.045) *Non-significant Findings* None