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Physical activity and pregnancy related health outcomes in overweight and obese pregnant women: A systematic review and meta-analysis

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Abstract---Background Maternal overweight and obesity are considered as one of the obstetric risk factors of many health problems, and physical activity is viewed as one of the strategies in promoting a healthier pregnancy. Hence, the aim of this systematic review is to study the effects of physical activity on various pregnancy-related outcomes in overweight and obese pregnant women. Methodology Three online databases were searched for randomized controlled trials published between the years 2010 and 2021. The articles that reported the effect of physical activity on maternal and/or fetal outcomes were retrieved. The study characteristics and the data on health outcomes were extracted. Effect estimates were calculated using relative risk (RR), mean difference (MD), and standardized mean difference (SMD) with a random-effect model and 95% confidence interval (CI). Results Eleven studies were included for the statistical meta-analysis study. Physical activity was observed to significantly reduced GWG by 0.89 kg (95% CI = -1.63 to -0.14, P=0.02) and no significant results were found for other maternal and fetal outcomes measured. Conclusion Physical activity-only intervention shown to be beneficial in improving gestational weight gain, and appear to have promising results towards promoting good

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pregnancy-related health outcomes in overweight and obese pregnant women overall.

***Keywords*---**physical activity; exercise; physical fitness; obese; overweight; pregnant women; child-bearing women; health outcomes; health effects.

Introduction

According to World Health Organization (WHO), the prevalence of obesity around the world continues to grow at an alarming rate. WHO estimates that in 2016, more than 1.9 billion adults aged 18 and above were overweight, where out of these 650 million were reported as obese. Around 13% of the world's adult population were obese in 2016, where 15% occurs among women and 11% among men [1]. Meanwhile, National Health and Morbidity Survey (NHMS) 2019 highlighted that 1 in 2 adults in Malaysia was overweight or obese (30.4% and 19.7% respectively) and found an increasing trend when the data are compared with findings from NHMS 2011 and NHMS 2015 [2]. The results are concerned as the numbers are continually rising each year, especially when the occurrence of overweight and obesity are shown to be highest among women aged 18 and above which are considered to be a child-bearing age.

The increasing rate of maternal overweight and obesity issues a major challenge in the aspects of maternal and child health, as it becomes one of the contributing factors towards the incidence of negative pregnancy-related health outcomes. Various studies previously discussed the effects of maternal pre-pregnancy BMI towards different maternal and fetal outcomes [3, 4]. Overall, most of them concluded that higher pre-pregnancy BMI is associated with a higher risk of pregnancy-related complications and adverse health outcomes such as gestational diabetes mellitus, preeclampsia, cesarean delivery, and preterm birth.

Lifestyle interventions such as a regular course of physical activity is identified as one of the modifiable lifestyle factors that can help to reduce the risk of overweight and obesity. A structured course of exercise during pregnancy is shown to offer benefits in preventing maternal and fetal complications, as well as various possible adverse outcomes [5]. An adequate physical activity is expected to provide a protective effect among pregnant women especially when the pre-pregnancy BMI is exceeding the recommended baseline value. Physical Activity Guidelines for Americans 2nd Edition suggest pregnant women to do at least 150 minutes of moderate-intensity aerobic activity every week throughout their gestation and the postpartum period [6]. Unless there are any medical reasons or conditions that require pregnant women to avoid or restrict their involvement in physical activity, it is safe for them to initiate or continue to do a light to moderate-intensity aerobic activity with the guidance of a health care provider.

However, still, 1 in 4 Malaysian are reported to be physically inactive and females take up 28% of the total findings as stated in NHMS 2019. A fair amount of studies also found a declining engagement in physical activity among pregnant women throughout the period of gestation [7, 8]. Hence, this study aims to identify, summarize and provide the latest insight on the effects of physical activity on pregnancy-related health outcomes in overweight and obese pregnant women so that more awareness on these issues can reach child-bearing women around the world.

2. Materials and Methods

The inclusion criteria include randomized controlled trials (RCT) that involved all or some overweight or obese pregnant women. The participants should be having a singleton, uncomplicated pregnancy and have no contraindicated towards physical activity. The relevant studies were included regardless of the treatment intensity, frequency, duration, or mode of delivery of the physical activity. Besides, the physical activity intervention should be the only intervention used during the studies and should be published in the English language between the years 2010 to 2021. As for the exclusion criteria, any studies that do not fulfill the inclusion criteria will not be included for review and analysis. Any studies that do not measure the outcomes of interest or the results for the outcomes of interest that were not reported will be ineligible to be included in both review and analysis.

Two reviewers independently searched the study literature and extracted the data from eligible studies. Any disagreement or differences in opinion between reviewers was resolved by discussion and independent assessment by the third reviewer. Literature searching was conducted using three main online databases; PubMed, Ovid MEDLINE®, and ScienceDirect®. The search term used includes (physical activity) OR (workout)) OR (exercise)) OR (physical fitness)) AND (overweight)) OR (obese)) AND (pregnant women)) OR (anticipating mother)) OR (child-bearing women)) AND (health outcomes)) OR (health impacts)) OR (health effects)) OR (health implications).

The study characteristics were extracted which includes information on the authors, publication year, the sample size for both intervention and control group, average body mass index of the participants, the intensity of exercise intervention and the measurement methods used, the weeks where exercise programs started and ended, frequency and total exercise sessions, as well as the total duration of the exercise intervention in weeks.

Additionally, the components of the exercise intervention were extracted from the articles which consist of data on the duration of each session in minutes, and the types of exercise intervention used by the participants during the study. The data obtained were tabulated along with the outcomes measured in each study. During the data extraction process, the pregnancy-related health outcomes measured were categorized into maternal outcomes and fetal outcomes. Maternal outcomes measured include gestational diabetes, gestational weight gain, excessive gestational weight gain, cesarean delivery, gestational hypertension, and psychological well-being/depression. The fetal outcomes measured include preterm birth, gestational age, gestational birth weight, 1 and 5 minutes Apgar score, and neonatal head circumference.

Quality assessment of the individualized study was evaluated based on the Cochrane Collaboration's tool for assessing the risk of bias. The first part of the tools was the evaluation based on seven criteria which include random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcomes assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other sources of bias. The second part of the tools is where each criteria for the study was assigned a judgment of either 'low risk' of bias, 'high risk' of bias, or 'unclear risk' of bias.

Statistical analysis was carried out using Cochrane Software Review Manager 5, version 5.4.1. Risk ratio (RR) was used to measure dichotomous data while continuous data were measured using either mean difference (MD) or standardized mean difference (SMD). Both dichotomous and continuous data used a random-effect model with a 95% confidence interval (CI), where $P < 0.05$ was considered as significant findings. Heterogeneity in each pooled analysis was assessed statistically using the Chi-Square test and Higgins' I^2 statistics, where heterogeneity was interpreted according to the Cochrane Handbook for Systematic Reviews of Interventions [9]. The I^2 value of 0% to 40% might considered to not be important; 30% to 60% may represent moderate heterogeneity; 50% to 90% may represent substantial heterogeneity and 75% to 100% interpreted as considerable heterogeneity.

3. Results

3.1. Study selection and study characteristics

The study selection process was presented in Figure 1. A total of 5978 references were retrieved from three main online databases which are PubMed (n=2496), Ovid Online (n=2966), and ScienceDirect (n=516). Of these, 268 references were selected for further screening based on the titles, with an additional one reference from another academic community source, Research Gate, which then adds up to 269 references. Duplicates were removed (n=8) and 261 abstracts were screened. Of these, full-text articles for 62 references were assessed for eligibility to be included in the study. The final articles included for the review are 12 studies [10-21]. Meta-analysis study includes 11 RCTs out of 12, and one study was excluded due to unfitting data for measurement of outcomes [10].

3.2 Study characteristics

All the studies included for analysis were published between the years 2011 and 2019 in English as shown in Table 1. Most of the randomized controlled trial is conducted in a developed country; three in Norway [10-12], three in Spain [13,17,19], and each one study in Ireland [15], New Zealand [18], United States [20], and the Netherlands [16], while the remaining two studies are conducted in developing countries; each one study in China [14] and Brazil [21]. In terms of the author, Garnæs et al. was the author of three studies, and each of the studies was analyzed as an individual study because they measured several different outcomes and the studies are published in a different time [10-12].

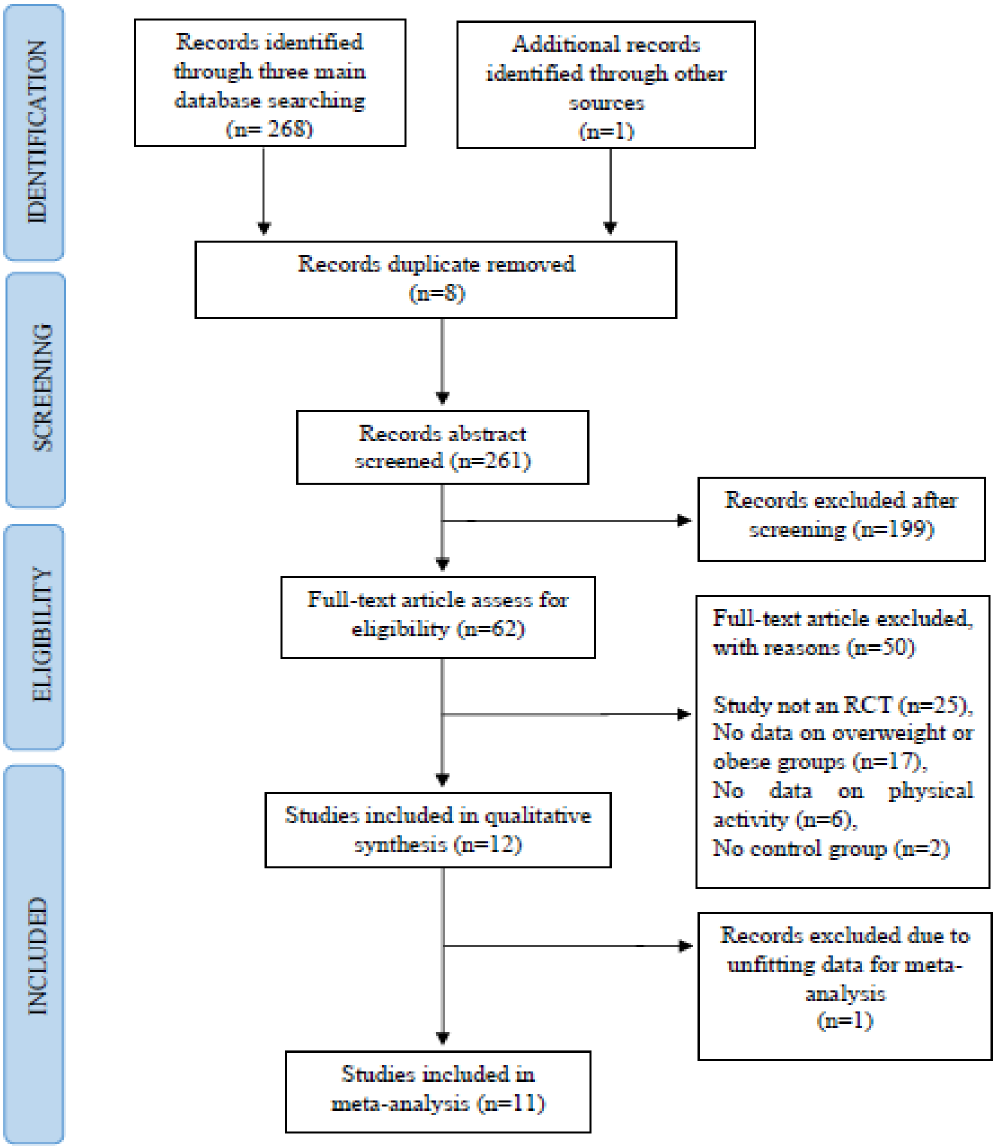

Figure 1 PRISMA Flow Chart

A total of 12 randomized controlled trials met the inclusion criteria and were selected for narrative review, and 11 studies were further included for meta-analysis. For all 12 RCTs included for review and analysis, the total participants recorded at the baseline were 2912 participants. The participants were allocated into two groups; the intervention group and the control group following the enrolment process.

3.3 Intervention characteristics

Most of the exercise intensity was measured using the Borg Rating of Perceived Exertion scale between 9 and 15 scale which indicates moderate intensity physical activity (see Table 1). Four studies [15,18,20,21] either did not mention the details on the Borg rating scale or did not use the Borg Rating of Perceived Exertion scale in their program. The exercise program was started on the first trimester of pregnancy in four papers [13,14, 17,19] selected which is between week 8 to 11 of gestation, and the remaining eight papers started on the second trimester which is between week 12 to 24 of gestation. In terms of the frequency of the exercise session, all of the programs were scheduled for at least two times per week throughout the intervention and can be up to five or seven times per week according to the types of exercise intervention and the study requirements.

In the majority of the exercise programs, each session consisted of three main parts; warm-up, core exercise, and cool-down (see Table 2). Each session lasted between 25 to 60 minutes; 5 to 12 minutes each for a warm-up and cool-down while 15 to 50 minutes for the main exercise. However, there are exceptions for studies conducted by Kong et al. (2014) where the duration of exercise gradually increases each week and studies by Garnæs et al. that described their exercise as resistance training and endurance training without specifying the exercise as a warm-up, core exercise or cool-down. The warm-up session explained by the authors in the articles consists of similar exercise programs which include walking, static stretching, joint mobility exercise, and low-intensity exercise such as slow cycling.

Aerobic exercise, resistance training, and muscle-strengthening exercise were commonly seen as part of the main exercise program. However, some studies were conducted with a specific exercise intervention such as a study carried out by Wang et al. (2017) that focused on a supervised cycling program with different intensities and intervals. It is almost similar to a study by Seneviratne et al. (2016) that utilizes the magnetic stationary bicycle for the main part of their program. The intervention for exercise programs done by Kong et al. (2014) also differs compared to other studies as they were specifically focused on unsupervised walking programs throughout the pregnancy.

The majority of the intervention programs evaluated from the studies was ended with 5 to 12 minutes of a cool down session which generally consisted of relaxation, static stretching, and pelvic floor muscles. However, there are few deviations from the study done by Wang et al. (2017) who ended their program with easy cycling, and few other studies which did not describe in detail the cool-down part in their programs. Most of the papers reported more than 50 percent compliance rates for the study group towards the exercise intervention. However, Seneviratne et al. (2016) and Oostdam et al. (2012) observed that there was a steady decline in terms of compliance towards the intervention as the pregnancy progressed.

3.4 Risk of bias

The results for risk of bias were presented in Figure 2 and Figure 3. All studies provide reports on the randomization process, with nine out of 12 studies used a computer-based random generator to randomly assign the participants into the intervention group or the control groups. The other three [16,18,19] studies either a random number table, randomization sequence generated by biostatistician or stratified by hospitals with block randomization to prevent the selection bias in

the respective trials. Six studies do not describe in detail the allocation concealment, and two [15,21] studies reported that the sequence was randomly distributed in opaque envelopes, which were sealed and sequentially numbered. The remaining four [10-12,18] studies mentioned that the allocation results were received by the study investigators that do not have access to a full randomization list in order to maintain the allocation concealment.

Table 1 Selected Programs and Their Characteristics

Author (Year)	Location	Participants		Average BMI		Intensity and measurement method	Start/End of exercise program (gestational week)	Frequency exercise session per week/Total exercise session	Duration (week)
		Exercise group	Control group	Exercise group	Control group				
Garnæs et al. (2019)	Trondheim, Norway	n=46	n=45	33.9 ± 3.8	35.1 ± 4.6	12-15 on the Borg Rating of Perceived Exertion scale	12-18/34-37	3/57-66	19-22
Wang et al. (2017)	Beijing, China	n=150	n=150	26.75 ± 2.74	26.82 ± 2.76	9-11 on the Borg Rating of Perceived Exertion scale, 55-65% of HRmax	<12/36-37	3/72-75	24-25
Daly et al. (2017)	Dublin, Ireland	n=44	n=44	34.7 ± 4.6	34.7 ± 5.1	Borg Rating of Perceived Exertion	<17/36-37	3/57-60	19-20
Garnæs et al. (2017)	Trondheim, Norway	n=46	n=45	33.9 ± 3.8	35.1 ± 4.6	12-15 on the Borg Rating of Perceived Exertion scale	12-18/34-37	3/57-66	19-22
Garnæs et al. (2016)	Trondheim, Norway	n=46	n=45	33.9 ± 3.8	35.1 ± 4.6	12-15 on the Borg Rating of Perceived Exertion scale	12-18/34-37	3/57-66	19-22

Barakat et al. (2016)	Madrid, Spain	n=420 o/w: n=89 obese: n=25	n=420 o/w: n=75 obese: n=29	23.6 ± 3.8 o/w: n=89 (23.3%) obese: n=25 (6.5%)	23 ±.4 4.2 o/w: n=75 (19.6%) obese: n=29 (7.6%)	12-14 on the Borg Rating of Perceived Exertion scale, HR monitor (Accurex Plus; Kempel, Finland)	9-11/38-39	3/84-87	28-29
Seneviratne et al. (2016)	Auckland, New Zealand	n=38	n=37	32.1 ± 4.4	34.1 ± 5.9	HR monitor (Polar S625/Polar RS800; Polar Electro OY, Kempele, Finland)	20/35	3 or 5/67	15
Perales et al. (2015)	Madrid, Spain	n=65	n=64	27.88 ± 3.11	28.00 ± 2.62	10-12 on the Borg Rating of Perceived Exertion scale , HR monitor (Accurex Plus, Polar Electro OY, Finland)	8-11/38-39	3/85	28-30
Kong et al. (2014)	Iowa, United States	n=19	n=23	o/w: 26.5 ±1.2 obese: 34.7 ±4.6	o/w: 27.4 ±1.4 obese: 34.2 ±3.6	StepWatch Activity Monitor (SAM), an ankle-worn accelerometer-based measurement tool, cadence (steps per minute	12-15/35	5-7/100	20
Ruiz et al. (2013)	Madrid, Spain	n=481 o/w or obese: n=146	n=481 o/w or obese: n=129	23.7 ± 3.9 o/w: n=111 (23.1%) obese: n=35 (7.3%)	23.5 ± 4.2 o/w: n=92 (19.1%) obese: n=37 (7.7%)	10-12 on the Borg Rating of Perceived Exertion scale, HR monitor (Accurex Plus, Polar Electro OY)	9/38-39	3/87-90	29-30
Oostdam et al. (2012)	Amsterdam, Netherlands	n=62	n=59	33.0 ± 3.7	33.9 ± 5.6	12 on the Borg Rating of Perceived Exertion scale, Accelerometer (ActiTrainer accelerometer; ActiGraph™, Pensacola,FL,USA)	15-20/12 weeks after delivery (9 months intervention)	2/72	36
Nascimento et al. (2011)	São Paulo, Brazil	n=40	n=42	34.8 ± 6.6	36.4 ± 6.9	HR not exceed 140 bpm	14-24/36	5/60-110	12-22

Table 2 Exercise Session's Components and the Outcomes of the Program

Author (Year)	Exercise Session Parameters			Outcomes in the exercise group (as compared to control group)
	Duration (minutes)	Intensity	Types of Exercise Used	
Garnæs et al. (2019)	60	12-15 on the Borg Rating of Perceived Exertion scale	Endurance training, resistance training, pelvic floor exercise, home exercise program	Maternal outcomes: Psychological General Well-being (six subscale; anxiety, depressed mood, positive well-being, self-control, general health, vitality)
Wang et al. (2017)	45-60 (5 minutes warm up, 50 minutes core exercise, 5 minutes cool down)	9-11 on the Borg Rating of Perceived Exertion scale 55-65% of HRmax	Warm up: low intensity exercise Core exercise: Interval stationary cycling (different intensities of the intervals, duration of the cycling progressively increased according to individual ability Cool down: easy cycling	Maternal outcomes: Gestational diabetes, gestational weight gain, excessive gestational weight gain, cesarean delivery, maternal hypertension Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score
Daly et al. (2017)	50-60 (10 minutes warm up, 30-40 minutes core exercise, 10 minutes cool down)	Borg Rating of Perceived Exertion scale	Warm up: core and pelvic floor exercise Core exercise: resistance or weight exercise, aerobic exercise	Maternal outcomes: Gestational diabetes, gestational weight gain, excessive gestational weight gain, cesarean delivery Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score
Garnæs et al. (2017)	60	12-15 on the Borg Rating of Perceived Exertion scale	Endurance training, resistance training, pelvic floor exercise, home exercise program	Maternal outcome: Cesarean delivery Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score, neonatal head circumference
Garnæs et al. (2016)	60	12-15 on the Borg Rating of Perceived Exertion scale	Endurance training, resistance training, pelvic floor exercise, home exercise program	Maternal outcomes: Gestational diabetes, gestational weight gain, excessive gestational weight gain, maternal hypertension Fetal outcome: Preterm birth
Barakat et al. (2016)	50-55 (10-12 minutes warm up, 25-30 minutes core exercise, 10-12 minutes cool down)	12-14 on the Borg Rating of Perceived Exertion scale HR monitor (Accurex Plus; Kempel, Finland)	Warm up: walking and light static stretching Core exercise: moderate resistance exercise Cool down: relaxation and pelvic floor exercise	Maternal outcomes: Gestational diabetes, excessive gestational weight gain, maternal hypertension Fetal outcome: Preterm birth

Seneviratne et al. (2016)	25-45 (5 minutes warm up, 15 to 30 minutes core exercise, 5 minutes cool down)	HR monitor (Polar S625/Polar RS800; Polar Electro OY, Kempele, Finland)	Core exercise: moderate intensity exercise (magnetic stationary bicycle)	Maternal outcomes: Gestational diabetes, gestational weight gain, cesarean delivery, maternal hypertension Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score, neonatal head circumference
Perales et al. (2015)	55-60 (5 minutes warm up, 20 minutes core exercise. 5-10 minutes cool down)	10-12 on the Borg Rating of Perceived Exertion scale 55-60% HR reserve	Warm up: walking, static exercise, joint mobility exercise Core exercise: Aerobic activities Cool down: pelvic floor muscle training	Maternal outcomes: Gestational weight gain, excessive gestational weight gain, cesarean delivery, depression Fetal outcomes: Gestational age, birth weight, 1 minute and 5 minutes Apgar score, neonatal head circumference
Kong et al. (2014)	First 2 weeks: 50min/ week Week 2: 100min/week Week 3: 30min/day for total of 150 min/week	StepWatch Activity Monitor (SAM), an ankle-worn accelerometer-based measurement tool, cadence (steps per minute	Unsupervised walking program	Maternal outcomes: Gestational diabetes, gestational weight gain, excessive gestational weight gain, cesarean delivery, maternal hypertension Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score

Ruiz et al. (2013)	50-55 (10 minutes warm up, 25-30 minutes core exercise, 10 minutes cool down)	10-12 on the Borg Rating of Perceived Exertion scale HR <60& predicted HR max	Warm up: walking, static stretching Core exercise: moderate-intensity exercise (low impact aerobic dance), resistance exercise Cool down: walking, static stretching, relaxation, pelvic floor exercise	Maternal outcomes: Gestational diabetes, gestational weight gain, excessive gestational weight gain, cesarean delivery, maternal hypertension Fetal outcomes: Preterm birth, gestational age, birth weight, 1 minute and 5 minutes Apgar score
Oostdam et al. (2012)	60 (5-10 minutes warm up, 40 minutes core exercise, 5-10 minutes cool down)	12 on the Borg Rating of Perceived Exertion scale Accelerometer (ActiTrainer accelerometer; ActiGraph™, Pensacola FL USA)	Warm up: light intensity activity such as slow cycling Core exercise: individualized program; 1 or 2 aerobic exercise and 4 to 6 strength exercise	Maternal outcomes: Gestational diabetes, gestational weight gain, cesarean delivery Fetal outcomes: Gestational age, birth weight
Nascimento et al. (2011)	40 (10 minutes warm up, 22 minutes core exercise, 10 minutes cool down)	HR not exceed 140 bpm	Warm up: general stretching Core exercise: exercise to strengthen the lower and upper limb muscles Cool down: supervised relaxation	Maternal outcomes: Gestational weight gain, excessive gestational weight gain, cesarean delivery, maternal hypertension Fetal outcomes: Gestational age, birth weight, 1 minute and 5 minutes Apgar score

In four [14,16,18,20] studies, due to the nature of the intervention programs, the participants were un-blinded to group allocation after completion of the baseline assessment, while the other studies do not provide a description on the blinding of participants. An intention-to-treat (ITT) analysis was performed in nine out of 12 studies, and reasons of participants lost to follow-up was stated accordingly by authors in all studies.

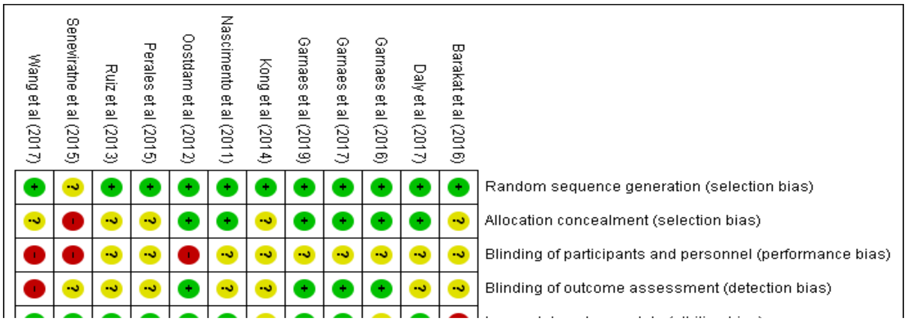

Figure 2 Risk of bias summary: review authors' judgements about each risk of bias item for each included study

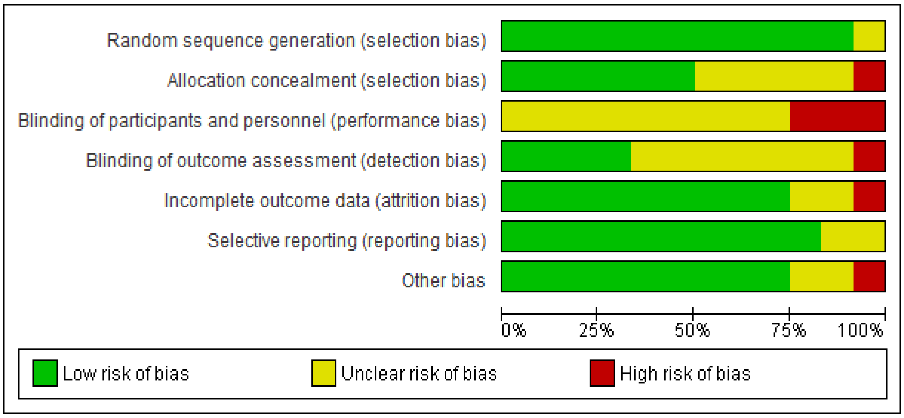

Figure 3 Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies

All pooled analyses for both maternal and fetal outcomes were based on random effect models and 95% CI. In two [19,20] studies, the author separates the subgroups based on pre-pregnancy BMI; where the data was presented separately for overweight and obese categories. Hence, the data for both subgroups were combined manually during the data extraction. For the outcome of gestational age, two out of nine studies measured the outcomes in days while the other seven studies measured gestational age in weeks. In this case, standardized mean difference (SMD) was used to combine the results. Additionally, the value of standard deviation (SD) was not given in one study for GWG outcome, hence the value was calculated using the Review Manager calculator based on the 95% CI range given.

3.5 Maternal outcomes

Data on gestational weight gain was reported in eight studies involving 953 participants. The pooled effect estimates do not cross the line of null effect which indicates that there were significant differences in gestational weight gain among the exercising group with a mean difference of -0.89 kg (95% CI = -1.63 to -0.14, P=0.02; Figure 4). The heterogeneity of the studies was found to be non-significant (X^2=10.83;I^2 = 35%; P=0.15). Meanwhile, for the pooled analysis on excessive gestational weight gain, there were no significant differences in terms of the effects of exercise in both intervention and control groups (RR=0.89; 95% CI 0.71 to 1.11; P=0.29; Figure 5). The evidence on heterogeneity was shown to be moderate (X^2=7.76, I^2 = 48%; P=0.10).

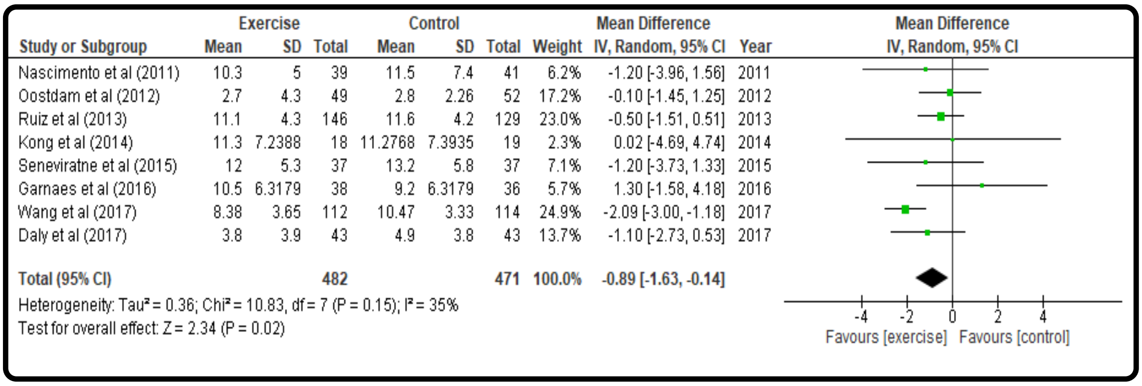

Figure 4 Forest plot of physical activity versus control group on gestational weight gain

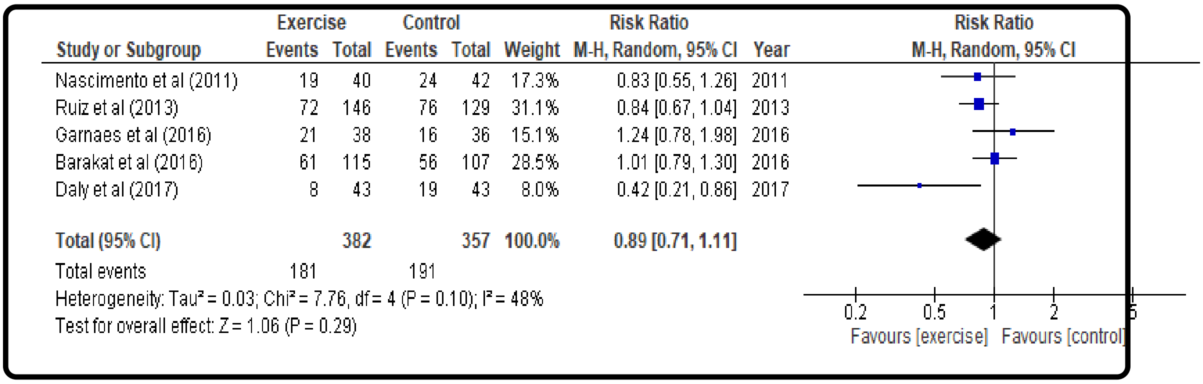

Figure 5 Forest plot of physical activity versus control group on excessive gestational weight gain

Gestational diabetes mellitus (GDM) was observed in 8 RCTs that involved 1134 participants. The total events of GDM in the intervention group were particularly lower compared to the control group, n=79 and n=116 respectively. However, from the pooled analysis, physical activity was observed to have no significant effect in reducing the incidence of GDM among participants as it crosses the line of null effect with RR of 0.73 (95% CI 0.52 to 1.04; P=0.08; Figure 6). The evidence of heterogeneity between studies was low (X^2=10.23; I^2=32%; P=0.18), which shows that the effect estimate is considered as homogenous.

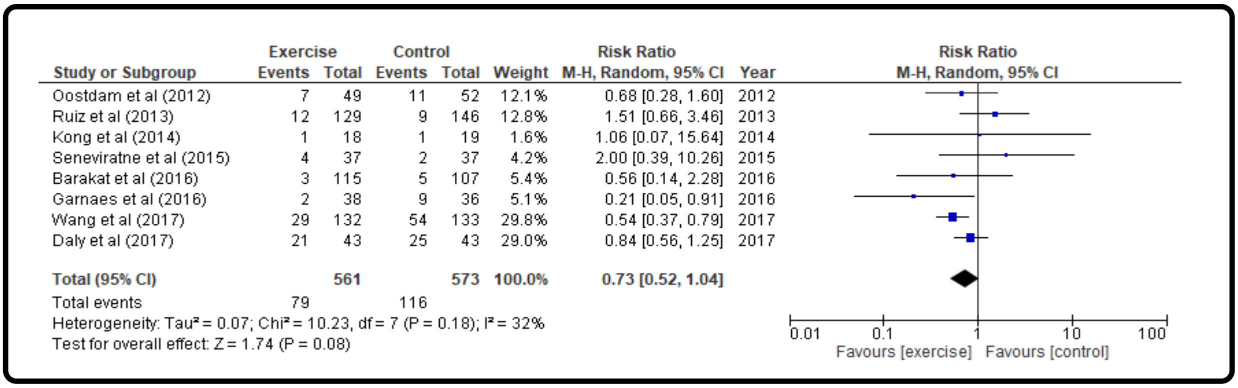

Figure 6 Forest plot of physical activity versus control group on gestational diabetes

Nine studies involving 1060 participants were analyzed for incidence of cesarean delivery and five studies of 871 participants were analyzed for maternal hypertension. The meta-analysis found no significant differences in the incidence of cesarean delivery between both groups with RR of 0.95 (95% CI 0.77 to 1.16; P=0.62; Figure 7). Even so, the incidence of cesarean delivery was slightly lower in the intervention group than standard care, n=153 and n=161 respectively. Similarly, the intervention group was shown to reduce the risk of maternal hypertension by 29%, but there is no significant difference observed (RR=0.71; 95% CI 0.45 to 1.12; P=0.14; Figure 8).

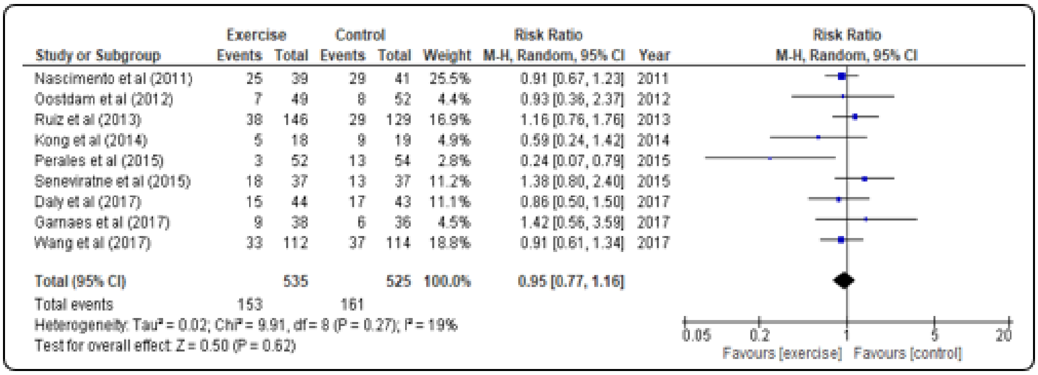

Figure 7 Forest plot of physical activity versus control group on cesarean delivery

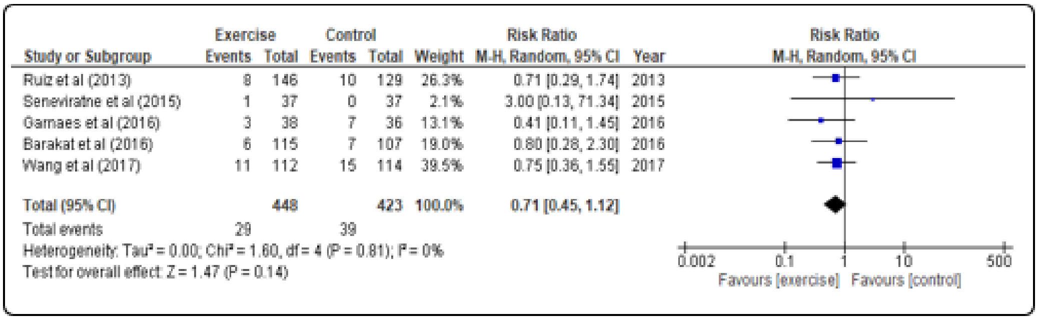

Figure 8 Forest plot of physical activity versus control group on gestational hypertension

3.3 Fetal outcomes

Data on preterm birth was analyzed from 8 studies with total participants of 1086. There was no significant difference in regards to the preterm birth incidence among participants in the intervention group or control group even though the risk was reduced by 16% with physical exercise (RR=0.84; 95% CI 0.49 to 1.46; P=0.54; Figure 9). No evidence of heterogeneity was observed which indicates that the effect estimates were homogenous (X^2=4.19;I^2 = 0%; P=0.76). Meanwhile, data on gestational age were available in 9 RCTs that involved 1064 participants. Similarly, no significant difference between the gestational age of newborns born to the intervention group and the control group was observed (SMD=0.02; 95% CI -0.15 to 0.19; P=0.83; Figure 10).

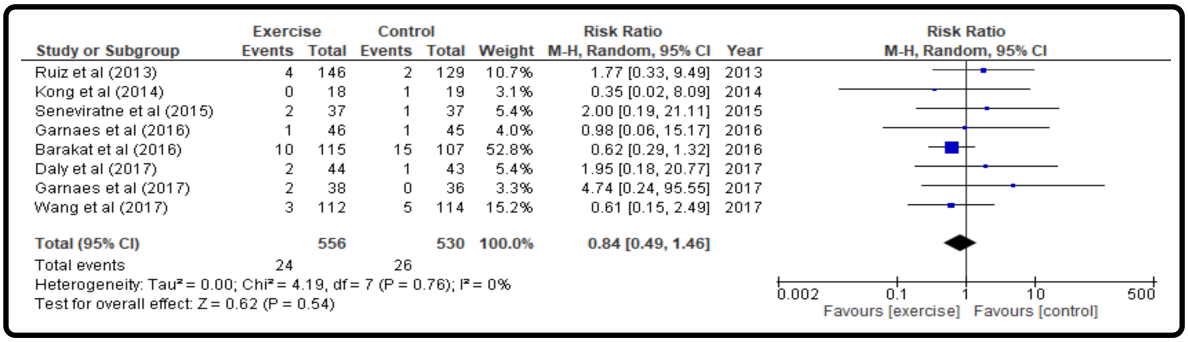

Figure 9 Forest plot of physical activity versus control group on preterm birth

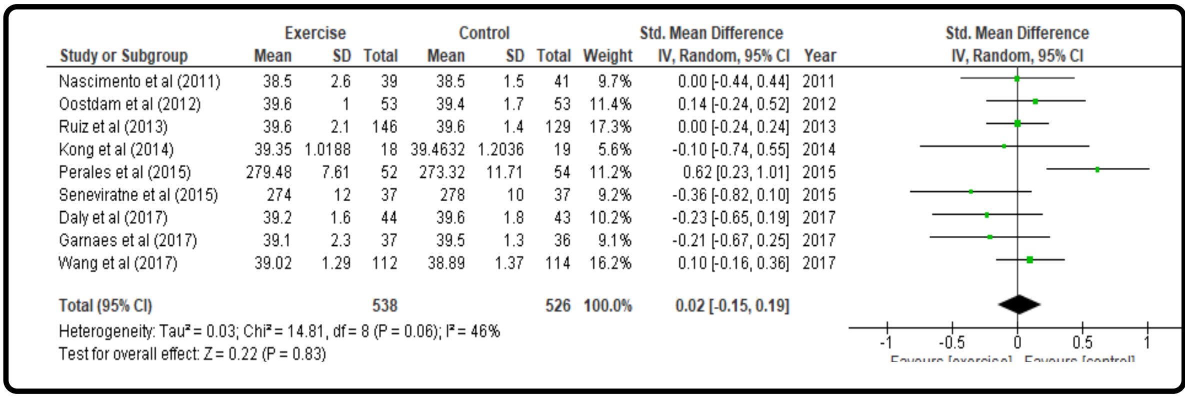

Figure 10 Forest plot of physical activity versus control group on gestational age

Data on neonatal birth weight was assessed in 8 studies with a total of 1026 participants. The random-effect model shows that there were no significant differences in terms of birth weight in newborns of the exercise group and the control group (SMD= -0.07; 95% CI = -0.19 to 0.06; P=0.29; Figure 11). In terms of analysis of 1 minute Apgar score which was reported from 6 studies, there is a lower 1-minute Apgar score in the control group compares to the exercise group and the difference is statistically significant (MD=0.20; 95% CI=0.05 to 0.34; P=0.01; Figure 12). The forest plot assumes with lower scores representing a better outcome, hence it favor towards control. No significant results observed from 5 minutes Apgar score (MD=0.12; 95% CI= -0.04 to 0.29; P=0.14; Figure 13) and neonatal head circumference (MD=0.21; 95% CI= -0.18 to 0.60; P=0.29; Figure 14).

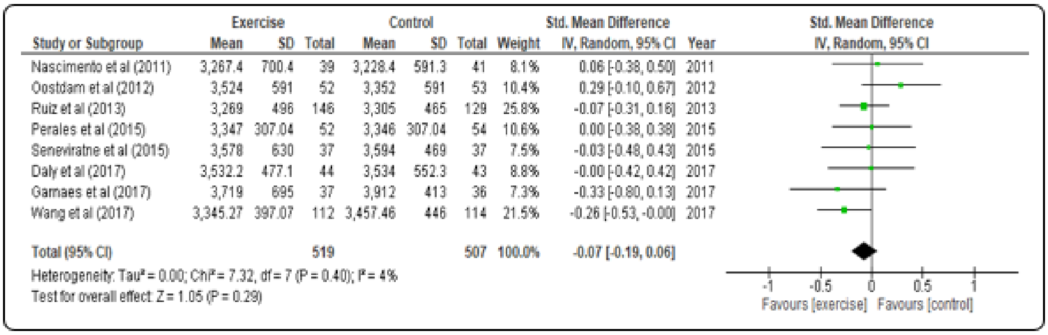

Figure 11 Forest plot of physical activity versus control group on birth weight

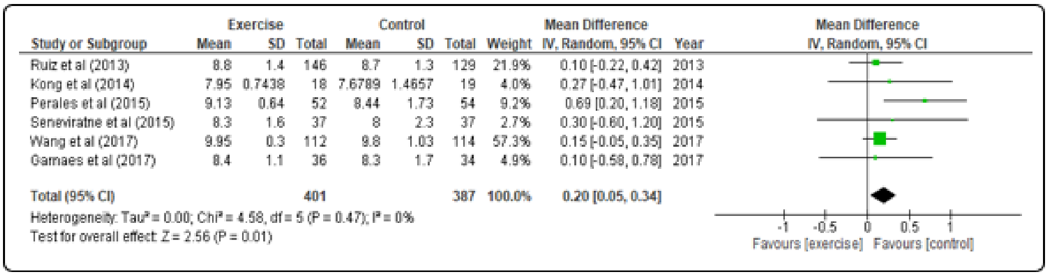

Figure 12 Forest plot of physical activity versus control group on 1 minute Apgar score

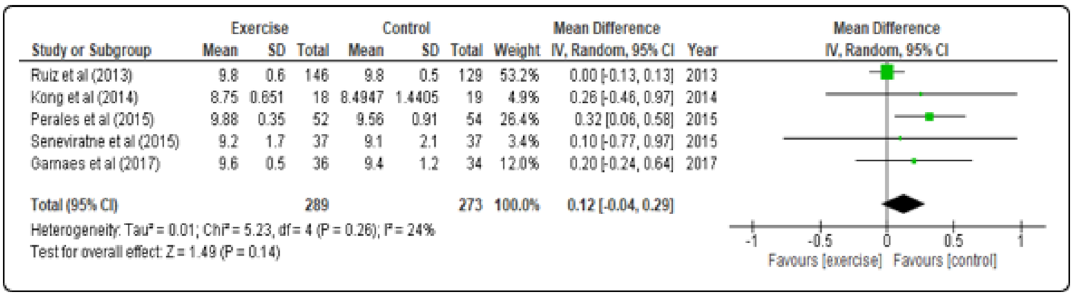

Figure 13 Forest plot of physical activity versus control group on 5 minutes Apgar score

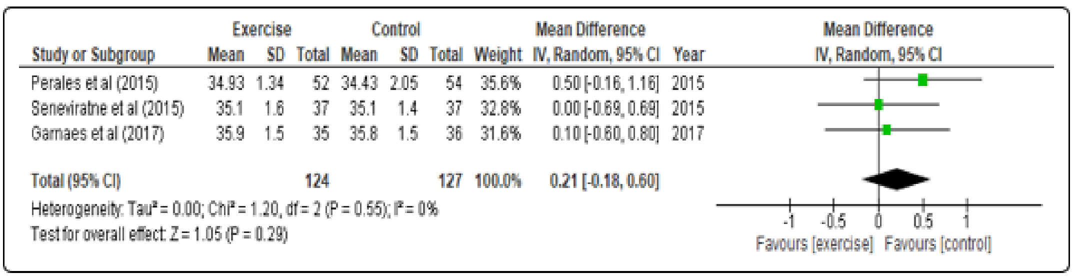

Figure 14 Forest plot of physical activity versus control group on neonatal head circumference

Discussion

Physical activity is one of the important elements in pregnancy. Suzanne Phelan in her study conceptualized pregnancy as a strong 'teachable moment' since the physical and emotional changes experienced by pregnant mothers will enhance the perceived value of a healthy lifestyle and exercise [22]. It makes pregnancy a great opportunity to initiate changes especially for pregnant women with pre-pregnancy BMI of overweight and obese, as they tend to be more motivated to improve their lifestyle in order to maintain good maternal and fetal health.

The results from the present study showed that a regular course of physical activity could significantly reduce the gestational weight gain (GWG) by 0.89 kg among overweight and obese pregnant women in the intervention group compared to the control group. The findings were supported by a meta-analysis study by Du et al [23] that observed a significantly lower average GWG in the exercising group which is by 1.14 kg. Domenjoz et al [24] and da Silva et al. [25] reported similar results, where the authors found that exercise could reduce GWG in pregnant women by 1.11 kg and 1.13 kg, respectively. Moreover, the present meta-analysis found that a regular course of physical activity also provides benefits in preventing excessive GWG by 11% reduction, even though there is no significant difference observed between both intervention and control group (P=0.29).

Gestational weight gain is a natural response to accommodate the growing fetus. However, too high or too low GWG contributes to short and long-term health complications, especially when a woman enters pregnancy with a BMI of 25 or above. Excess weight gain happens when there is too much energy consumed and a little of them burnt, which leads to storage of the unused energy as body fat. Increasing energy expenditure through regular physical activity can help to reduce excess adipose tissue by breaking down the stored triacylglycerol (lipolysis) exceeding that of storage and hence, promoting an adequate weight gain especially in overweight and obese individuals [26].

The findings from the present study of 11 RCTs reported that exercise intervention could reduce the risk of GDM incidence by 27% (P=0.08) when compared to the control group in the overweight and obese pregnant women population. Even though the results for the statistical analysis were not significant, the GDM cases reported in the intervention group (n=79) are much lower compared to the control group (n=116). Du et al [23] observed that those who involve in physical activity have a 29% reduction in the risk of developing GDM compared to non-exercising participants, which further supports the findings from the current meta-analysis study (P = 0.004). Another study of 11 trials involving all weight categories of pregnant women also found positive effects of exercise on the incidence of GDM. Physical activity was shown to reduce the risk of GDM when compared with a control group, with a RR of 0.69 (31% risk reduction) [27]. Exercise seems to promote greater glucose uptake by the skeletal muscle cells and reduce high blood glucose levels in gestational diabetes mellitus.

The incidence of GDM, GWG, and maternal obesity is closely associated with the risk of cesarean delivery. Results from the present study found a 5% reduction in risk of cesarean delivery among exercising participants but with no significant differences between both groups (P=0.62). Even so, the total incidence of cesarean delivery among 9 RCTs included for analysis was lower in the intervention group compared to the standard care, n=153 and n=161 respectively. Domenjoz et al. [24] in their study on the effect of physical activity during pregnancy on mode of delivery reported that there was a 14.2% and 17.8% incidence of cesarean delivery in the intervention group and study group, respectively with a mean difference of – 0.03. The exact mechanism on how physical activity affects the incidence of cesarean delivery was unclear, however, it may be due to the protective effect that it provides towards the contributing risk factors of cesarean delivery such as obesity and maternal diabetes.

Current meta-analysis on gestational hypertension reported that exercise could reduce the risk of gestational hypertension by 29% among the participants in the exercise intervention group, and the total incidence from 5 RCTs was shown to be lower in the exercising group than in the control group. It was supported by Magro-Malosso et al [28] that found aerobic exercise could significantly reduce the risk of hypertensive disorder overall and in gestational hypertension specifically (RR 0.54). Isabel Witvrouwen [29] mentioned that adaptations of maternal cardiovascular systems occur during pregnancy in order to allow sufficient placental perfusion. Women who develop hypertensive disorders during pregnancy such as gestational hypertension appear to fail the stress test of pregnancy, likely due to insufficient cardiovascular adaptation. Regular engagement in physical exercise throughout the gestation period is seen to boost these adaptations and has been demonstrated for angiogenesis and improve endothelial function in pregnant women

Besides maternal outcomes, the concern related to pregnant women will be the risk of negative fetal outcomes such as preterm birth. The results from this meta-analysis that reported exercise intervention could reduce the risk of premature delivery by 16% (P=0.54). Even so, the incidence of preterm birth was shown to be slightly lower among the participants in the intervention group compared to the control group, n=24 and n=26 respectively. When compared to other previous meta-analysis studies, Aune et al [30] observed a significant reduction in risk of premature delivery which is by 14% among participants with a higher leisure-time physical activity compared to lower leisure-time physical activity. The author also found that for every 3 hours and 5 hours increase in leisure-time physical activity, there was a 10% and 16% reduction in risk of preterm birth among the exercising pregnant women respectively. The findings further support the evidence that a regular engagement in physical activity during pregnancy could improve the birth outcomes in the aspects of full-term delivery of the baby. However, another two studies that measured the effects of physical activity on the incidence of premature birth observed that physical activity did not have notable effects on birth outcomes among pregnant women in both the intervention group and standard care [23,31].

The present study does not found any significant results for gestational age and birth weight between both groups (P=0.83 and P=0.29, respectively). The results were consistent with other meta-analyses on gestational age at delivery conducted by Gema Sanabria-Martínez et al [32] and Veisy et al [33]. Both authors found no significant differences in terms of gestational age at delivery for the exercise intervention group and control group with P=0.284 and P=0.72 respectively. However, both studies also mentioned that physical activity during pregnancy did not adversely affect the gestation period and cause premature delivery. The results of the current study on birth weight are also consistent with studies by da Silva et al [25], Veisy et al [33], and Du et al [23], where there was no significant evidence observed in both groups that show the effect of physical exercise on neonatal birth weight. Evidence on the roles of exercise in maintaining an optimum gestational age and birth weight at delivery is limited and inconclusive in most studies, hence makes it difficult to draw a clear conclusion on the matter.

Besides, findings from the current meta-analysis found that there is a lower 1-minute Apgar score in the control group compares to the exercise group and the difference is statistically significant (P=0.01). The analysis assumes that lower scores representing a better outcome, thus it is in favor of control. Even though the results were opposite to what was expected, it may be due to other contributing factors that can affect the precision of the results such as adherence to the exercise intervention. Meta-analysis on Apgar score at 5 minutes shows no significant differences in both intervention and control group which aligned with the study by Veisy et al [33] that does not record any remarkable effect of physical activity on the neonatal Apgar score at 1 minute and 5 minutes. However, the available evidence that discussed the association between physical activity and Apgar score may not be sufficient to provide a clear conclusion on the matter and a more thorough study on regards to Apgar score should be conducted for further evidence.

As for now, studies on neonatal head circumference and exercise were not widely discussed compared to other health outcomes either in all-weight pregnant women or specifically in overweight and obese pregnant women. The present meta-analysis of three RCTs found that there was no notable effect of physical activity intervention towards the neonatal head circumference, which was supported by another meta-analysis of 5 studies with 1,855 participants by Veisy et al [33] that found no significant differences between both interventions and control group (p = .86). Due to the limited evidence, there are no clear conclusions that can be made to relate the effects of physical activity towards neonatal head circumference in overweight and obese pregnant women. More future studies with higher quality evidence are needed to further discuss and provide more insight on the role of exercise in the outcomes of neonatal head circumference.

Overall, the relationship between exercise and maternal and fetal outcomes was shown to be inconclusive, which could be due to the small sample population of the trials involved in this study. The results were varied across different studies as the health outcomes observed may be influenced by the differences in terms of the types of exercise intervention used during the study, duration of each exercise session, the exercise intensity, the number of sessions per week as well as the history of exercise before pregnancy. Even though there were findings that observed an indistinct correlation between exercise and pregnancy-related health outcomes, the role of regular exercise may indirectly contribute to maintaining the overall health condition of the women especially in improving maternal overweight and obesity that is one of the risks factors of many health comorbidities.

Strength and limitations of study

To the best of our knowledge, this study provides the latest evidence in discussing the effects of physical activity on pregnancy-related health outcomes such as maternal and fetal outcomes among overweight and obese pregnant women. The strength of the present study is that all the articles included are randomized controlled trials, which could provide robust and reliable evidence on the effectiveness of exercise interventions towards the measured outcomes. Besides, the included trials for the present study were focusing on physical activity intervention only among study participants, without other co-intervention such as dietary intervention that may affect the results of the study. It gives us a better overview on analyzing the roles of physical activity during pregnancy especially for pregnant women with a higher pre-pregnancy BMI that may receive more benefits from the findings.

However, there are a few limitations that can be observed from our review and meta-analysis study. Firstly, more than half of the trials included have a relatively small sample population which is likely to affect the precision of effect estimates in each outcome measured. Secondly, even though our study analyzed the pregnancy-related health outcomes in overweight and obese pregnant women, two studies by Ruiz et al [13] and Barakat et al [19] also consisted of participants of other weight categories of pregnant women (underweight and/or normal weight). We excluded all non-overweight and non-obese participants during our analysis, however, there may be a possibility of inconsistent estimation of effects of exercise intervention towards the outcomes.

Thirdly, since we only include articles that were published in the English language, it may limit our access to other related articles published in other languages and introduced a selection bias. Fourthly, many randomized controlled trials that used a combination of exercise intervention and dietary intervention were excluded, which may narrow the present study but restrict the ability for us to draw conclusions on the outcomes. Besides, some outcomes such as maternal hypertension, Apgar score, and neonatal head circumference were only reported in certain studies, which may likely cause the pooled analysis to be less reliable to be used to deduce any clear conclusions

Conclusions

In summary, the systematic review and meta-analysis study found that physical activity-only intervention was shown to significantly reduce the gestational weight gain in overweight and obese pregnant women. Besides that, the other maternal and fetal outcomes also show promising results as the trend was evident towards the benefits of physical activity in improving maternal and fetal health, even though it was not statistically notable from the present analysis.

Engagement in regular exercise and being physically active throughout the gestation period is associated with a greater overall health state in overweight and obese pregnant women. Higher pre-pregnancy BMI is often seen as a risk factor for various health problems which in turn can also be improved with a regular course of physical activity. The indirect role of physical activity in improving obstetric risk factors of overweight and obesity could be the mechanism behind the improvement of maternal and fetal outcomes in pregnancy. Even so, future evidence with a larger sample size and higher quality is needed to further strengthen the present findings and helps to provide clear conclusions regarding the roles of physical activity in pregnancy.

Conflicts of Interest: The authors declare no conflict of interest

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