Impact of structured physical exercise during pregnancy on maternal health and fetal outcomes: A systematic review

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ABSTRACT

Introduction: Current guidelines recommend that pregnant women engage in physical activity. Exercise during pregnancy has been shown to positively impact both maternal and fetal outcomes. Therefore, we conducted a systematic review to evaluate the impact of structured physical activity during pregnancy on maternal health and fetal outcomes.

Materials and Methods: A systematic search was conducted on relevant articles published between 2015 and 2020 using PubMed, Google Scholar, ScienceDirect, Scopus, and the Cochrane Library. Studies on pregnant women, comparative study designs with concurrent controls, structured physical intervention and health outcomes for both maternal and fetal were targeted. Maternal outcomes include gestational weight gain, lumbopelvic pain, gestational diabetes and pre-eclampsia, while fetal outcomes include prematurity and birth weight. Only original studies with published data were included. This review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

Results: A total of 3441 published articles were retrieved from different databases. After assessing the obtained papers, studies that did not meet the inclusion criteria were excluded. Twenty studies involving 5188 populations that met the inclusion criteria were included in this review. However, due to the heterogeneity of the studies, meta-analysis was not done. Structured physical activity significantly reduced the risk of gestational diabetes (OR: 0.57; 95% CI: 0.40–0.81; p = 0.002), but had no statistically significant effect on lumbopelvic pain (OR 0.98 (95% CI: 0.49 to 1.93) p=0.95), gestational weight gain (OR 0.88 95% CI: (0.44, 1.76) p=0.71), pre-eclampsia (OR 0.78, 95% CI: 0.41, 1.49, p=0.46) causing preterm delivery (OR 0.91, 95% CI (0.69, 1.20), p=0.50) or affecting fetal birth weight (mean difference 0.93, 95% CI (-42.67, 44.53), p=0.97)

Conclusion: Structured physical activity during pregnancy, three times a week, 30 minutes per day of moderate intensity, is safe and benefits pregnant women and the fetus. Our findings challenge the view that physical exercise during pregnancy is not helpful and can be harmful. To generate further evidence, there is a need for high-quality, standardised trials that assess specific types of structured exercise program with better reporting of adherence and outcomes.

KEYWORDS:
Physical activity, lumbopelvic pain, pre-eclampsia, gestational diabetes, preterm, birthweight, pregnancy

INTRODUCTION

Physical activity is beneficial and vital in preventing non-communicable diseases, cancer, and other health conditions and improving overall well-being, including that of pregnant women. Despite its benefits, an estimated 1.4 billion adults are physically inactive. It is reported that inactive people have a 20% to 30% increased risk of death than those who are sufficiently active.[1]

Pregnancy represents a critical window for both maternal and fetal health, with physiological and metabolic changes that can significantly influence long-term outcomes. Among the most concerning complications during pregnancy are gestational diabetes mellitus (GDM), excessive gestational weight gain (GWG), pre-eclampsia and lumbopelvic pain, all of which are associated with adverse perinatal and postpartum outcomes.[2]

Physical activity has emerged as a promising, non-pharmacological intervention to mitigate pregnancy-related risks. Current international guidelines, including those from the World Health Organization (WHO, 2022) and the American College of Obstetricians and Gynecologists (ACOG, 2020), recommend that pregnant women without contraindications engage in at least 150 minutes of moderate-intensity physical activity per week before, during and after pregnancy.[3] The benefits of regular prenatal exercise may extend beyond physical fitness, potentially reducing the risk of GDM, managing weight gain within recommended limits, alleviating musculoskeletal discomfort, and enhancing mental well-being.[2]

Structured physical exercise refers to planned, organised, and repetitive physical activities designed to improve or maintain specific aspects of physical fitness, such as strength, endurance, flexibility, or cardiovascular health.[4] Unlike general physical activity, which includes any bodily movement that increases energy expenditure (e.g., walking

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to work or household chores), structured exercise follows a defined regimen with set goals, intensity levels, and durations.

For example, structured physical exercise may include supervised training programs, aerobic workouts, resistance training, or high-intensity interval training (HIIT), often tailored to individual needs or health objectives. Research highlights its effectiveness in improving physical fitness and health outcomes, particularly when systematically prescribed based on factors like frequency, duration, and type of exercise.[3]

Previous studies have shown a positive impact of physical exercise on maternal health and fetal development. For example, exercise intervention has been proven to prevent excessive weight gain [5,7] , reduce the incidence of gestational diabetes [5,7] and pregnancy-induced hypertension [8], and decrease the intensity of lower back pain and pelvic girdle pain.[9,10] Furthermore, exercise also helps reduce the total duration of labour,[11] and decrease the incidence of instrumental delivery.[12] In addition, more studies have shown that physical activity during pregnancy does not cause preterm birth or low birth weight.[7]

Studies have shown that most pregnant women are not physically active during pregnancy due to several factors, such as lack of energy or sickness due to pregnancy, lack of motivation, lack of time or busyness due to work and myths regarding exercise can cause miscarriage.[13] Nevertheless, the forms of exercise during pregnancy that benefit pregnancy, and maternal outcomes are still debatable.

Although several studies have investigated exercise during pregnancy, there is a lack of a comprehensive review that synthesizes the evidence on the impact and effect of structured physical activity on maternal and fetal outcomes. Hence, this systematic review aims to evaluate the effect and impact of structured physical activity on maternal health and fetal outcomes, particularly gestational diabetes, pre-eclampsia, gestational weight gain, lumbopelvic pain, birth weight, and preterm delivery. This review focuses on articles from 2015 onwards based on the establishment of ACOG guidelines on physical activity and exercise, which was published in 2015.

MATERIALS AND METHODS

Protocol and Registration

The present review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) with clinical trial CRD42021229914 and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Search strategy

All authors developed and reviewed a search strategy (Box 1). Medical Subject Headings terms and keywords were used in various combinations. We searched published literature from five online databases: PubMed, Google Scholar, Science Direct, Scopus, and Cochrane Library databases to identify studies examining the effect of the type of structured exercise program during pregnancy on maternal and fetal health outcomes. We conducted the search in May 2021.

Box I. Search strategy for impact of exercise on maternal and fetal health

1. Effect OR Impact
2. Structured OR Supervised
3. Physical exercise OR exercise
4. Pregnancy OR pregnant women OR gestation
5. #1 AND #2 AND #3 AND #4

Inclusion criteria

We selected all Randomized Controlled Trials (RCTs) worldwide involving a structured plan on physical activity that reported the effect of structured physical exercise on maternal and fetal health outcomes and fulfilled the following criteria. The criteria included English peer review articles published from January 2015 to December 2020 due to the establishment of ACOG guidelines on physical activity and exercise, which was published in 2015, studies involving pregnant women with singleton pregnancies and low-risk and uncomplicated pregnancy. Articles for which the full text could not be obtained after two email contacts from the principal investigator and quasi-experimental studies were excluded. In addition, conference abstracts and grey literature were excluded because they may not be subjected to the same peer review rigour.

Study selection

We imported relevant articles identified through the databases into a Microsoft Excel Spreadsheet and removed duplicate publications. Two reviewers independently performed the screening using the titles and abstracts to search for potentially eligible articles based on the inclusion and exclusion criteria mentioned above. Discussions were held to resolve any disagreement with a final consensus before reviewing the full text of each relevant article.

Data Extraction

Two review authors (FHMN and NAJ) screened the titles and abstracts independently to identify potentially relevant citations. These review authors retrieved the full texts of all potentially relevant articles and independently assessed the eligibility of the studies using predefined inclusion criteria. We extracted data from all the articles found to be relevant. The authors of the primary studies were contacted by email in case more complete information was needed. Any disagreements or discrepancies between reviewers were resolved by discussion and, if necessary, consulting a third author (KHAA). In addition to the electronic search, we searched for reference lists of the articles identified.

Quality assessment

We evaluated the quality of the studies using the risk of bias by the Cochrane Collaboration tool.[14] It covers six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases. Within each domain, assessments are made for one or more items, which may cover different aspects of the domain or different outcomes.

Data synthesis
We analyzed the maternal and fetal outcomes among pregnant women who participated in a structured exercise program compared to those in the control groups. Statistical analysis was conducted using Review Manager (RevMan) software version 5.4. Only published data were used. No attempts were made to retrieve raw data from the original study authors.

Odd ratios (OR) or mean differences (MDs) were calculated with 95% confidence intervals using the Mantel-Haenszel method. A fixed effects model was applied. Heterogeneity was assessed with I2 statistics, and a random effects model would have been used if significant heterogeneity was detected (I2>50%).

The ORs were reported for dichotomous data (excessive gestational weight gain, gestational diabetes, pre-eclampsia, lumbopelvic pain intensity, and preterm delivery). In contrast, MDs were reported for the continuous outcome of birth weight.

A meta-analysis was not conducted due to substantial clinical and methodological heterogeneity across the included studies, notably variations in participants' gestational age, differences in study quality and varying risk of bias.

RESULTS

Characteristics of the studies
A total of 3441 studies were retrieved from different databases. After removing the duplicate articles (n=814) and reading the titles and abstracts, articles not fulfilling the inclusion criteria were excluded. A total of 33 full-text articles were downloaded, and their eligibility was assessed. Of these articles, 13 were excluded because they did not meet the inclusion criteria (among the ten papers, the outcome of interest was not reported, and the other three papers were not primary studies). Finally, 20 articles were used for this systematic review. The detailed selection procedure, as outlined in the PRISMA guidelines, is illustrated in Figure I.

The summary characteristic of the included studies is listed in Table I. Fourteen (14) studies were conducted in Europe; nine were in Spain [15-22], two in Norway [23-24], and each one in Sweden [25], Denmark [26], and France.[27] The rest of the studies were conducted: one in Brazil [28], Colombia [29], Slovenia [30], Iran [31], Nigeria [32], and Australia [33]. A total of 5,179 participants were involved in the studies, comprising 2,378 pregnant women in the exercise group and 2,801 participants in the control group. The majority of the exercise took place in hospitals or medical centre [15,16,31,32,34,17,19,20,22,23,27,29,30], three in universities, [18,26,28] two at public facilities [21,24] and one at the clinic.[25] For the studies, the exercise sessions were conducted by a physiotherapist-supervised exercise session[17,22,25,30,32,33], an exercise instructor[16,19,23,24,26,28,31,34], fitness instructors[15,18,20], gynaecologist[27] or dietician[29]. All women in the control group were given standard antenatal care.

Type of structured physical exercise
The types of exercise varied among the studies. Most studies have conducted aerobic exercises [15,16,30,32,33,17,19,20,22–24,28,29], three studies performed aquatic exercises [18,21,26], and each one conducted yoga [31], Pilates [34], and resistance exercises.[25] Meanwhile, Cordero et al., 2015 [18] conducted mixed land-based and aquatic activities. Most of the intensity levels were moderate, except for three studies that had light to moderate intensity.[17,20,27] and there were two studies on vigorous intensity.[25,29] These categories were established according to the Borg scale.[21,23,28,32] with the scoring of perceived exertion, heart rate [17,22,29], the combination of the Borg scale and heart rate [15–20,30,33], and a questionnaire to assess metabolic equivalents of task (METs).[24] Five studies did not mention the indications of the intensity of the exercise.[25–27,31,34] The exercise groups were done at least twice to three times per week, ranging from 45 to 65 min. Most of these studies were conducted in the first or second trimester until delivery, except for a study by Sklempekokic et al. [30], which started in the third trimester.

Risk of bias
Risk of bias was assessed using the Cochrane Risk of Bias Tool, as implemented in Review Manager (RevMan). Two independent reviewers (FHMN, NAJ) performed the assessment. Disagreements were resolved through discussion or consulting a third reviewer (KHAA).

The following seven domains were evaluated: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other sources of bias. Based on the information reported in the individual studies, each domain was judged as having a 'low risk,' 'high risk,' or 'unclear risk' of bias. Figures II and III present a graphical summary of the risk of bias across all included studies (generated via RevMan). Figure II illustrates the quality assessment regarding random sequence generation. Nine studies lacked sufficient data on the randomised process, so we assessed the risk of bias as unclear.[15,18,20,23,25–27,30,32] One study randomised participants based on volunteerism, which we evaluated as a high risk of bias.[25]

Most studies used numbered, opaque, and sealed envelopes to conceal the allocation, which we considered to be a low risk of bias. However, nine studies were assessed as having an unclear risk of bias due to insufficient methodological details on allocation concealment. [18, 19, 21, 22, 27, 29, 30, 32, 33] All twenty studies reported that participants were blinded; therefore, the risk of bias was assessed as low. However, eleven studies did not specify whether the outcome assessors were blinded. Despite attempts to confirm this with the authors, we concluded these studies as having an unclear risk of bias.[18-20,22,26,27,29,31-34] One study was judged to be at high risk of bias because the researchers were not blinded.[21]

Approximately 65% of the studies analysed all enrolled participants, resulting in a low risk of bias. Seven studies were

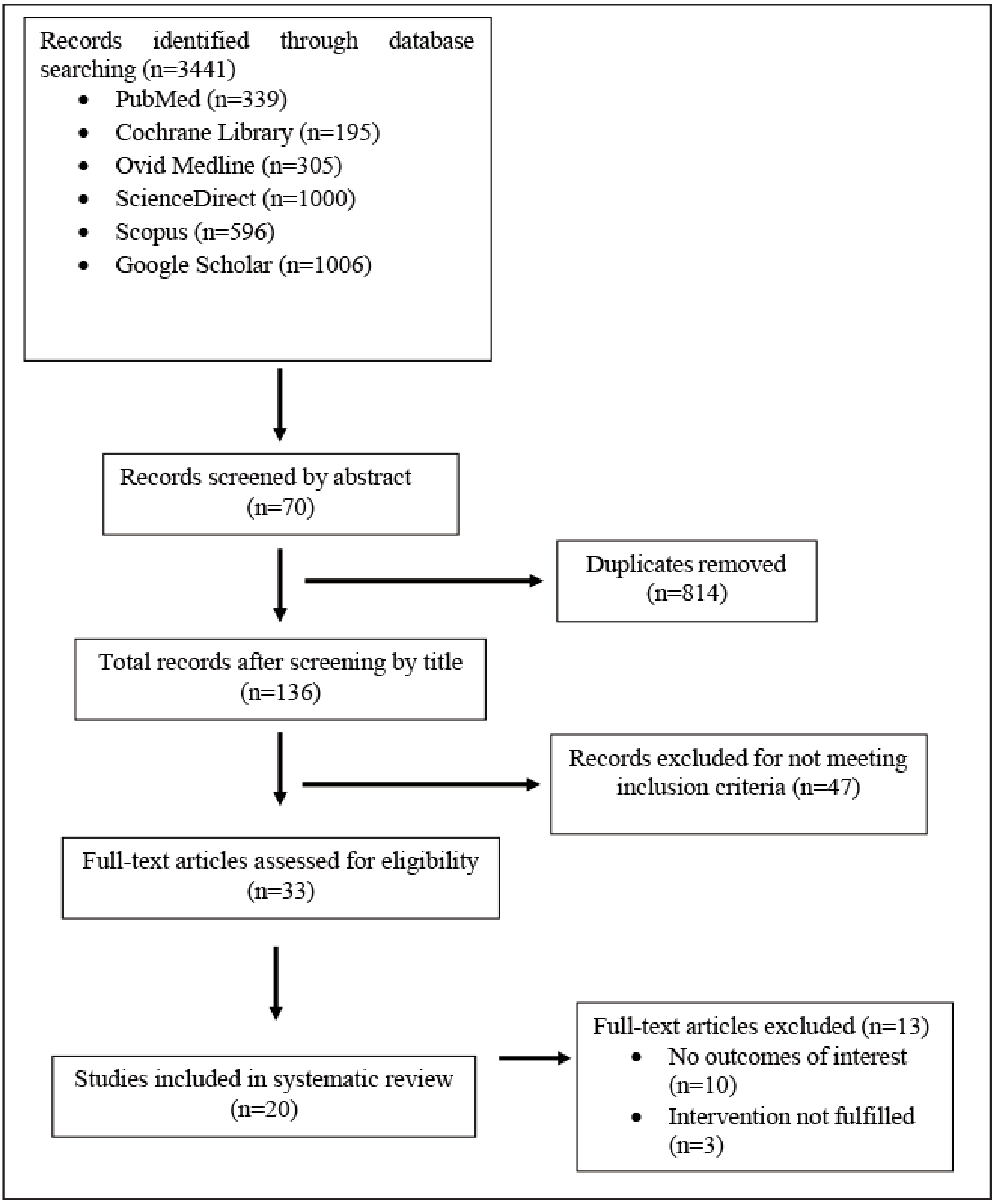

Fig. 1: PRISMA flow diagram of literature search for the effects of structured physical exercise during pregnancy

judged to have a high risk of bias due to inadequate reporting of missing data and the inclusion of participants who dropped out of the intervention group.[17,20,22,25,28,29,32] One study had an unclear risk of bias because it presented findings without providing absolute values for pregnant women in the exercise and control groups.[26]

Regarding other biases, three studies were assessed as having an unclear risk of bias. In one study[21], although an intention-to-treat analysis was stated to have been used, not all participants were included in the analysis. Two studies did not report the participants' baseline characteristics.[18,22]

Table I: Characteristics of included studies on structured physical activity and the outcome

Authors/ year	Subject		Intervention description					Outcomes	
	IG	CG	Type of exercise	Duration (min)	Intensity	Frequency (times/week)	Gestational period (weeks)	Maternal	Fetal
Daniel 2015	35	35	Aerobic	45-60	Moderate	2	From 16 weeks until the week of delivery	Exercise programs in pregnant women did not increase the risk of preterm labour. However, the gestation duration was significantly longer in the exercise group than in the control t (68) = 2.315; p = 0.026).	No statistical difference in birth weight (EG 3.37kg; CG 3.31kg; MD 60.00; 95% CI -252.28,372.28; p=0.72).
Cordero 2015	122	220	Aquatic water-based activity	50-60	Moderate	3	From 10-14 weeks until 36 weeks	Maternal exercise using aerobic and muscular conditioning on land and in the water with high compliance reduced the incidence of GDM (OR 0.10; 95% CI 0.013,0.803; p=0.009). It was associated with a decrease in gestational weight gain (OR 0.56; 95% CI 0.31,0.99; p=0.04).	No statistical difference in birth weight (mean difference EG 3324.1 ± 433.1; CG 3250.1± 425.01; MD 74.00, 95% CI -33.62,181.62; p=0.177).
Haakstad 2015	52	53	Aerobic	60	Moderate	At least 2	From 24 weeks to 36 weeks	There were no statistical differences between the exercisers and controls in numbers reporting low back pain after the intervention (OR = 1.10; CI 0.47–2.60; p=0.83).	
Fieril 2015	51	41	Resistance	60	Moderate-vigorous	2	From 14 weeks until 28 weeks		**Birth weight** Newborns delivered by women who underwent resistance exercise during pregnancy were significantly heavier than those born to control women (EG 3561±452g; CG 3251±437g; MD 310.00; 95%CI 104.50, 515.50; p= 0.02), a difference that disappeared when gestational age was adjusted (p = 0.059).
Barakat 2016	420	420	Aerobic	40	Moderate	3	From 9-11weeks until 38-39 weeks	**Pre-eclampsia** The exercise intervention reduced the incidence of pre-eclampsia (0.5% vs 2.3%; OR 0.22; 95% CI 0.05, 1.02; p=0.03). **Gestational weight gain** Pregnant women who did not exercise were 1.5 times more likely to gain excessive weight (OR 1.47; 95% CI 1.06, 2.03; p= 0.02). **Gestational diabetes** Exercise reduced the incidence of GDM (2.4% vs 5.5%; OR 2.05; 95% CI 0.91, 4.6; p=0.03).	**Birth weight** Pregnant women who do not exercise were 2.5 times more likely to give birth to a macrosomic infant (OR, 2.53; 95% CI 1.03, 6.20; p=0.04).

Table I: Characteristics of included studies on structured physical activity and the outcome (Continued)

Authors/ year	Subject		Intervention description					Outcomes	
	IG	CG	Type of exercise	Duration (min)	Intensity	Frequency (times/week)	Gestational period (weeks)	Maternal	Fetal
Guelfi 2016	85	87	Pedalling cycling	60	Moderate	3	From 14 weeks until delivery	The supervised home-based exercise started at 14 weeks of gestation did not prevent the recurrence of GDM (OR 1.02; 95% CI 0.55, 1.89; p=0.95). No statistical difference in the: - Pre-eclampsia (OR 2.05; 95% CI 0.18, 23.03; p=1.000)	No statistical difference in the: - Preterm delivery (OR 0.75; 95% CI 0.16, 3.46; p=1.000) - Birth weight (EG 3552 ± 469g; CG 3419± 518g; MD 133.00; 95% CI; -16.04,282.04; p=0.82)
Jahdi 2016	30	30	Supervised yoga	60	Moderate	3	From 26 weeks until 37 weeks		No statistical differences in birth weight (EG 3005.6 ± 176.5g; CG 3156.6 ± 469.1g; MD -151.00; 95% CI -330.35, 28.35; p=1.0).
Perales 2016	122	117	Aerobic	55-60	Light-moderate	3	From 9-11 weeks until 39-40 weeks	The groups did not differ in - Total gestational weight gain (OR 0.47; 9 5% CI 0.22, 0.99; p=0.06)	The groups did not differ in - Birth weight (EG 3183.6 ± 446.8g; CG 3232.1 ± 383.2g; MD -48.50; 95% CI-175.13, 78.13; p=0.46)
Ramirez- Velez 2017	24	26	Aerobic, resistance	60	Moderate-vigorous	3	From 16-20 weeks until 28-34 weeks	Lumbopelvic pain Low back pain intensity was 0.38 (95% CI 0.02-0.74); p=0.04) lower in the water exercise group.	There was no significant difference between the exercise and control groups regarding mean birth weight (EG 3133 ± 406g; CG 3013 ± 494g; MD 120.00; 95% CI -129.88, 369.88; p=0.34).
Backhausen 2017	258	258	Water exercises	45	Moderate	2	From 20 weeks until 32 weeks	There was no difference in: Pre-eclampsia (OR 0.83; 95% CI 0.30, 2.34; p=0.57) - gestational diabetes (OR 0.96; 95% CI 0.06, 15.41)	There was no difference in: - Preterm delivery (OR 0.56; 95% CI 0.20, 1.58; p=0.34) - Birth weight (EG 3549 ± 531g ; CG 3540 ± 531g; MD 9.00 ; 95% CI -87.03, 105.03; p=0.66)
Rodriguez-Diaz 2017	50	53	Pilates method	40-45	Moderate	2	From 26-28 weeks until 34-36 weeks		Eight weeks of the Pilates program did not cause an adverse effect on birth weight (EG 336.23 ± 361.88; CG 3417.6 ± 473.54; MD -55.37; 95%CI -221.57, 108.83; p=0.005).
Sklempekokic 2017	22	23	Aerobic, resistance	50-55	Moderate	2	From 30 weeks until 36 weeks	The exercise program had a beneficial effect on the severity of lumbopelvic pain in pregnancy as it reduced the intensity of the pain (the numeric rating scale PGQ (p=0.017) and RMDQ score (p=0.005) in the 36th week of pregnancy.	

Table I: Characteristics of included studies on structured physical activity and the outcome (Continued)

Authors/ year	Subject		Intervention description					Outcomes	
	IG	CG	Type of exercise	Duration (min)	Intensity	Frequency (times/ week)	Gestational period (weeks)	Maternal	Fetal
Watelain 2017	45	45	Muscle strengthening	60	Light-moderate	2	From 24 weeks until 36 weeks	Strengthening exercises centred on the trunk reduce low back pain intensity (p<0.0001).	
Sanda 2018	303	303	Cardiovascular	60	Moderate	2	From mean gestational week 17.6 ±2.6) until delivery (mean gestational week 39.9 ±1.8)		No statistical differences in - Preterm delivery (OR 1.00; 95% CI 0.50, 1.99; p=0.83) - Birth weight (EG 3410.6 ± 486.2g; CG 3449.7 ± 539.3g; MD -39.10; 95% CI -122.04, 43.84; p=0.36)
Brik 2019	42	43	Cardiovascular	60	Light-moderate	3	From 9 weeks until 38 weeks	**Gestational weight gain** No difference in maternal weight was measured at 20, 28, 36, and 38 weeks gestation or in weight gain at 38 weeks between women who followed the exercise program and those who did not (OR 0.86 95%; CI 0.26, 2.80; p=0.51).	No significant difference in the - Preterm birth (OR 0.50; 95% CI 0.04, 5.73; p=0.66) - Birth weight (EG 3161 ± 564.4g; CG 3477.11 ± 414.51g; MD -40.00; 95% CI -242.68, 162.68; p=0.36)
Barakat 2019	260	260	Aerobic	55-60	Moderate	3	From 8-10 weeks until 38-39 weeks	Gestational weight gain Exercise throughout pregnancy can reduce the risk of excessive maternal weight gain (OR 0.60; 95% CI 0.39, 0.92; p=0.018). Gestational diabetes the prevalence of gestational diabetes was significantly higher in the CG than the EG (6.8% vs 2.6% respectively; OR 0.363; 95% CI 0.138,0.953; p = 0.033).	**Birth weight** No differences were found in birth weight between study groups (p=0.6). The ratio of neonate macrosomic was slightly higher in the control group than in the intervention group (7.2% vs 3.4%; OR 0.456; 95% CI, 0.191,1.087).
Rodriguez 2019	65	64	Aquatic aerobic exercises	60	Moderate	3	From 20 weeks until 37 weeks		The median birth weight was 3259g in EG and 3477 grams in IG, and the difference was statistically significant (MD -218.1; 95% CI - 388.81, -47.41; p=0.011).
Roldan- Reoyo 2019	64	67	Aerobic	60	Moderate	3	From 10-12 weeks until 36-40 weeks		No statistical difference in birth weight (EG 3139 ±451.52g; CG 3222.41 ± 416.62g; MD - 83.41; 95% CI -273.65, 106.83; p>0.005).

Table I: Characteristics of included studies on structured physical activity and the outcome (Continued)

Authors/ year	Subject		Intervention description					Outcomes	
	IG	CG	Type of exercise	Duration (min)	Intensity	Frequency (times/ week)	Gestational period (weeks)	Maternal	Fetal
Pelaez 2019	115	230	Aerobic, resistance	60-65	Moderate	3	From 12 weeks until 36 weeks	Supervised moderate to vigorous exercise performed throughout gestation was influential in preventing EGW gain (22 [22.0%] vs 69 [34.3%]; OR 0.54; 95% CI 0.31, 0.04; p=.03). It also prevented gestational diabetes (OR 0.45; 95% CI 0.12, 1.61; p=0.03)	
Da Silva 2017	213	426	Aerobic	60	Moderate	3	From 16-20 weeks 32-36 weeks	No differences between the two groups in - mean gestational weight gain (OR 1.03; 95% CI 0.70, 1.52; p=0.10) - pre-eclampsia (OR 0.99; 95% CI 0.47, 2.09; p=1.0) - gestational diabetes (OR 1.03; 95% CI 0.55, 1.92; p=1.0)	No differences between the two groups in - birth weight (EG 3234 ± 511g; CG 3254 ± 467g; MD -20.00; 95% CI -103.52, 63.52; p=0.63). The exercise program did not cause adverse impacts on preterm birth (OR 1.10; 95% CI 0.66, 1.83; p=1.1)

Maternal Health Outcomes

Gestational weight gain

Seven randomised controlled trials were analysed to evaluate the effect of maternal exercise on gestational weight gain, as shown in Figure IV. The pooled analysis included 2,218 participants, with 961 in the exercise group and 1,257 in the control group. The overall odds ratio (OR) for excessive gestational weight gain in the exercise group compared to the control group was 0.88 (95% CI: 0.44 to 1.76), indicating a non-significant risk reduction ($Z = 0.37$, $p = 0.71$). While several studies demonstrated a favorable trend toward reduced weight gain with exercise, the confidence intervals often overlapped the line of no effect. Notably, substantial heterogeneity was observed across studies ($Tau^2 = 0.76$; $Chi^2 = 62.12$, $df = 6$, $p < 0.00001$; $I^2 = 90\%$), likely reflecting differences in study populations, exercise protocols, and outcome definitions. Despite the lack of statistical significance in the pooled estimate, the direction of effect suggests a potential benefit of maternal exercise, warranting further investigation through well-designed, homogeneous trials.

Lumbopelvic pain

Four studies were identified that reported on lumbopelvic pain (LBP), measuring pain intensity level [26,27,30] and prevalence of LBP pain among pregnant women.[23] Out of these studies, one study reported no statistically significant results.[23] Three randomised controlled trials were analysed to assess the effectiveness of exercise in reducing lumbopelvic pain during pregnancy, as shown in Figure V. The analysis included a total of 753 participants (375 in the exercise group and 378 in the control group). The pooled odds ratio (OR) was 0.98 (95% CI: 0.49 to 1.93), indicating no statistically significant difference in the odds of experiencing lumbopelvic pain between the exercise and control groups ($Z = 0.06$, $p = 0.95$). The test for heterogeneity revealed no significant variation across studies ($X^2 = 0.63$, $df = 2$, $p = 0.73$; $I^2 = 0\%$), indicating consistent findings. While individual study estimates varied, none demonstrated a significant benefit of exercise. One study could not be included in the meta-analysis due to non-estimable data.[27] Overall, the findings suggest that exercise may not significantly impact the prevention or reduction of lumbopelvic pain in pregnancy. However, the wide confidence intervals and limited number of studies indicate that further high-quality trials are warranted.

Gestational Diabetes

Seven randomised controlled trials were analysed to evaluate the effect of maternal exercise during pregnancy on the risk of developing gestational diabetes mellitus (GDM), as shown in Figure VI. Two studies used the American Diabetes Association (ADA) criteria, [18,19], and one study was based on the International Association of Diabetes and Pregnancy Study Groups (IADPSP), [33]. Four other studies did not specify their diagnostic criteria.[15,16,26,28] Four studies reported statistically significant results.[16,18,19,35]

The pooled data comprised 2,887 participants, consisting of 1,222 women in the exercise group and 1,665 in the control group. The analysis yielded a statistically significant reduction in the odds of GDM among women who engaged in exercise, with a pooled odds ratio (OR) of 0.57 (95% CI: 0.40 to 0.81; $Z = 3.10$, $p = 0.002$). The findings suggest a 43% lower risk of GDM in the exercise group than in controls. Heterogeneity among the studies was low ($Chi^2 = 8.53$, $df = 6$, $p = 0.20$; $I^2 = 30\%$), indicating consistency across the included trials. Several studies, including those by Barakat (2016, 2019) and Cordero (2015), reported significant protective effects of exercise.[15,16,18] The results support the role of prenatal exercise as an effective intervention for reducing the incidence of GDM, reinforcing current public health recommendations promoting physical activity during pregnancy.

Pre-eclampsia

Figure VII shows the analysis that explores the impact of exercise on the risk of pre-eclampsia, synthesising data from four studies published between 2016 and 2017. The included studies span a total of 2,062 participants, comparing exercise interventions to control groups. The cumulative analysis revealed an odds ratio (OR) of 0.78 (95% CI: 0.46–1.32), suggesting a potential reduction in pre-eclampsia risk among individuals who engage in exercise, although the result did not achieve statistical significance ($P = 0.35$). The heterogeneity among the studies was low ($I^2 = 19\%$, $P = 0.30$), indicating consistency across findings. The most pronounced benefit was observed in the study by Barakat et al. (2016)[15], which reported an OR of 0.22 (95% CI: 0.05–1.02). Despite these promising trends, the results highlight the need for further large-scale, randomised controlled trials to confirm the protective effects of exercise on pre-eclampsia, particularly in diverse populations.

Fetal health Outcome

Premature delivery

Figure VIII shows the analysis that evaluates the impact of exercise on preterm delivery, incorporating data from seven studies conducted between 2016 and 2019.[15,16,24,26,28,29,32,33] The pooled analysis included 2,648 participants, comparing preterm delivery outcomes between exercise intervention groups and control groups. While the overall odds ratio (OR) of 0.80 (95% CI: 0.56–1.12) indicates a trend toward reduced risk with exercise, the association was not statistically significant ($P = 0.19$). The analysis demonstrated low heterogeneity ($I^2 = 0\%$, $P = 0.94$), suggesting consistency across studies. The study by Barakat et al. (2016)[15] contributed the most weight (46.4%) to the analysis, with an OR of 0.87 (95% CI: 0.46–1.28). These results underscore the potential benefits of exercise in reducing preterm delivery, but highlight the necessity for further high-quality, randomised controlled trials to confirm these effects and elucidate the mechanisms.

Birthweight

Analysis from 16 studies conducted between 2015 and 2019 investigates the effect of exercise during pregnancy on infant birthweight as shown in Figure IX. The pooled analysis, encompassing a total of 3,681 participants, compared birth weight outcomes between the exercise and control groups. The overall mean difference (MD) of 7.84 grams (95% CI: -22.69 to 38.36) suggests a negligible effect of exercise on birthweight, with statistical insignificance ($P = 0.61$). Moderate heterogeneity ($I^2 = 49\%$, $P = 0.02$) is observed, indicating variation across study findings. The most significant contribution to the analysis was observed in the study by Ramirez-Velez et al. (2017), which reported a MD of

-340.60 grams (95% CI: -544.00 to -137.20). These results suggest that while exercise during pregnancy does not substantially influence birth weight, further research is warranted to examine specific contexts and subpopulations where exercise may have significant impacts.

DISCUSSION

This systematic review evaluated the impact of structured exercise on gestational outcomes among pregnant women, mainly gestational diabetes mellitus (GDM), gestational weight gain (GWG), lumbopelvic pain, pre-eclampsia, preterm delivery, and fetal birth weight. The exercise programs in the intervention group combined aerobic exercise, dance, resistance training, aquatic workouts, cardiovascular workouts, and Pilates, which were easily incorporated into the structured exercise regimen. Most of the studies were liked by pregnant women, as indicated by the high adherence rate.

Our findings suggest that structured physical activity during pregnancy significantly reduced the incidence of gestational diabetes by 40% compared to the control group. These findings are aligned with a meta-analysis by Sanabria-Martinez et al.[36] A meta-analysis involving 2,873 pregnant women from 13 studies found that structured physical exercise during pregnancy reduced the incidence of gestational diabetes by 31%. The impact was seen as greater when the exercise program was initiated during early pregnancy. Nasiri-Amiri et al. (2019), evaluated the effect of exercise on 1441 pregnant women in eight studies.[54] They reviewed that exercise decreased the risk of GDM in obese and overweight pregnant women. However, Davenport et al., (2018) found that antenatal exercise was ineffective in reducing the incidence of GDM.[40] This could be because unsupervised exercise leads to poor compliance with the exercise protocol, which in turn influences the results. Nevertheless, this finding may support that a healthy lifestyle initiated pre-conception and in the early trimester may be a fundamental method in preventing chronic disease risk in pregnant women.

Our review found that exercise intervention during low-risk pregnancy did not significantly impact the prevention of excessive weight gain. Still, considering the OR, exercise had a 25% protective effect in preventing excessive weight gain. Our findings aligned with a review and meta-analysis study by Shieh et al. (2018) concluded that physical exercise is ineffective in preventing excessive weight gain during pregnancy.[37] In addition, Kunath et al. (2019) demonstrated that combining physical exercise and diet was ineffective in avoiding excessive weight gain.[38]

In contrast, Wang et al., (2019) in a meta-analysis study found that active pregnant women in all BMI categories significantly gained less weight than the control group.[39] Furthermore, another review by Sui et al. (2012), which examined the effects of exercise among 276 overweight and obese pregnant women, found that supervised antenatal exercise lowered the risk of excessive weight gain. The authors also concluded that the impact of limiting gestational weight gain is more significant in the combination of exercise and diet groups.[6]

Structured physical activity has been associated with reduced risk of developing pre-eclampsia. Our review found that structured antenatal exercise lowered the risk of developing pre-eclampsia by 22% even though it was not statistically significant. Davenport et al. (2018) in their meta-analysis evaluated the effect of structured physical activity on 273,182 pregnant women in 106 studies and found that exercise reduced the risk of gestational hypertension by 39% and pre-eclampsia by 41%. The authors suggest following ACOG recommendations to achieve at least a 25% reduction in the odds of developing pre-eclampsia.[12] However, a descriptive study by Babili et al., (2021) reported that moderate to vigorous antenatal exercise did not reduce the incidence of pre-eclampsia.[41] Exercise performed during pregnancy was hypothesised to suppress peripheral insulin resistance, reduce oxidative stress, and promote placental growth and vascular development.[42-44] This mechanism reduces blood glucose and controls blood pressure.

Our systematic review also found that structured physical activity during antenatal did not reduce lumbopelvic pain (LBP) intensity or prevalence. Despite this, our review suggests that antenatal exercise improves the quality of life and disability caused by LBP. Shiri et al. (2018) evaluated the association between physical activity during pregnancy and LBP, which found that exercise intervention had no protective effect on LBP or pelvic girdle pain. However, they found that pregnant women taking sick leave due to LBP were less compared to the control group.[9] This could be explained by the fact that exercise improves muscle strength, lowers stress on the spine, and increases joint stabilization.[10] In contrast, a protective effect of exercise against LBP was seen in a few studies. A meta-analysis by Kinser et al. (2017) demonstrated that exercise during pregnancy reduced LBP, discomfort, and related symptoms.[55] Furthermore, a meta-analysis by Davenport et al. (2018) also found that exercise performed during pregnancy and the early postpartum period did reduce the severity of LBP compared to those who did not exercise.[12]

Our review also found that exercise during pregnancy does not affect birth weight and gestational length. Women with a higher exercise energy expenditure during pregnancy delivered infants with appropriate gestational age (AGA) birth weight without evidence of an increased risk for small or large gestational age (SGA/LGA). Betham et al., (2019) in their review examining the effect of vigorous physical activity on 32080 pregnant women in 13 studies, found that the exercise program did not increase the risk of delivering an SGA infant and reduced the risk of prematurity.[45] Moreover, our study and others suggest a reduction in the risk of delivering LGA infants with antenatal exercise.[46-48] In contrast, a case-control study by Mahmoodi et al., (2013) found that sports participation was linked to a greater risk of LBW infants.[49]

We also found no relationship between structured physical activity during pregnancy and the risk of prematurity. In contrast to a review by Aune et al. (2017), 20 RCTs and 20 cohort studies found that a high intensity of physical exercise during antenatal care decreased the risk of preterm birth by 14%.[50] Similarly, Di Mascio et al., (2016) showed that pregnant women can safely perform aerobic exercise as it was not related to an increased risk of preterm birth.[51] Exercise increases insulin sensitivity and decreases the inflammatory process which may contribute to reducing the risk of preterm birth.[52] However, previous studies showed inconsistent findings, as they reported inverse associations between physical activity during pregnancy and preterm birth.[52-53] Takami et al. (2018) conducted a cohort study that showed physical activity during pregnancy increased the risk of preterm birth.

The findings of this review have important implications for clinical practice, particularly in the context of routine antenatal care. Given the observed reduction in the risk of gestational diabetes mellitus (GDM) among women who engaged in prenatal structured exercise, healthcare providers should proactively promote physical activity as a standard component of pregnancy care. Clinical guidelines recommend at least 150 minutes of moderate-intensity exercise per week during pregnancy for women without contraindications.[3]

Providers—obstetricians, family physicians, and midwives—should offer individualized exercise counselling, considering gestational age, medical history, and physical limitations. Structured programs, such as supervised group sessions or home-based regimens with follow-up, may improve adherence and outcomes.[12] Although the evidence for reducing lumbopelvic pain, gestational weight gain, pre-eclampsia, premature delivery and low birth weight remains inconclusive, the overall maternal benefits—ranging from improved glycemic control to enhanced psychological well-being—support the broader integration of exercise into antenatal pathways. Integrating exercise promotion into routine antenatal visits, supported by patient education and local resources, could improve pregnancy outcomes and long-term maternal health.

The limitations of our study include the fact that only randomized controlled studies, and English articles were included in our review. We excluded quasi-experimental studies or literature reviews. Additionally, we were unable to investigate the effect of specific exercise types on pregnancy outcomes due to differences in exercise type, the use of various exercises in some studies, and variations in exercise intensity and duration. Moreover, the variation in exercise duration across studies may impact the outcomes of this review. Another limitation was the inconsistency in the quality of evidence across the included studies, which could impact the results.

CONCLUSION

Structured physical activity of moderate intensity, at least 150 minutes per week, can be safely performed during the antenatal period. It significantly reduces the overall incidence of GDM and is not associated with an increased risk of preterm birth or affecting birth weight. Our review also found that structured physical activity among uncomplicated pregnant women reduced the incidence of pre-eclampsia, prevented excessive weight gain, and improved LBP pain, even though it was not statistically significant. However, most studies were based on various types, intensities, or durations of exercise and were inconsistent in quality. Hence, more trials are needed to find the effect of structured physical activity during pregnancy on gestational outcomes. As this review only includes randomised controlled trials, further study must be conducted to arrive at a complete conclusion on the impact of structured physical activity on pregnancy outcomes.

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CONFLICT OF INTEREST

There is no conflict of interest.

ETHICAL APPROVAL

This study was approved by the Research and Ethical Committee of researchers' institution (IREC 2021-189)

AUTHOR'S CONTRIBUTION

NAJ and KHAA conceived and designed the study. FHMN and NAJ conducted the literature search, provided research materials, and collected and organized data. FHMN, NAJ, and KHAA analyzed and interpreted the data. FHMN, NAJ, and KHAA wrote the initial and final drafts of the article and provided logistic support. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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