Received: 9 November 2020 | Revised: 15 January 2021 | Accepted: 17 February 2021
DOI: 10.1002/nop2.838

REVIEW ARTICLE

NursingOpen Open Access WILEY

Effect of prenatal aerobic exercises on maternal and neonatal outcomes: A systematic review and meta-analysis

Afsaneh Veisy[1] | **Sakineh Mohammad Alizadeh Charandabi**[2] | **Shahla Hematzadeh**[1] | **Mojgan Mirghafourvand**[3]

[1]Student's Research Committee, Midwifery Department, Tabriz University of Medical Sciences, Tabriz, Iran

[2]Department of Midwifery, Faculty of Nursing and Midwifery, Tabriz University of Medical Sciences, Tabriz, Iran

[3]Department of Midwifery, Social Determinants of Health Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

Correspondence
Mojgan Mirghafourvand, Social Determinants of Health Research Center, Tabriz University of Medical Sciences, Shariati Street, P.O. Box: 51745-347, Tabriz 513897977, Iran.
Email: mirghafourvand@gmail.com

Abstract

Aim: This study aimed to evaluate the effect of prenatal aerobic exercises on maternal and neonatal outcomes.

Design: A systematic review and meta-analysis.

Method: A search was carried out in databases including PubMed, ProQuest, EMBASE, Cochrane Library, Scopus, Web of Science, Magiran and SID until 30 September 2020. Two reviewers independently assessed the articles for quality and risk of bias using the Cochrane handbook. The statistical heterogeneity was determined using the Cochran's *Q* test and Higgins' I^2 coefficient.

Results: Of the 2,790 extracted articles, 16 were included in this review. The results of the meta-analysis showed that prenatal exercise can increase the frequency of vaginal delivery significantly (RR: 1.24; 95% CI: 1.08–1.43), but had no statistically significant effect on other maternal and neonatal outcomes, such as first, second and third stages of labour, gestational age at birth, first and fifth-minute Apgar score, umbilical cord pH, neonatal weight, height and head circumference ($p > .05$).

Conclusions: The meta-analysis results suggested that prenatal exercise can reduce the frequency of caesarean section.

KEYWORDS
exercise, maternal outcomes, meta-analysis, neonatal outcomes, systematic review

1 | INTRODUCTION

Pregnancy is among the most sensitive and important stages in the life of parents, and childbirth is an important event in a woman's life. The duration of labour varies in different women and is affected by factors such as age, parity, foetal size and maternal weight (Chen et al., 2018). A prolonged first stage of labour entails complications such as compressed foetal head in the birth canal, lower neonatal Apgar score and foetal death (Allen et al., 2007). A prolonged second stage of labour is associated with increased frequency of caesarean section, tearing of the birth canal and damage to the perineal muscles (Brown et al., 2011). Moreover, a prolonged delivery is also associated with many other maternal complications such as uterine atony and increased maternal mortality, and foetal complications such as foetal distress and reduced foetal Apgar score (Direkvand-Moghadam & Rezaeian, 2012). Given that maternal and neonatal complications increase with the duration of labour, measures should be taken to prevent prolonged deliveries (Allen et al., 2009; Cheng et al., 2007; Stephansson et al., 2016).

One of the factors potentially affecting the duration of labour is exercise and physical activity during pregnancy (Ghodsi & Asltoghiri, 2014; Morgan et al., 2014; Sabbaghian Rad & Jahanshiri, 2013; Salvesen & Mørkved, 2004). Exercise alleviates a number of pregnancy outcomes, including gestational diabetes and pre-eclampsia (Magro-Malosso et al., 2017; Ming et al., 2018). The positive effects of regular exercise during pregnancy include reduced concentration of blood glucose in diabetic women (Wolfe & Weissgerber, 2003), reduced back pain (Mirmolaei et al., 2018), improved mental health and quality of life (Abedzadeh et al., 2011) and improved maternal physical functioning (Doustan et al., 2012), as confirmed in various studies. The American College of Sports Medicine (ACSM) and the World Health Organization (WHO) recommend that pregnant women get at least 30 min of daily exercise, including various aerobic moves, walking and swimming for 3 days or more per week (Ghodsi & Asltoghiri, 2014; Hesketh & Evenson, 2016).

Although regular exercise generally improves health, its effects on pregnancy and childbirth are controversial. Many studies have been conducted on the effect of exercise on pregnancy outcomes. Previous studies have produced contradictory reports about the effects of exercise on pregnancy outcomes (Doustan et al., 2012; Hesketh & Evenson, 2016; Ming et al., 2018).

Although healthy women are recommended to exercise during pregnancy, many researchers worldwide have rejected such recommendations and consider them imprudent and believe that there is insufficient evidence about the advantages and disadvantages of exercise during this period (Melzer et al., 2010). There is little information about prenatal exercises, and many questions remain unanswered about their effects on the duration of pregnancy, duration of labour, type of delivery, birthweight, SGA (small for gestational age), LBW (low birthweight), gestational age at delivery, preterm birth, or gestational weight gain and other maternal and neonatal outcomes (Barakat et al., 2009).

Systematic review studies have examined a number of maternal outcomes, such as harm to the mother during labour and childbirth as a result of exercise, maternal weight change (Beetham et al., 2019; Elliott-Sale et al., 2015) and improved maternal health (Wiebe et al., 2015), and neonatal outcomes, such as foetal development (Beetham et al., 2019), improved neonatal health (Perales et al., 2016), back pain (Tseng et al., 2015) and preterm labour (Beetham et al., 2019; Di Mascio et al., 2016), but the researchers' review of literature led to no systematic review studies on the effect of exercise on the duration of the different stages of labour. The present study thus seeks to systematically investigate the effect of exercise on outcomes such as the duration of the different stages of labour, gestational age, type of delivery and certain neonatal outcomes such as the first- and fifth-minute Apgar scores, umbilical cord pH and neonatal weight and height. The research question for this study was: Do prenatal aerobic exercises improve maternal and neonatal outcomes?

2 | METHODS

2.1 | Data sources and search strategy

The present systematic review meta-analysis was conducted according to the PRISMA checklist using the following keywords: Pregnan*, exercise, aerobic, physical activit*, apgar, head circumference, pH cord, weight, height, delivery, gestational age, labour, neonatal outcome*, maternal outcome* and also their controlled subject heading (MeSH).

The clinical trials published until September 2020 were retrieved, without imposing any time constraints, from databases including PubMed, ProQuest, EMBASE, Cochrane Library, Scopus and Web of Science (Figure 1).

2.2 | Inclusion and exclusion criteria

All the randomized, clinical trials published in English and Persian that assessed the effect of prenatal exercise on maternal and neonatal outcomes during labour and met the PICO (population, intervention, comparison and outcomes) criteria were included. The Studies that did not assess the effect of aerobic exercises as per the standard definitions, such as yoga and aquatic exercises were excluded. Furthermore, following the review of the studies' titles and abstracts, duplicate articles and those not consistent with the present study's objectives and also the non-RCTs were excluded.

2.2.1 | Population

All the pregnant women over 18 years of age who had entered the studies from their 10th week of pregnancy onwards.

2.2.2 | Intervention

The intervention group received exercise programmes, including aerobics, walking and various exercises referred to as "aerobic" in the American College of Sports Medicine definition, as well as standard pregnancy care.

2.2.3 | Comparison

The comparison group included pregnant women who received only standard pregnancy care.

2.2.4 | Outcomes

Primary outcomes

The duration of the different stages of labour.

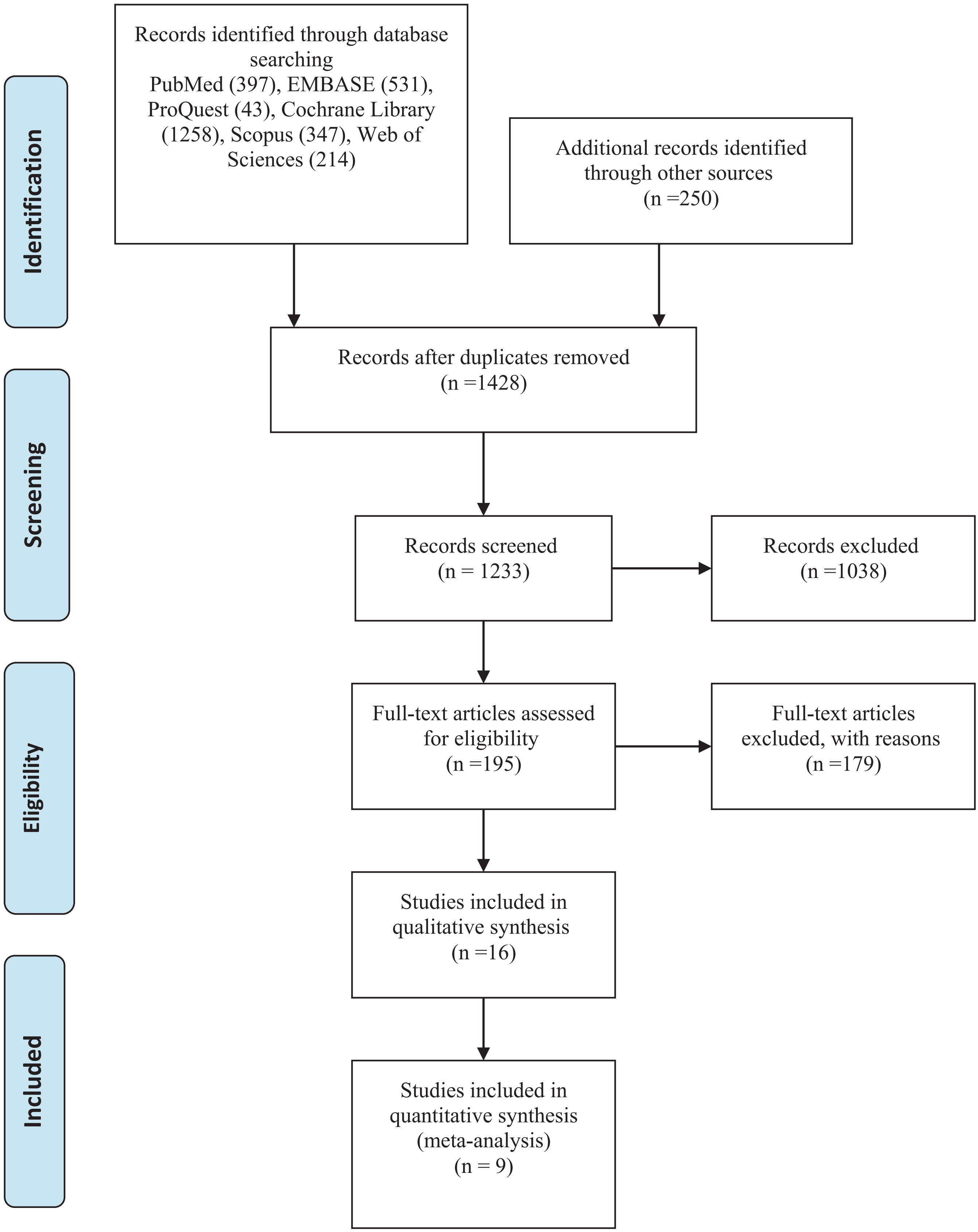


FIGURE 1 PRISMA flow chart summarizing the study screening and selection process

Secondary outcomes

Gestational age at birth, type of delivery, first- and fifth-minute Apgar scores, birthweight, neonatal height and head circumference and umbilical cord pH.

2.3 | Study selection and data extraction

Results of the searches were exported to EndNote X8 for removal of duplicates. Two authors (AV and SH) separately assessed the studies in terms of quality and acceptability, and differences were resolved by seeking the opinion of a third person (MM). The data extracted in this systematic review included the authors' names, publication year, publication country, study design, number of participants, study participants' details and details of the interventions and results. The risk of bias was also assessed using the Cochrane handbook (Higgins, 2011).

2.4 | Statistical analysis

The extracted data were analysed in Review Manager version 5.3, and to assess the effect of the intervention on the outcomes, mean differences were calculated for the continuous data and relative risk for the dichotomous data. The statistical heterogeneity was determined using the Cochran's *Q* test and Higgins' I^2 coefficient. A non-significant finding for the *Q* test with a small number of studies can cause a reviewer to assume erroneously a fixed effect model when there is true heterogeneity among the included studies and vice versa. Therefore, in order to overcome the weakness of the *Q* test, I^2 index has been proposed for assessing heterogeneity in a meta-analysis (Higgins et al., 2003; Huedo-Medina et al., 2006). In this study, the I^2 index was used to assess the statistical heterogeneity of the data, and the random effect model was used instead of the fixed effect model if heterogeneity was high. $I^2 \geq 75\%$, 25%–75% and <25% were considered as high, moderate and low heterogeneity, respectively. Also, we conducted sensitivity analysis and removed trials that ran a high risk of bias based on selection bias.

2.5 | Risk of bias assessment

The quality of studies was assessed in terms of various risks, including the selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessor), attrition bias (dropouts and exclusion addressing and conducting of intention to treat analysis), and reporting bias (selective or non-selective reporting) and other biases (registration of protocol, ethical approve, conflict of interest criteria, funding source, inclusion and exclusion criteria and sample size calculating) by two independent researchers according to the Cochrane handbook. Each study was rated as either low risk, unclear or high risk according to the reports, and disagreements were resolved by consulting a third person. Performance bias had the highest risk due to the nature of these studies, as blinding the participants and providers was not possible (Figures 2 and 3). The risk of bias table for each included study, with judgements about risks of bias, and explicit support for these judgements is available in supplementary file.

3 | RESULTS

A total of 2,790 studies were extracted from databases using the search strategy, and after eliminating duplicate cases, 1,233 studies

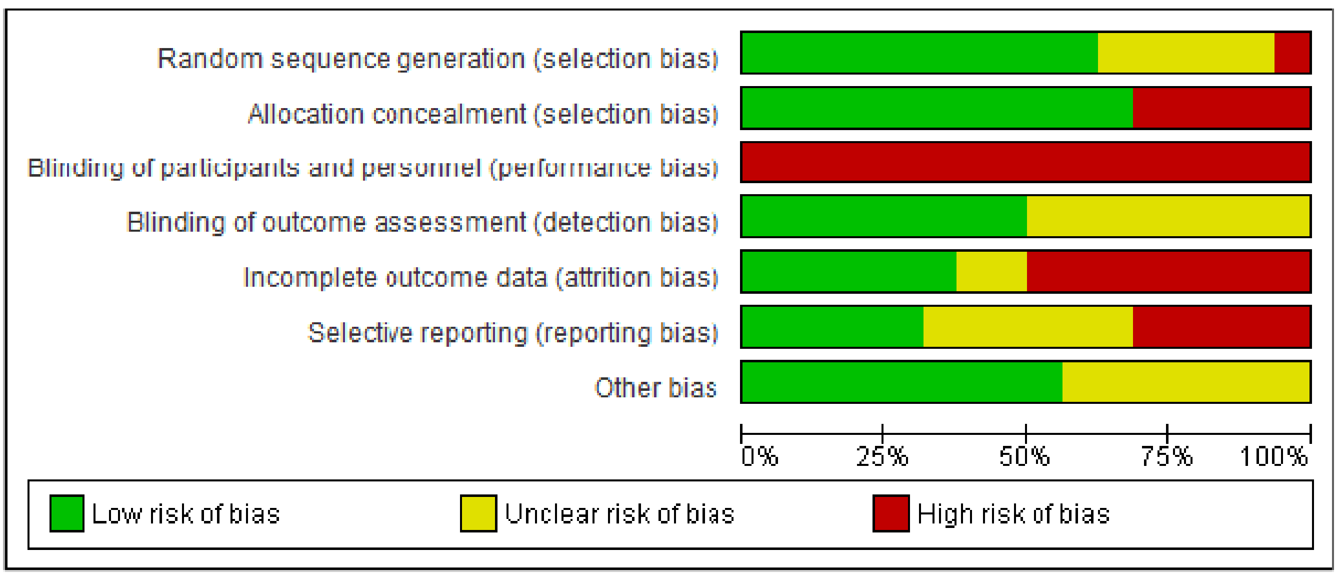
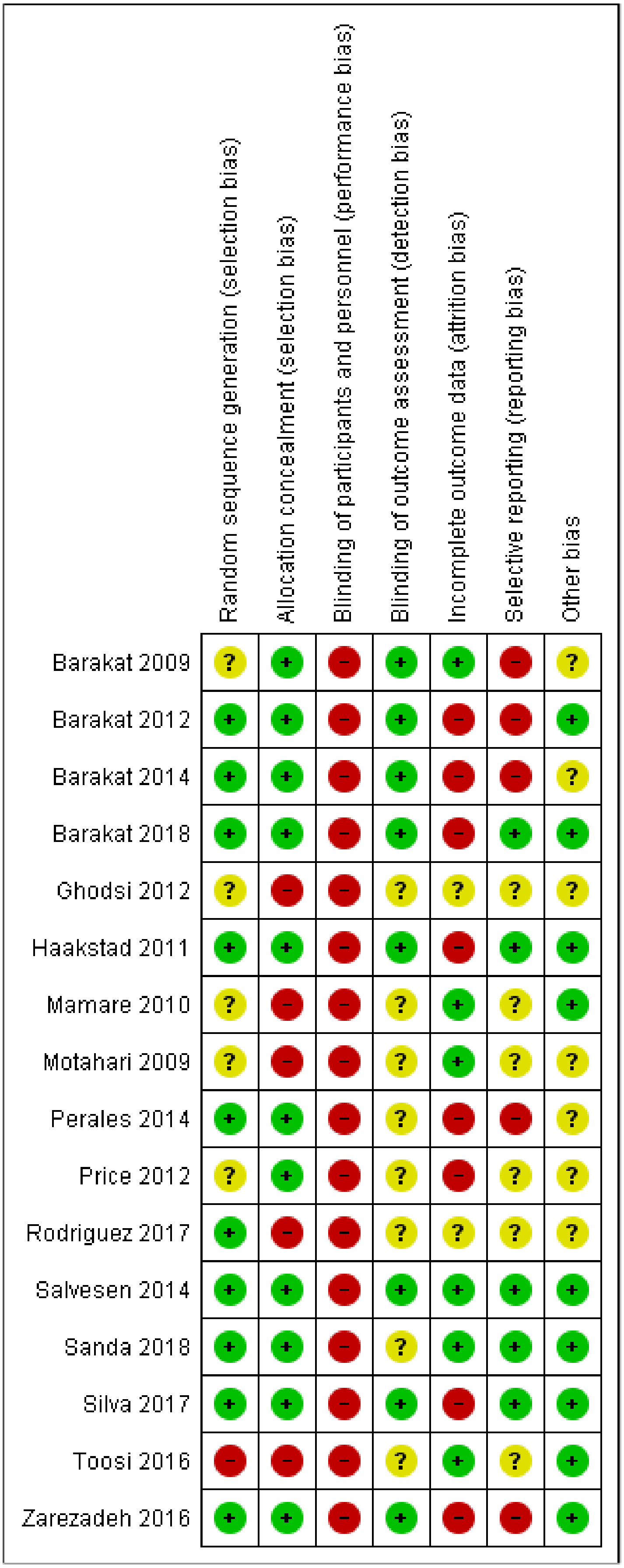


FIGURE 2 Risk of bias graph

FIGURE 3 Risk of bias summary



remained, and then, 1,038 studies were excluded after the review of the titles due to their irrelevance. The abstracts of 195 studies were reviewed, and 179 were discarded for incompatibility with the outcomes examined in this systematic review study and their greater emphasis on prenatal outcomes. Finally, 16 studies(14 studies in English and 2 studies in Persian) with a total of 3,605 participants were included in this systematic review, including 6 from Spain (Barakat et al., ,2009, 2012, 2014, 2018; Perales, Calabria, et al., 2016; Rodriguez-Diaz et al., 2017), one from the United States (Price et al., 2012), five from Iran (Ghodsi & Asltoghiri, 2014; Memari et al., 2006; Tab ari et al., 2010; Toosi & Akbarzadeh, 2016; Zarezadeh & Nemati, 2016), two from Norway (Haakstad & Bø, 2011; Sanda et al., 2018), one from Brazil (da Silva et al., 2017) and one from Sweden (Salvesen et al., 2014), and nine meta-analyses were ultimately carried out. Motahhari's study (Tab ari et al., 2010) had the lowest number of participants ($n = 44$) and da Silva's (da Silva et al., 2017) the highest ($n = 611$).

The majority of the studies on this subject were conducted in Spain by Barakat et al. from 2009 until the present. The variety of aerobic exercises performed in these studies included aerobic dance moves (Barakat et al., ,2009, 2018; Perales, Santos-Lozano, et al., 2016), walking (Zarezadeh & Nemati, 2016) and cycling (Ghodsi & Asltoghiri, 2014). The interventions had begun at 9–12 weeks of gestation in the Spanish studies (Barakat et al., ,2009, 2018; Perales, Santos-Lozano, et al., 2016) but after week 20 of gestation in the Iranian studies (Tab ari et al., 2010; Toosi & Akbarzadeh, 2016) and, in some cases, even after week 26 and late into the second trimester (Ghodsi & Asltoghiri, 2014; Zarezadeh & Nemati, 2016).

The highest frequency of exercise sessions during pregnancy was observed in the study by Barakat et al. ($n = 85$) (Barakat et al., ,2012, 2014, 2018) and the lowest in the study by Memari Tabari et al. (Tab ari et al., 2010) ($n = 24$); in some of the studies, three exercise sessions (Perales, Calabria, et al., 2016) or two exercise sessions (Haakstad & Bø, 2011; Rodriguez-Diaz et al., 2017; Salvesen & Mørkved, 2004; Sanda et al., 2018) were held per week.

The duration of exercise per session varied from 20 min (Ghodsi & Asltoghiri, 2014)–60 min (Perales, Calabria, et al., 2016). Some studies were conducted solely on primiparous women (da Silva et al., 2017; Tab ari et al., 2010) while others had not distinguished between the primiparous and the multiparous women or had not made note of this distinction (Barakat et al., ,2009, 2012, 2014; Perales, Calabria, et al., 2016; Rodríguez-Díaz et al., 2017; Salvesen et al., 2014) (Table 1).

3.1 | Meta-analysis results

3.1.1 | Duration of the first stage of labour

The meta-analysis of 9 studies conducted on 2,048 participants showed that exercise has no effect on the duration of the first stage of labour (MD: −29.92; 95% CI: −65.72 to 5.89; $p = .10$), and the random effect model was used due to the high heterogeneity ($I^2 = 78\%$); (Figure 4).

3.1.2 | Duration of the second stage of labour

The meta-analysis of 8 studies conducted on 2,074 participants showed that exercise has no effect on the duration of the second stage of labour (MD: 0.31; 95% CI: −3.23 to 3.86; $p = .86$); and the random effect model was used due to the high heterogeneity ($I^2 = 64\%$); (Figure 5).

3.1.3 | Type of childbirth

Of the above studies, 11 with 1,609 participants had investigated the effect of prenatal exercise on the type of delivery, and the meta-analysis results showed that prenatal exercise affects the type of delivery and increases the frequency of vaginal delivery significantly (RR: 1.24; 95% CI: 1.08–1.43; $p = .003$); and the random effect model was used due to the high heterogeneity ($I^2 = 78\%$); (Figure 6).

3.1.4 | Gestational age at delivery

The results of the meta-analysis of 10 studies with 2,167 participants showed that exercise has no effect on gestational age, and no significant differences were observed between the intervention and control groups in terms of gestational age at childbirth. In other words, the meta-analysis results showed that prenatal exercise does not lead to conditions such as preterm labour (MD: 0.14; 95% CI: −0.65 to 0.94; $p = .72$) ($I^2 = 0\%$); (Figure 7).

3.1.5 | First-minute Apgar

The results of the meta-analysis of 8 studies with 1,905 participants showed no significant differences between the intervention and control groups in terms of the first-minute Apgar score (MD: 0.01; 95% CI: −0.12 to 0.14; $p = .85$); and the random effect model was used due to the high heterogeneity ($I^2 = 23\%$); (Figure 8).

3.1.6 | Fifth-minute Apgar

The results of the meta-analysis of 9 studies with 1,985 participants showed no significant differences between the intervention and control groups in terms of the fifth-minute Apgar score (MD: 0.03; 95% CI: −0.10 to 0.15; $p = .68$); and the random effect model was used due to the high heterogeneity ($I^2 = 80\%$); (Figure 9).

TABLE 1 Characteristics of included studies

Author, Year, Country	Study design	Study population	Intervention	Primary outcomes	Conclusions
Barakat et al. (2009) Spain	Randomized controlled trial	Women were randomly assigned to training (*n* = 80) or control (*n* = 80) groups	The exercise training programme started in the beginning of the second trimester and continued until the end of the third trimester (weeks 38–39)	Type of delivery	There was no significant difference between groups in terms of the type of delivery
Barakat et al. (2012) Spain	Randomized controlled trial	290 healthy pregnant Caucasian (Spanish) women with a singleton gestation were randomly assigned to either an exercise (*n* = 138) or a control (*n* = 152) group	Programme included a total of three 40–45-min sessions per week, beginning at the start of the pregnancy (weeks 6–9) until the end of the third trimester (weeks 38–39)	Rate of caesarean and instrumental deliveries	The intervention caused a reduction in the rate of caesarean and instrumental delivery
Barakat et al. (2014) Spain	Randomized controlled trial	160 healthy pregnant women were randomly assigned to either a control group (*n* = 160) or an exercise group (*n* = 160)	The exercise programme included 85 sessions (general fitness class, 3 times/week, 55–60 min/session from weeks 8–10 to weeks 38–39 of pregnancy	Preterm delivery	There was no significant difference between groups in terms of the preterm delivery
Barakat et al. (2018) Spain	Randomized controlled trial	508 healthy pregnant women were randomly assigned to either a control group (*n* = 253) or an exercise group (*n* = 255) between 9–11 weeks of gestation	Moderate aerobic exercise programme throughout pregnancy (three sessions weekly)	Duration of labour	Intervention decreased the duration of the first phase of labour
Ghodsi et al. (2014) Iran	Randomized controlled trial	Nulliparous healthy women at 20–26 weeks of gestation	A cycling programme on a bicycle ergometer for 15 min three times per week	Maternal and neonatal outcomes	Safe for mother and neonate
Haakstad et al. (2011) Norwegian	Randomized controlled trial	Sedentary, nulliparous pregnant women (*n* = 105), mean age 30.7 ± 4.0 years, pre-pregnancy BMI 23.8 ± 4.3 were randomized to either an exercise group (*n* = 52) or a control group (*n* = 53)	The exercise programme consisted of supervised aerobic dance and strength training for 60 min, twice per week for a minimum of 12 weeks, with an additional 30 min of self-imposed physical activity on the non-supervised week days	Birthweight	Aerobic dance exercise had no effect on the birthweight, preterm birth rate or neonatal well-being
Memari et al. (2006) Iran	Randomized controlled trial	Sedentary, pregnant women with gestational age of 18 weeks (*n* = 80 were randomized to either an exercise group (*n* = 40) or a control group (*n* = 40)	The exercise programmes consisted of aerobic dance for 15–30 min, 3 times/week for 8 weeks	Gestational age, Apgar score, birthweight	Aerobic dance exercise had no effect on gestational age and birthweight, but it had positive effects on fifth-minute Apgar score
Motahhari et al. (2010) Iran	Randomized controlled trial	44 pregnant women with 24–32 weeks of gestational age were divided into intervention (*n* = 20) and control groups (*n* = 24)	Exercise programme training included stretching and flexibility exercise for 15 min and then aerobic exercise included constant walking for 5 to 15 min	delivery mood, cause of caesarean section, increase of other and foetus weight and duration of pregnancy	Intervention was safe for mother and neonate
Perales et al. (2016) Spain	Randomized controlled trial	166 pregnant women were allocated to the exercise group (*n* = 83) or the control group (*n* = 83)	Women from the exercise group participated in a physical conditioning programme including 55- to 60-min sessions, 3 days per week	Duration of the stages (Minutes) of labour in the exercise and control groups	A physical exercise programme during pregnancy is associated with a shorter first stage of labour

(Continues)

TABLE 1 (Continued)

Author, Year, Country	Study design	Study population	Intervention	Primary outcomes	Conclusions
Price et al. (2012) USA	Randomized controlled trial	91 pregnant women were allocated to the exercise group ($n = 43$) or the control group ($n = 48$)	Moderate aerobic exercise 45–60 min, 4 days per week, through 36 weeks gestation		Fitness and delivery outcomes improved in previously sedentary women who began exercising at 12–14 weeks
Salvesen et al. (2014) Norway	Randomized controlled trial	A total of 855 pregnant women were allocated to the exercise group ($n = 429$) or the control group ($n = 426$)	Intervention was a 12-week exercise programme, including aerobic and strengthening exercises, conducted between the 20th–36th week of gestation	Duration of labour	The intervention did not influence on the duration of the active phase of labour or the proportion of women with prolonged active second stage
Rodriguez-Diaz et al. (2017) España	Randomized controlled trial	A total of 105 pregnant women were divided into two groups: intervention group ($n = 50$) (32.87 ± 4.46 years old) and control group ($n = 55$) (31.52 ± 4.95 years old)	Pilates method, 2 sessions weekly	Maternal outcomes and functional parameters	The intervention improved functional parameters in pregnant women and also maternal outcomes
Sanda et al. (2018) Norway	Randomized controlled trial	Healthy nulliparous women were randomized to an intervention group, $n = 303$ (twice weekly exercise classes) or a control group, $n = 303$ (standard care)	A twice weekly standardized exercise programme	Duration and mode of delivery	A high physical activity level in late pregnancy was associated with lower odds of acute caesarean delivery compared with a low physical activity level
da Silva et al. (2017) Brazil	Randomized controlled trial	639 healthy pregnant women, 213 in the intervention group and 426 in the control group.	Women in the intervention group received a structured, individually supervised, moderate intensity exercise programme for 1 hr 3 days/week planned according to the ACOG recommendations	Maternal and neonatal outcomes	There were no significant differences in the incidence of preterm birth, pre-eclampsia, gestational weight gain, gestational diabetes, birthweight, infant length, and head circumference
Zarezadeh et al. (2016) Iran	Randomized controlled trial	102 healthy pregnant women, 51 in the intervention group and 51 in the control group	The intervention group received an 8-week regular walking programme and the control group was only followed up	Active and latent phases of labour	The intervention reduced the length of delivery stages
Toosi & Akbarzadeh (2016) Iran	Randomized controlled trial	120 pregnant females allocated into the an intervention group ($n = 60$) or a control group ($n = 60$)	Participants were required to do aerobic exercises for eight weeks since the 20th week.	Pregnancy outcome such as Apgar score, weight, height and head circumference	Exercising had positive effects on mothers' and infants' health

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2009	486	138	72	462	102	70	13.8%	24.00 [-15.84, 63.84]
Barakat 2018	409.15	185.74	176	462.83	208.37	149	13.4%	-53.68 [-96.95, -10.41]
Ghodsi 2012	299.6	126.87	40	384	147.8	40	11.3%	-84.40 [-144.76, -24.04]
Perales 2014	399.1	322.1	83	537.4	409.3	83	6.3%	-138.30 [-250.35, -26.25]
Price 2012	555	300	31	504	204	31	5.3%	51.00 [-76.71, 178.71]
Salvesen 2014	373	266	245	377	373	239	11.6%	-4.00 [-61.84, 53.84]
Sanda 2018	293.4	201	295	257.1	181	294	14.8%	36.30 [5.41, 67.19]
Toosi 2016	252	84	60	288	54	60	15.4%	-36.00 [-61.27, -10.73]
Zarezadeh 2016	329.86	220.68	40	451.3	187.89	40	8.1%	-121.44 [-211.26, -31.62]
Total (95% CI)			**1042**			**1006**	**100.0%**	**-29.92 [-65.72, 5.89]**

Heterogeneity: Tau² = 2007.01; Chi² = 36.21, df = 8 (P < 0.0001); I² = 78%
Test for overall effect: Z = 1.64 (P = 0.10)

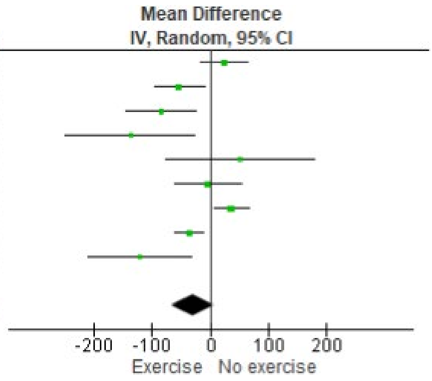


FIGURE 4 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on duration of the first stage of labour

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2009	32.5	24.7	72	36.1	31.5	72	8.8%	-3.60 [-12.85, 5.65]
Barakat 2018	33.23	22.53	227	36.21	25.93	202	16.1%	-2.98 [-7.60, 1.64]
Ghodsi 2012	29.5	13.99	40	32.5	13.68	40	13.4%	-3.00 [-9.06, 3.06]
Perales 2014	40.6	42.8	83	37.4	44.7	83	5.4%	3.20 [-10.11, 16.51]
Price 2012	47.4	36	31	28.4	12.5	31	5.3%	19.00 [5.59, 32.41]
Salvesen 2014	44	27	245	38	24	239	16.2%	6.00 [1.45, 10.55]
Sanda 2018	40.5	25	295	41.5	24.1	294	17.3%	-1.00 [-4.97, 2.97]
Toosi 2016	48.9	11.9	60	51.6	10	60	17.4%	-2.70 [-6.63, 1.23]
Total (95% CI)			**1053**			**1021**	**100.0%**	**0.31 [-3.23, 3.86]**

Heterogeneity: Tau² = 14.77; Chi² = 19.68, df = 7 (P = 0.006); I² = 64%
Test for overall effect: Z = 0.17 (P = 0.86)

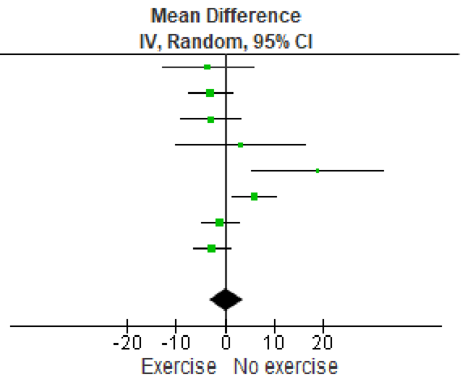


FIGURE 5 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on duration of the second stage of labour

3.1.7 | Neonatal weight

The results of the meta-analysis of 13 studies with 2,820 participants showed no significant differences between the two groups in terms of neonatal weight (MD: −26.28; 95% CI: −59.90 to 7.34; $p = .13$) ($I^2 = 3\%$); (Figure 10).

3.1.8 | Neonatal height

The results of the meta-analysis of 5 studies with 1,715 participants showed no significant differences between the two groups in terms of neonatal height (MD: −0.11; 95% CI: −0.37 to 0.15; $p = .42$); and the random effect model was used due to the high heterogeneity ($I^2 = 28\%$); (Figure 11).

3.1.9 | Neonatal head circumference

The results of the meta-analysis of 5 studies with 1,855 participants showed no significant differences between the two groups in terms of head circumference (MD: −0.01; 95% CI: −0.16 to 0.13; $p = .86$) ($I^2 = 0\%$); (Figure 12).

3.1.10 | Umbilical cord pH

The results of the meta-analysis of 2 studies with 456 participants showed no significant differences between the two groups in terms of umbilical cord pH (MD: 0.02; 95% CI: −0.09 to 0.13; $p = .71$) ($I^2 = 0\%$); (Figure 13).

Of the studies included in the present systematic review, only one with 166 participants had investigated the outcome of the third stage of labour and had found no statistically significant differences between the intervention and control groups (MD: −0.80; 95% CI: −0.3.04 to 1.44; $p = .48$) (Perales, Santos-Lozano, et al., 2016).

3.2 | Quality of evidence

GRADE approach was used to assess the quality of the evidence. The level of evidence was downgraded due to high heterogeneity,

Study or Subgroup	Exercise Events	Exercise Total	No exercise Events	No exercise Total	Weight	Risk Ratio M-H, Random, 95% CI
Barakat 2009	51	72	50	70	10.4%	0.99 [0.80, 1.22]
Barakat 2012	100	138	88	152	11.3%	1.25 [1.06, 1.48]
Barakat 2014	72	107	52	93	10.1%	1.20 [0.96, 1.51]
Barakat 2018	139	176	115	149	12.4%	1.02 [0.91, 1.15]
Ghodsi 2012	35	40	35	40	11.4%	1.00 [0.85, 1.18]
Motahari 2009	7	20	5	24	1.8%	1.68 [0.63, 4.49]
Perales 2014	69	83	71	83	12.1%	0.97 [0.85, 1.11]
Price 2012	27	31	19	31	8.2%	1.42 [1.04, 1.94]
Rodriguez 2017	45	50	23	50	8.1%	1.96 [1.43, 2.68]
Toosi 2016	41	60	29	60	8.2%	1.41 [1.03, 1.93]
Zarezadeh 2016	34	40	14	40	5.9%	2.43 [1.56, 3.78]
Total (95% CI)		**817**		**792**	**100.0%**	**1.24 [1.08, 1.43]**
Total events	620		501			

Heterogeneity: Tau² = 0.04; Chi² = 45.93, df = 10 (P < 0.00001); I² = 78%
Test for overall effect: Z = 2.97 (P = 0.003)

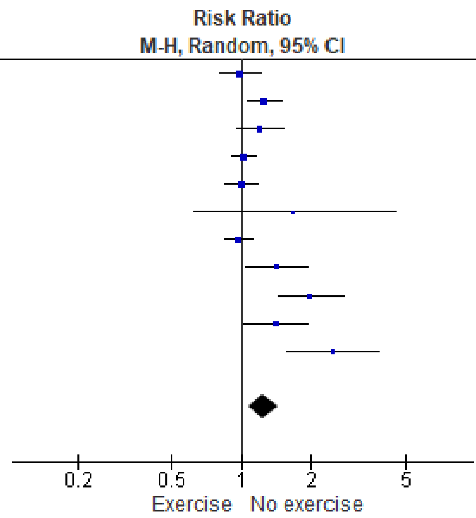


FIGURE 6 Forest plot of included study-Effect of prenatal aerobic exercise compared with no exercise on type of childbirth

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Fixed, 95% CI
Barakat 2009	277	9	72	278	9	72	7.3%	-1.00 [-3.94, 1.94]
Barakat 2012	278.3	9.9	138	278	10.3	152	11.7%	0.30 [-2.03, 2.63]
Barakat 2014	276.23	13.35	107	274.4	15.5	93	3.9%	1.83 [-2.21, 5.87]
Barakat 2018	278.5	11	227	277.79	8.57	202	18.3%	0.71 [-1.15, 2.57]
Haakstad 2011	279	8	52	277	8	53	6.7%	2.00 [-1.06, 5.06]
Mamare 2010	276	6	40	275	4	40	12.6%	1.00 [-1.23, 3.23]
Motahari 2009	274	6	20	274	6	24	5.0%	0.00 [-3.56, 3.56]
Perales 2014	277	8.8	83	277.9	8.3	83	9.3%	-0.90 [-3.50, 1.70]
Sanda 2018	279	12	295	279	13	294	15.4%	0.00 [-2.02, 2.02]
Toosi 2016	274	8	60	276	6	60	9.8%	-2.00 [-4.53, 0.53]
Total (95% CI)			**1094**			**1073**	**100.0%**	**0.14 [-0.65, 0.94]**

Heterogeneity: Chi² = 7.00, df = 9 (P = 0.64); I² = 0%
Test for overall effect: Z = 0.35 (P = 0.72)

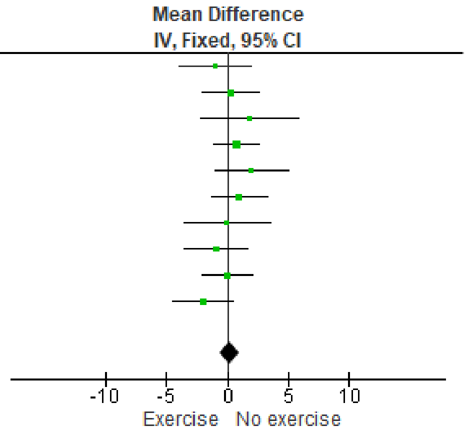


FIGURE 7 Forest plot of included study-Effect of prenatal aerobic exercise compared with no exercise on gestational age

relatively small sample size and performance and selection biases (Table 2).

3.3 | Results of sensitivity analysis

Sensitivity analysis did not change the results of primary meta-analysis for all outcomes. The summary of sensitivity analysis is shown in Table 3.

4 | DISCUSSION

The results of the present study showed that the mean duration of the various stages of labour was similar in women who exercised regularly and controls. Women in the exercise group had a significantly lower incidence of caesarean. Moreover, prenatal aerobic exercises had no significant difference on gestational age and other neonatal outcomes, such as first- and fifth-minute Apgar scores, umbilical cord pH, weight, height and head circumference.

Studies conducted on prenatal aerobic exercise have been mainly conducted in Spain, Iran and Norway. Six studies in Spain, five in Iran, one in Brazil, one in the United States, two in Norway and one in Sweden evaluated pregnancy outcomes following aerobic exercise.

The meta-analysis result did not show any significant difference between aerobic exercise and control groups in terms of the duration of the first stage of labour. In studies conducted by Barakat et al. (2018) from Spain (Barakat et al., 2018), Ghodsi et al. (Ghodsi & Asltoghiri, 2014), Toosi et al. (Toosi & Akbarzadeh, 2016) and Zarezadeh et al. (Zarezadeh & Nemati, 2016), prenatal exercise did not reduce the duration of the first stage of labour, but the results obtained in studies by Price et al. (Price et al., 2012) and Salvesen et al. (Salvesen et al., 2014) disagree with this finding. A study by Perales et al. (Perales, Calabria, et al., 2016) on 166 pregnant women concluded that the duration of the first stage of labour was reduced in the intervention group as a result of performing aerobic exercises. It should be noted, and however, that in the cited study, the exercise sessions were longer (60 min) and had a frequency of three sessions per week. Exercise moves strengthen the pelvic muscles,

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2009	8.9	1.1	72	8.8	1.2	72	9.7%	0.10 [-0.28, 0.48]
Barakat 2012	8.7	1.4	138	8.6	1.36	152	12.6%	0.10 [-0.22, 0.42]
Barakat 2018	8.78	1.21	227	3.76	1.22	202	20.1%	0.02 [-0.21, 0.25]
Haakstad 2011	8.8	1.2	52	8.6	1.2	53	6.9%	0.20 [-0.26, 0.66]
Perales 2014	8.6	1.3	83	8.7	0.9	83	11.4%	-0.10 [-0.44, 0.24]
Price 2012	8.1	0.9	31	8.2	1.9	31	2.8%	-0.10 [-0.84, 0.64]
Sanda 2018	8.5	1.1	295	8.7	1.3	294	24.6%	-0.20 [-0.39, -0.01]
Toosi 2016	9.3	1.3	60	9	0.1	60	11.9%	0.30 [-0.03, 0.63]
Total (95% CI)			**958**			**947**	**100.0%**	**0.01 [-0.12, 0.14]**

Heterogeneity: Tau² = 0.01; Chi² = 9.03, df = 7 (P = 0.25); I² = 23%
Test for overall effect: Z = 0.19 (P = 0.85)

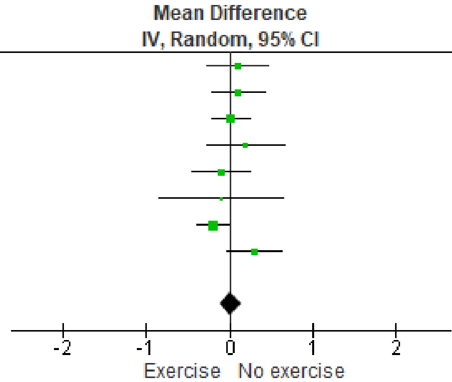


FIGURE 8 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on first-minute Apgar

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2009	9.9	0.2	72	9.9	0.3	72	14.7%	0.00 [-0.08, 0.08]
Barakat 2012	9.7	0.6	138	9.8	0.8	152	12.4%	-0.10 [-0.26, 0.06]
Barakat 2018	9.8	0.5	227	9.94	0.85	202	13.3%	-0.14 [-0.27, -0.01]
Haakstad 2011	9.6	0.6	52	9.4	0.8	53	8.9%	0.20 [-0.07, 0.47]
Mamare 2010	9.3	0.5	40	9	0.5	40	10.5%	0.30 [0.08, 0.52]
Perales 2014	9.8	0.5	83	9.9	0.2	83	13.8%	-0.10 [-0.22, 0.02]
Price 2012	9	0.5	31	8.7	0.5	31	9.6%	0.30 [0.05, 0.55]
Sanda 2018	9.6	0.7	295	9.4	1.1	294	12.8%	0.20 [0.05, 0.35]
Toosi 2016	9.2	1.3	60	10	1.6	60	4.1%	-0.80 [-1.32, -0.28]
Total (95% CI)			**998**			**987**	**100.0%**	**0.03 [-0.10, 0.15]**

Heterogeneity: Tau² = 0.02; Chi² = 39.36, df = 8 (P < 0.00001); I² = 80%
Test for overall effect: Z = 0.42 (P = 0.68)

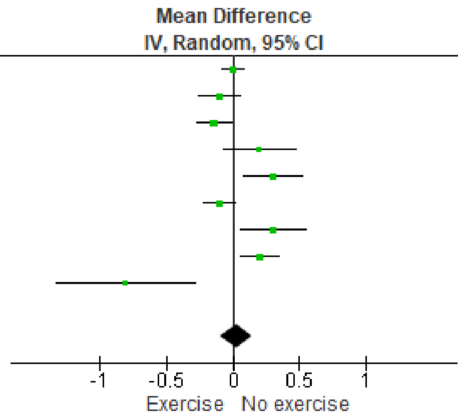


FIGURE 9 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on five-minute Apgar

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	No exercise Mean	No exercise SD	No exercise Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2009	3,165	411	72	3,307	477	72	5.2%	-142.00 [-287.44, 3.44]
Barakat 2012	3,203	461	138	3,232	448	152	9.9%	-29.00 [-133.82, 75.82]
Barakat 2018	3,273	415	227	3,256	466	202	15.0%	17.00 [-66.93, 100.93]
Ghodsi 2012	3,059	339	40	3,255	350	40	4.9%	-196.00 [-347.00, -45.00]
Haakstad 2011	3,477	424	52	3,542	462	53	3.9%	-65.00 [-234.56, 104.56]
Mamare 2010	3,364	249	40	3,282	353	40	6.1%	82.00 [-51.87, 215.87]
Motahari 2009	3,285	331	20	3,350	537	24	1.7%	-65.00 [-324.23, 194.23]
Perales 2014	3,183	446	83	3,232	383	83	6.9%	-49.00 [-175.47, 77.47]
Price 2012	3,329	519	31	3,308	103	31	3.2%	21.00 [-165.26, 207.26]
Rodriguez 2017	3,361	361	50	3,417	473	50	4.1%	-56.00 [-220.93, 108.93]
Sanda 2018	3,410	486	295	3,449	539	294	15.4%	-39.00 [-121.90, 43.90]
Silva 2017	3.244	424	204	3.254	467	407	19.1%	-0.01 [-73.79, 73.77]
Toosi 2016	3,185	453	60	3,175	392	60	4.8%	10.00 [-141.58, 161.58]
Total (95% CI)			**1312**			**1508**	**100.0%**	**-26.28 [-59.90, 7.34]**

Heterogeneity: Tau² = 126.82; Chi² = 12.40, df = 12 (P = 0.41); I² = 3%
Test for overall effect: Z = 1.53 (P = 0.13)

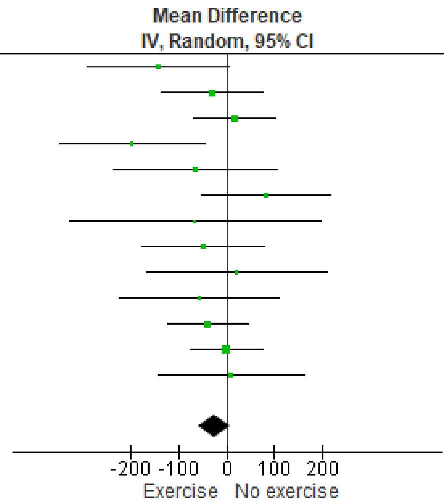


FIGURE 10 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on neonatal weight

increase the pelvic diameters and cause muscle relaxation and ultimately improve the position of the presenting part in the birth canal and can also affect the duration of labour. The conflicting results of these studies could be due to their different sample sizes (ranging from 40–600) as well as the different intervention start times; for instance, the exercises began in the ninth week of pregnancy in some of the studies and in the 26th week in others, which might have affected the results. Moreover, the number of exercise sessions per week was different; for instance, in the Iranian studies, the number of sessions was two per week in some and three in others. The different durations of the exercise sessions, which varied from 15–60 min, might have affected the results, as well. Another important point is that some studies, such as the one by Zarezadeh et al. (Zarezadeh & Nemati, 2016), were conducted only on primiparous women, while

Study or Subgroup	Exercise Mean	SD	Total	No exercise Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Barakat 2012	49.7	2.06	138	49.5	2.07	152	21.0%	0.20 [-0.28, 0.68]
Haakstad 2011	50.2	2	52	50.8	1.9	53	10.3%	-0.60 [-1.35, 0.15]
Sanda 2018	50	2.1	235	49.9	2.7	294	27.2%	0.10 [-0.29, 0.49]
Silva 2017	48.4	2	234	48.7	2.2	407	31.2%	-0.30 [-0.65, 0.05]
Toosi 2016	51.1	2.1	30	51.3	2.1	60	10.2%	-0.20 [-0.95, 0.55]
Total (95% CI)			**749**			**966**	**100.0%**	**-0.11 [-0.37, 0.15]**

Heterogeneity: $Tau^2 = 0.02$; $Chi^2 = 5.59$, df = 4 (P = 0.23); $I^2 = 28\%$
Test for overall effect: Z = 0.81 (P = 0.42)

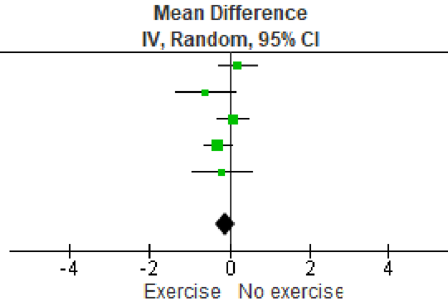


FIGURE 11 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on neonatal height

Study or Subgroup	Exercise Mean	SD	Total	No exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Haakstad 2011	34.9	1.6	52	35.1	1.6	53	5.5%	-0.20 [-0.81, 0.41]
Perales 2014	34.1	1.3	83	34.2	1.1	83	15.2%	-0.10 [-0.47, 0.27]
Salvesen 2014	34.2	1.6	427	34.2	1.6	426	44.4%	0.00 [-0.21, 0.21]
Silva 2017	34.2	1.6	204	34.2	1.6	407	28.3%	0.00 [-0.27, 0.27]
Toosi 2016	34.3	1.5	60	34.1	1.6	60	6.6%	0.20 [-0.35, 0.75]
Total (95% CI)			**826**			**1029**	**100.0%**	**-0.01 [-0.16, 0.13]**

Heterogeneity: $Chi^2 = 1.16$, df = 4 (P = 0.88); $I^2 = 0\%$
Test for overall effect: Z = 0.18 (P = 0.86)

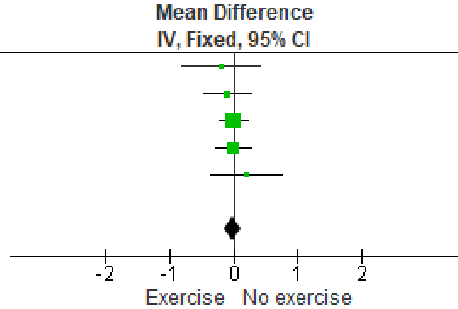


FIGURE 12 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on neonatal head circumference

Study or Subgroup	Exercise Mean	SD	Total	No exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Barakat 2012	7.28	0.5	138	7.26	0.6	152	71.0%	0.02 [-0.11, 0.15]
Perales 2014	7.28	0.7	83	7.26	0.6	83	29.0%	0.02 [-0.18, 0.22]
Total (95% CI)			**221**			**235**	**100.0%**	**0.02 [-0.09, 0.13]**

Heterogeneity: $Chi^2 = 0.00$, df = 1 (P = 1.00); $I^2 = 0\%$
Test for overall effect: Z = 0.37 (P = 0.71)

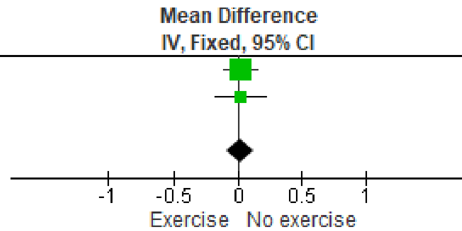


FIGURE 13 Forest plot of included study-Effect of prenatal aerobic exercises compared with no exercise on umbilical cord pH

others had no such limitations in this regard and did not distinguish between the primiparous and the multiparous women; and since the duration of the first stage of labour is different in primiparous versus multiparous women, this issue could have also affected the results.

The results of meta-analysis showed that prenatal exercise had no effect on the duration of the second stage of labour. The results obtained by Price et al. and Salvesen et al. (Price et al., 2012; Salvesen et al., 2014), however, showed that the duration of the second stage of labour was shorter in those who exercised compared to the control group. In these two studies, the participants included both multiparous and nulliparous women. The duration of the different stages of labour, particularly the second stage was shorter for the multiparous women, and the larger number of multiparous women in these studies may have affected the results. Two issues could be responsible for these findings. First, multiparous women have different labour progress patterns than primiparous women and give birth in a shorter duration of time. Second, multiparous women perform more daily activities due to their greater family responsibilities, including taking care of their other children. Investigating the duration of the different stages of labour as an outcome requires studies with larger sample sizes that also take account of potential confounding variables such as weight, height and BMI as well as personal differences in terms of physical activity in daily life, previous history of being an athlete and occupation, and it seems that primiparous and multiparous women should be assessed separately or in a stratified manner.

Only one study with 166 participants had assessed the duration of the third stage of labour, and it reported no significant differences between the aerobic exercise and control groups, as placental excision had lasted 8 min in both groups (Perales, Calabria, et al., 2016). Investigating this outcome also requires clinical trials with larger sample sizes.

The results of the meta-analysis showed that exercise had a positive effect on mode of delivery and increased the rate of vaginal childbirth. These results agree with the results of the meta-analysis conducted by Poyatos-León in 2015 (Poyatos-León et al., 2015) regarding the effect of exercise on the mode of childbirth. Evidence from both meta-analyses emphasizes that regular prenatal exercise is effective in increasing the rate of vaginal childbirth. Prenatal

TABLE 2 Quality assessment of randomized trials on effect of prenatal aerobic exercises on maternal and neonatal outcomes based on GRADE approach

No. of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Exercise group *n/N*	No exercise group *n/N*	Pooled effect relative (95% CI)	Final judgment
Duration of the first stage of labour (Minute)										
9	Randomized trials	Serious	Serious inconsistency	No serious indirectness	Serious imprecision	Publication bias	1,042/2,048	1,006/2,048	(MD[a] = −29.92; 95% CI[c] = −65.72 to 5.89; $p = .10$)	OOO⊕ Very Low
Duration of the second stage of labour (Minute)										
8	Randomized trials	Serious	Serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	1,053/2,074	1,021/2,074	(MD = 0.31; 95% CI = −3.23 to 3.86; $p = .86$)	OO⊕⊕ Low
Frequency of vaginal delivery										
11	Randomized trials	Serious	Serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	817/1,609	792/1,609	(RR[b] = 1.24; 95% CI = 1.08 to 1.43)	OO⊕⊕ Low
Gestational age (Day)										
11	Randomized trials	Serious	No serious inconsistency	No serious indirectness	No serious imprecision	None	1,166/2,309	1,143/2,309	(MD = 0.14; 95% CI = −0.65 to 0.94; $p = .86$)	O⊕ ⊕⊕ Moderate
Neonatal weight (Gram)										
13	Randomized trials	Serious	No serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	1,312/2,820	1,508/2,820	(MD −26.28; 95% CI: −59.90 to 7.34; $p = .13$)	O⊕ ⊕⊕ Moderate
Neonatal height (cm)										
5	Randomized trials	Serious	No serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	749/1,715	966/1,715	(MD = −0.11; 95% CI = −0.37 to 0.15; $p = .42$)	O⊕ ⊕⊕ Moderate
Neonatal head circumference (cm)										
5	Randomized trials	Serious	No serious inconsistency	No serious indirectness	No serious imprecision	None	826/1,855	1,029/1,855	(MD = −0.01; 95% CI = −0.16 to 0.13; $p = .86$)	O⊕ ⊕⊕ Moderate
First-minute Apgar										
9	Randomized trials	Serious	No serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	1,030/2,047	1,017/2,047	(MD = 0.01; 95% CI = −0.12 to 0.14; $p = .45$)	O⊕ ⊕⊕ Moderate
Fifth-minute Apgar										
10	Randomized trials	Serious	Serious inconsistency	No serious indirectness	No serious imprecision	Publication bias	1,057/2,125	1,057/2,125	(MD = 0.03; 95% CI = −0.10 to 0.15; $p = .45$)	OO ⊕⊕ Low
Umbilical cord pH										
2	Randomized trials	Serious	No serious inconsistency	No serious indirectness	Serious imprecision	None	221/456	235/456	(MD = 0.02; 95% CI = −0.09 to 0.13; $p = .71$)	OO ⊕⊕ Low

[a]MD: mean difference.

[b]Risk ratio.

[c]95% confidence interval.

TABLE 3 The summary of sensitivity analyses

Number	Measured outcome	Meta-analysis of all studies (*p*-value)	Sensitivity analysis* (*p*-value)
1	First stage of labour	.10	.07
2	Second stage of labour	.86	.73
3	Type of childbirth	.003	.01
4	Gestational age	.72	.96
5	First-minute Apgar	.85	.23
6	Five-minute Apgar	.68	.54
7	Neonatal weight at birth	.13	.38
8	Neonatal height at birth	.42	.81

*Studies with high risk of bias (Sanda et al., 2018; Rodriguez-Diaz et et al., 2017; Ghodsi et al., 2014; Memari et al., 2006; Motahhari et al., 2010) removed from meta-analysis.

exercises can cause the descent of the foetal head in the mother's pelvis and help the process of natural childbirth. According to the results of the present systematic review, women can be advised to perform exercise during their pregnancy. Moreover, health policy-makers should facilitate exercise programmes for pregnant women. It should be noted that the discussed studies have generally examined women with no midwifery risk factors or healthy women with singleton pregnancies, and their results can therefore be generalized to healthy women. Separate studies need to be conducted on women with midwifery issues.

Gestational age was one of the outcomes investigated during childbirth. The meta-analysis results showed that prenatal exercise did not adversely affect the duration of pregnancy or cause preterm childbirth. The results of a systematic review study showed that exercise has no association with gestational age (Nascimento et al., 2012).

The neonatal outcomes investigated in the present systematic review included weight, height, head circumference, changes in Apgar score and umbilical cord pH. The meta-analysis results showed that neonatal weight, height, head circumference, first and fifth-minute Apgar scores and umbilical cord pH were similar in women who exercised regularly and controls, while the study conducted by Clark et al. produced totally different results and demonstrated that exercise can affect neonatal weight, height and head and abdomen circumference (Clark et al., 2019). Also, similar to our results regarding neonatal weight, the results of a systematic review and meta-analysis showed that no significant difference observed in birthweight for infants of mothers who had vigorous intensity exercise in the third trimester of pregnancy compared to mothers who lacked this exposure (Beetham et al., 2019).

The results of the meta-analysis showed that prenatal aerobic exercises had no effect on neonatal weight. Neonatal weight is one of the important factors in increasing maternal and neonatal risks during childbirth. The likelihood of caesarean section, shoulder dystocia, difficult childbirth, tearing of the birth canal and foetal distress increases with neonatal weight (Begum et al., 2011). Neonatal weight during pregnancy is affected by the mother's initial weight, age, parity and diet, which were not considered in the discussed studies. More extensive studies that control the noted factors are thus required. Regarding the Apgar score, the meta-analysis results indicate that prenatal exercises have no effects on the first- and fifth-minute Apgar scores. In the study conducted by Haakstad et al. (Haakstad & Bø, 2011), the first-minute Apgar score, and in the study by Memari Tabari et al., the fifth-minute Apgar score were higher in the exercise groups compared to the controls, and their neonates were in a better condition, too (Tab ari et al., 2010). Prenatal physical activity can have potential health benefits for the foetus by maintaining the placental vascular function (Cid & González, 2016).

The exercise intensity, duration of each session, number of sessions per week, history of exercise before pregnancy and type of exercise may have affected these outcomes. Although the findings of this systematic review showed that aerobic exercise affects only the mode of childbirth and revealed no differences between the intervention and control groups in terms of the other outcomes, previous studies have shown that the implementation of exercise programmes in pregnant women reinforces their cardiopulmonary preparation (Bisson et al., 2015; Rodríguez-Díaz et al., 2017), which is an indicator that has a positive relationship with the health-related quality of life (Gierlaszyńska et al., 2016). This issue highlights the importance of the implementation of exercise programmes in pregnant women.

4.1 | Strengths and limitation

The strengths of the present study included investigating the effect of aerobic exercises on the duration of the different stages of labour in systematic studies for the first time and also the inclusion of all the studies published on this subject in English and Persian. The main limitations of the study included problems related to the reviewed clinical trials, such as non-randomization in some cases, small sample sizes in most studies, differences in the interventions in terms of type, intensity and the time of starting aerobic exercises and their duration. It should be noted that most studies had not fully explained their sample allocation procedure. Moreover, all studies ran a huge risk of qualitative bias due to non-blinding their participants. Another limitation of the present systematic review study was the poor design of the included studies. In a number of the studies, the participants were primiparous, and in others, multiparous and primiparous women had not been separated, and parity had not been considered as a possible confounding factor. In some studies, the interventions were fully supervised by a trainer, and in others, the participants carried out aerobic exercises at home with no supervision. Furthermore, most studies had been conducted in Spain by a single group from 2008–the present, and given their different sample sizes, the researchers e-mailed them to obtain their protocol and ask some questions, but received no response. All of these limitations may contribute to the high heterogeneity in the meta-analyses. The high heterogeneity in the results indicates that the results of this study should be interoperated cautiously.

5 | CONCLUSION

The results showed that prenatal aerobic exercises are safe and do not put the mother and the neonate at any risk, and in addition to potential health benefits for the mother, they also affect the mode of childbirth and help increase the frequency of vaginal deliveries and reduce caesarean section. Knowledge of the benefits of prenatal exercise will therefore help health and medical policymakers reduce many of the childbirth complications caused by non-vaginal delivery by implementing regular exercise programmes for pregnant women.

CONFLICT OF INTEREST

The authors declared that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

AV, SMA, SHH and MM (corresponding author) participated in the study designing. AV and SHH searched the literature and selected studies, extracted data, assessed quality and drafted the manuscript. SMA and MM (corresponding author) revised the draft, and all authors read and approved the final version of the manuscript.

ETHICAL APPROVAL

Ethical Approval was not required.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

ORCID

Mojgan Mirghafourvand https://orcid.org/0000-0001-8360-4309

REFERENCES

Abedzadeh, M., Taebi, M., Sadat, Z., & Saberi, F. (2011). Knowledge and performance of pregnant women referring to Shabihkhani hospital on exercises during pregnancy and postpartum periods. *Journal of Jahrom University of Medical Sciences*, *8*(4), 212–218. https://doi.org/10.12691/jpar-3-1-9

Allen, V. M., Armson, B. A., Wilson, R. D., Allen, V. M., Blight, C., Gagnon, A., Johnson, J.-A., Langlois, S., Summers, A., Wyatt, P., Farine, D., Armson, B. A., Crane, J., Delisle, M.-F., Keenan-Lindsay, L., Morin, V., Schneider, C. E., & Van Aerde, J. (2007). Teratogenicity associated with pre-existing and gestational diabete. *Journal of Obstetrics and Gynaecology Canada*, *29*(11), 927–934. https://doi.org/10.1016/S1701-2163(16)32653-6

Allen, V. M., Baskett, T. F., O'Connell, C. M., McKeen, D., & Allen, A. C. (2009). Maternal and perinatal outcomes with increasing duration of the second stage of labor. *Obstetrics & Gynecology*, *113*(6), 1248–1258. https://doi.org/10.1097/AOG.0b013e3181a722d6

Barakat, R., Franco, E., Perales, M., López, C., & Mottola, M. F. (2018). Exercise during pregnancy is associated with a shorter duration of labor. A randomized clinical trial. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *224*, 33–40. https://doi.org/10.1016/j.ejogrb.2018.03.009

Barakat, R., Pelaez, M., Lopez, C., Montejo, R., & Coteron, J. (2012). Exercise during pregnancy reduces the rate of cesarean and instrumental deliveries: Results of a randomized controlled trial. *The Journal of Maternal-Fetal & Neonatal Medicine*, *25*(11), 2372–2376. https://doi.org/10.3109/14767058.2012.696165

Barakat, R., Perales, M., Bacchi, M., Coteron, J., & Refoyo, I. (2014). A program of exercise throughout pregnancy. Is it safe to mother and newborn? *American Journal of Health Promotion*, *29*(1), 2–8. https://doi.org/10.4278/ajhp.130131-QUAN-56

Barakat, R., Ruiz, J. R., Stirling, J. R., Zakynthinaki, M., & Lucia, A. (2009). Type of delivery is not affected by light resistance and toning exercise training during pregnancy: A randomized controlled trial. *American Journal of Obstetrics and Gynecology*, *201*(6), 590.e1–590.e6. https://doi.org/10.1016/j.ajog.2009.06.004

Beetham, K. S., Giles, C., Noetel, M., Clifton, V., Jones, J. C., & Naughton, G. (2019). The effects of vigorous intensity exercise in the third trimester of pregnancy: A systematic review and meta-analysis. *BMC Pregnancy and Childbirth*, *19*(1), 281. https://doi.org/10.1186/s12884-019-2441-1

Begum, K. S., Sachchithanantham, K., & De Somsubhra, S. (2011). Maternal obesity and pregnancy outcome. *Clinical and Experimental Obstetrics & Gynecology*, *38*(1), 14–20.

Bisson, M., Alméras, N., Dufresne, S. S., Robitaille, J., Rhéaume, C., Bujold, E., Frenette, J., Tremblay, A., & Marc, I. (2015). A 12-week exercise program for pregnant women with obesity to improve physical activity levels: An open randomised preliminary study. *PLoS One*, *10*(9), e0137742. https://doi.org/10.1371/journal.pone.0137742

Brown, S., Gartland, D., Donath, S., & MacArthur, C. (2011). Effects of prolonged second stage, method of birth, timing of caesarean section and other obstetric risk factors on postnatal urinary incontinence: An Australian nulliparous cohort study. *BJOG: An International Journal of Obstetrics & Gynaecology*, *118*(8), 991–1000. https://doi.org/10.1111/j.1471-0528.2011.02928.x

Chen, H., Cao, L., Cao, W., Wang, H., Zhu, C., & Zhou, R. (2018). Factors affecting labor duration in Chinese pregnant women. *Medicine*, *97*(52), e13901. https://doi.org/10.1097/MD.0000000000013901

Cheng, Y. W., Hopkins, L. M., Laros, R. K. Jr, & Caughey, A. B. (2007). Duration of the second stage of labor in multiparous women: Maternal and neonatal outcomes. *American Journal of Obstetrics & Gynecology*, *196*(6), 585.e1–585.e6. https://doi.org/10.1016/j.ajog.2007.03.021

Cid, M., & González, M. (2016). Potential benefits of physical activity during pregnancy for the reduction of gestational diabetes prevalence and oxidative stress. *Early Human Development*, *94*, 57–62. https://doi.org/10.1016/j.earlhumdev.2016.01.007

Clark, E., Isler, C., Strickland, D., McMillan, A. G., Fang, X., Kuehn, D., Ravisankar, S., Strom, C., & May, L. E. (2019). Influence of aerobic exercise on maternal lipid levels and offspring morphometrics. *International Journal of Obesity*, *43*(3), 594–602. https://doi.org/10.1038/s41366-018-0258-z

da Silva, S. G., Hallal, P. C., Domingues, M. R., Bertoldi, A. D., Silveira, M. F. D., Bassani, D., da Silva, I. C. M., da Silva, B. G. C., Coll, C. D. V. N., & Evenson, K. (2017). A randomized controlled trial of exercise during pregnancy on maternal and neonatal outcomes: Results from the PAMELA study. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 175. https://doi.org/10.1186/s12966-017-0632-6

Di Mascio, D., Magro-Malosso, E. R., Saccone, G., Marhefka, G. D., & Berghella, V. (2016). Exercise during pregnancy in normal-weight women and risk of preterm birth: A systematic review and meta-analysis of randomized controlled trials. *American Journal of Obstetrics & Gynecology*, *215*(5), 561–571. https://doi.org/10.1016/j.ajog.2016.06.014

Direkvand-Moghadam, A., & Rezaeian, M. (2012). Increased intravenous hydration of nulliparas in labor. *International Journal of Gynecology & Obstetrics*, *118*(3), 213–215. https://doi.org/10.1016/j.ijgo.2012.03.041

Doustan, M., Seifourian, M., Zarghami, M., & Azmsha, T. (2012). Relationship between physical activity of mothers before and during pregnancy with the newborn health and pregnancy outcome. *Journal of Physical Education and Sport*, *12*(2), 222.

Elliott-Sale, K., Barnett, C., & Sale, C. (2015). Exercise interventions for weight management during pregnancy and up to 1 year postpartum among normal weight, overweight and obese women: A systematic review and meta-analysis. *British Journal of Sports Medicine*, *49*(20), 1336–1342. https://doi.org/10.1136/bjsports-2014-093875

Ghodsi, Z., & Asltoghiri, M. (2014). Effects of aerobic exercise training on maternal and neonatal outcome: A randomized controlled trial on pregnant women in Iran. *Journal of Pakistan Medical Association*, *64*(9), 1053–1056.

Gierlaszyńska, K., Pudlo, R., Jaworska, I., Byrczek-Godula, K., & Gąsior, M. (2016). Tools for assessing quality of life in cardiology and cardiac surgery. *Kardiochirurgia I Torakochirurgia Polska= Polish Journal of Cardio-Thoracic Surgery*, *13*(1), 78. https://doi.org/10.5114/kitp.2016.58974

Haakstad, L. A., & Bø, K. (2011). Exercise in pregnant women and birth weight: A randomized controlled trial. *BMC Pregnancy and Childbirth*, *11*(1), 1–7. https://doi.org/10.1186/1471-2393-11-66

Hesketh, K. R., & Evenson, K. R. (2016). Prevalence of US pregnant women meeting 2015 ACOG physical activity guidelines. *American Journal of Preventive Medicine*, *51*(3), e87–e89. https://doi.org/10.1016/j.amepre.2016.05.023

Higgins, J. (2011). Analysing data and undertaking meta-analyses. In J. Higgins, & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions (Version 5.1. 0)*. Wiley. training.cochrane.org/handbook/current

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal*, *327*, 557–560. https://doi.org/10.1136/bmj.327.7414.557

Huedo-Medina, T. B., Sánchez-Meca, J., Marín-Martínez, F., & Botella, J. (2006). Assessing heterogeneity in meta-analysis: Q statistic or I2 index? *Psychological Methods*, *11*(2), 193–206.

Magro-Malosso, E. R., Saccone, G., Di Tommaso, M., Roman, A., & Berghella, V. (2017). Exercise during pregnancy and risk of gestational hypertensive disorders: A systematic review and meta-analysis. *Acta Obstetricia et Gynecologica Scandinavica*, *96*(8), 921–931. https://doi.org/10.1111/aogs.13151

Melzer, K., Schutz, Y., Soehnchen, N., Othenin-Girard, V., Martinez de Tejada, B., Irion, O., Boulvain, M., & Kayser, B. (2010). Effects of recommended levels of physical activity on pregnancy outcomes. *American Journal of Obstetrics & Gynecology*, *202*(3), 266.e1–266.e6. https://doi.org/10.1016/j.ajog.2009.10.876

Memari, A., Ramim, T., Amini, M., Mehran, A., Ajor, L. A., & Shakibaei, P. (2006). Investigation of effects of aerobic exercise on pregnancy and its circumstances. *Hayat*, *12*(3), 35–41.

Ming, W.-K., Ding, W., Zhang, C. J. P., Zhong, L., Long, Y., Li, Z., Sun, C., Wu, Y., Chen, H., Chen, H., & Wang, Z. (2018). The effect of exercise during pregnancy on gestational diabetes mellitus in normal-weight women: A systematic review and meta-analysis. *BMC Pregnancy and Childbirth*, *18*(1), 1–9. https://doi.org/10.1186/s12884-018-2068-7

Mirmolaei, S. T., Ansari, N. N., Mahmoudi, M., & Ranjbar, F. (2018). Efficacy of a physical training program on pregnancy related lumbopelvic pain. *International Journal of Women's Health and Reproduction Sciences*, *6*(2), 161–166. https://doi.org/10.15296/ijwhr.2018.27

Morgan, K. L., Rahman, M. A., Hill, R. A., Zhou, S.-M., Bijlsma, G., Khanom, A., Lyons, R. A., & Brophy, S. T. (2014). Physical activity and excess weight in pregnancy have independent and unique effects on delivery and perinatal outcomes. *PLoS One*, *9*(4), e94532. https://doi.org/10.1371/journal.pone.0094532

Motahhari, T. N., Mirdar, S., Khaldan, A., & Ahmad Shirvani, M. (2010). The effect of aerobic exercise on pregnancy outcomes. *Journal of Babol University of Medical Sciences*, *12*, 36–43.

Nascimento, S. L., Surita, F. G., & Cecatti, J. G. (2012). Physical exercise during pregnancy: A systematic review. *Current Opinion in Obstetrics and Gynecology*, *24*(6), 387–394. https://doi.org/10.1097/GCO.0b013e328359f131

Perales, M., Calabria, I., Lopez, C., Franco, E., Coteron, J., & Barakat, R. (2016). Regular exercise throughout pregnancy is associated with a shorter first stage of labor. *American Journal of Health Promotion*, *30*(3), 149–157. https://doi.org/10.4278/ajhp.140221-QUAN-79

Perales, M., Santos-Lozano, A., Ruiz, J. R., Lucia, A., & Barakat, R. (2016). Benefits of aerobic or resistance training during pregnancy on maternal health and perinatal outcomes: A systematic review. *Early Human Development*, *94*, 43–48. https://doi.org/10.1016/j.earlhumdev.2016.01.004

Poyatos-León, R., García-Hermoso, A., Sanabria-Martínez, G., Álvarez-Bueno, C., Sánchez-López, M., & Martínez-Vizcaíno, V. (2015). Effects of exercise during pregnancy on mode of delivery: A meta-analysis. *Acta Obstetricia et Gynecologica Scandinavica*, *94*(10), 1039–1047. https://doi.org/10.1111/aogs.12675

Price, B. B., Amini, S. B., & Kappeler, K. (2012). Exercise in pregnancy: Effect on fitness and obstetric outcomes—a randomized trial. *Medicine & Science in Sports & Exercise*, *44*(12), 2263–2269. https://doi.org/10.1249/MSS.0b013e318267ad67

Rodriguez-DDiaz, L., Ruiz-Frutos, C., Vázquez-Lara, J. M., Ramírez-Rodrigo, J., Villaverde-Gutiérrez, C., & Torres-Luque, G. (2017). Effectiveness of a physical activity programme based on the Pilates method in pregnancy and labour. *Enfermería Clínica (English Edition)*, *27*(5), 271–277. https://doi.org/10.1016/j.enfcli.2017.05.008

Sabbaghian Rad, L., & Jahanshiri, A. (2013). Effect of a period of exercise during pregnancy on certain delivery parameters. *European Journal of Experimental Biology*, *3*(2), 78–85.

Salvesen, K. Å., & Mørkved, S. (2004). Randomised controlled trial of pelvic floor muscle training during pregnancy. *BMJ*, *329*(7462), 378–380. https://doi.org/10.1136/bmj.38163.724306.3A

Salvesen, K. Å., Stafne, S. N., Eggebø, T. M., & Mørkved, S. (2014). Does regular exercise in pregnancy influence duration of labor? A secondary analysis of a randomized controlled trial. *Acta Obstetricia et Gynecologica Scandinavica*, *93*(1), 73–79. https://doi.org/10.1111/aogs.12260

Sanda, B., Vistad, I., Sagedal, L. R., Haakstad, L. A. H., Lohne-Seiler, H., & Torstveit, M. K. (2018). What is the effect of physical activity on duration and mode of delivery? Secondary analysis from the Norwegian

Fit for Delivery trial. *Acta Obstetricia et Gynecologica Scandinavica*, *97*(7), 861–871. https://doi.org/10.1111/aogs.13351
Stephansson, O., Sandström, A., Petersson, G., Wikström, A. K., & Cnattingius, S. (2016). Prolonged second stage of labour, maternal infectious disease, urinary retention and other complications in the early postpartum period. *BJOG: An International Journal of Obstetrics & Gynaecology*, *123*(4), 608–616. https://doi.org/10.1111/1471-0528.13346
Tabari, M., Mirdar, S., Khaldan, A., & Ahmad Shirvani, M. (2010). The effect of aerobic exercise on pregnancy outcomes. *Journal of Babol University of Medical Sciences*, *12*(1), 36–43.
Toosi, M., & Akbarzadeh, M. (2016). The effect of aerobic exercises on maternal outcomes: A randomized controlled clinical trial. *Women's Health Bulletin*, *3*(4), e31337. https://doi.org/10.17795/whb-31337
Tseng, P.-C., Puthussery, S., Pappas, Y., & Gau, M.-L. (2015). A systematic review of randomised controlled trials on the effectiveness of exercise programs on Lumbo Pelvic Pain among postnatal women. *BMC Pregnancy and Childbirth*, *15*(1), 316. https://doi.org/10.1186/s12884-015-0736-4
Wiebe, H. W., Boulé, N. G., Chari, R., & Davenport, M. H. (2015). The effect of supervised prenatal exercise on fetal growth: A meta-analysis. *Obstetrics & Gynecology*, *125*(5), 1185–1194. https://doi.org/10.1097/aog.0000000000000801
Wolfe, L. A., & Weissgerber, T. L. (2003). Clinical physiology of exercise in pregnancy: A literature review. *Journal of Obstetrics and Gynaecology Canada*, *25*(6), 473–483. https://doi.org/10.1016/s1701-2163(16)30309-7
Zarezadeh, T., & Nemati, N. (2016). The effect of exercise on childbirth in primiparous women: A clinical trial study. *Nursing Practice Today*, *3*(2), 70–78.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Veisy A, Mohammad Alizadeh Charandabi S, Hematzadeh S, Mirghafourvand M. Effect of prenatal aerobic exercises on maternal and neonatal outcomes: A systematic review and meta-analysis. *Nurs Open*. 2021;8:2301–2317. https://doi.org/10.1002/nop2.838