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Physical activity during pregnancy and gestational weight gain depending on pre-pregnancy body mass index: systematic review and meta-analysis

Miguel Sánchez-Polán¹, Rita Santos-Rocha^{2,3*}, Dingfeng Zhang⁴, Cristina Silva-José⁴, Evelia Franco⁵ and Rubén Barakat⁴

Abstract

Background Maternal weight gain during pregnancy is one of the most important outcomes that healthcare professionals have, as excessive weight gain is associated with maternal, foetal, and newborn complications. However, the prevalence of excessive weight gain continues to increase worldwide. The benefits that physical activity could have during pregnancy have been demonstrated in several areas, including adequate control of weight gain, therefore, the objective of this meta-analysis was to examine the impact of physical activity during pregnancy on gestational weight gain.

Methods Systematic review and meta-analysis (Registration No.: CRD42022374014). Articles written in English and Spanish published between January 2010 and May 2024 were searched. This study exclusively included randomised controlled trials involving pregnant women and interventions consisting of physical activity during pregnancy. The primary outcome was gestational weight gain, and other outcomes were excessive weight gain and gestational weight gain depending on body mass index during pregnancy.

Results Fifty-four studies were included in this review. The intervention groups were compared with the control groups. Pregnant women in intervention groups experienced a significant reduction in gestational weight gain compared to control group ($z=4.73, p<0.001$), with greater effects in terms of mean differences to gain less gestational weight gain in supervised physical activity interventions and comprising various types of physical activity in the intervention programme, despite the absence of significant differences in the test for subgroup differences ($p>0.05$). Furthermore, the appearance of excessive gestational weight gain resulted in a large reduction in intervention group ($z=6.09, p<0.001$). Analyses based on body mass index before pregnancy revealed that women with normal weight in intervention group experienced lower gestational weight gain ($z=3.58, p<0.01$).

*Correspondence:
Rita Santos-Rocha
ritasantosrocha@esdrm.ipsantarem.pt

Full list of author information is available at the end of the article



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Conclusions Physical activity during pregnancy can help better control an adequate gestational weight gain, in women of normal weight, reduce the risk of excessive weight gain, and with a trend to better manage the weight gain after a supervised intervention or involving more than one type of physical activity.

Keywords Pregnancy, Physical activity, Exercise, Cardiovascular, Body composition, Women

Background

Adequate gestational weight gain (GWG) during pregnancy is a determining factor for the present and future health of mother and child; therefore, it is considered a basic and essential result to generate a healthy pregnancy, delivery, and postpartum process [1]. In this complex situation, the control of this parameter during pregnancy is critical, but also the Body Mass Index (BMI) at the beginning of pregnancy, because it will determine the limits to gaining weight during gestation. In this vein, the Institute of Medicine (IoM) in 2009, developed ranges of optimal weight gain during pregnancy guidelines, depending on pregestational BMI [2]. Overtaking these ranges during pregnancy will cause excessive GWG.

In this sense, the world population is currently in a 'global pandemic' that increases every year and affects the pregnant population [3]. Due to several factors, such as low levels of physical activity (PA) reported worldwide, poor nutrition habits, and other cultural and environmental factors, the percentage of overweight or obese people is frighteningly increasing. In 2016, World Health Organisation (WHO) estimates put overweight at 39% and obesity at 13% of the adult population [4]. The 2022 data for the European region are even more worrying, almost 60% of adults and approximately 30% of the child population were overweight or obese [5]. The strong association between high BMI in early pregnancy and excessive GWG has been scientifically demonstrated [2], as well as the increasing prevalence of pregnant women with excessive GWG pregnancy, recent evidence suggested that two of each five pregnant women gain more weight than recommended [6].

The consequences of this excessive gain during pregnancy pose significant risks to the general health and well-being of both mother and child, not only physiological factors, but could also be a determinant of increasing the risk of mental disorders such as prenatal major depression [7]. Among the most common complications are gestational diabetes mellitus (GDM), an increased risk of preterm delivery, a higher probability of caesarean delivery, or even affecting the newborn by increasing the risk of having a higher birth weight than usual for the number of weeks of gestation [8–10]. As mentioned above, overweight or obese pregnancies are also associated with psychological and emotional complications [2, 7].

The finding of preventive actions that aim to control weight gain during pregnancy by avoiding excess

is extremely necessary. As stated by American College of Obstetricians & Gynaecologists (ACOG), "Exercise, defined as physical activity consisting of planned, structured, and repetitive bodily movements done to improve one or more components of physical fitness, is an essential element of a healthy lifestyle (...)" [11]. Moderate intensity PA generates significant improvements in pregnancy outcomes without causing risks to maternal, foetal, and newborn well-being, implying benefits such as improved systolic blood pressure, lower instrumental and caesarean delivery rates, prevention of gestational diabetes mellitus (GDM), improvements in resting hearing rate, and foetal heart rate as demonstrated in several recent studies [12–15].

In the context of controlling GWG during pregnancy through PA, the scientific literature suggests positive effects [16, 17], while PA may be powerful in reducing excessive cases of GWG [13] and weight gain [18] during pregnancy. However, new scientific evidence is needed, and in this sense, it is highly recommended to rely on large-scale and high-quality studies, such as systematic review and meta-analysis (SR + MA) as the best value option within the body of scientific literature. Regarding weight gain during pregnancy, it is relevant to analyse continuous variables such as gestational weight gain throughout pregnancy (in kilogrammes) or classified according to BMI prior to pregnancy, as well as categorical aspects of great importance such as the percentage of pregnant women who exceed their limit of weight gain, in order to obtain robust conclusions.

The purpose of this systematic review was to examine the effect of PA interventions during pregnancy on GWG and the appearance of excessive weight gain.

Methods

A systematic review with five meta-analyses was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 [19] guidelines and the study was registered in the International Prospective Register of Systematic Reviews (PROSPERO). Registration number: CRD42022374014 [20].

Eligibility criteria and data items

Population

Pregnant women over 18 years of age, without obstetric contraindications that could imply a risk of exercising during pregnancy (supported by the last clinical guidelines for physical activity during pregnancy) [21, 22],

Table 1 Characteristics of the retrieved articles

Authors, year	Country	N	IG	CG	Intervention			Super	Dur	Adh	Main variables	Secondary variables
					Freq	Inten	Time					
Aktan et al., 2021 [28]	Turkey	43	21	22	2	Mod	8 w	Sup	60 min	NR	Weight gain, anxiety, and intensity of pain during labour	Birth outcomes, gestational age and duration of labour
Atkinson et al., 2022 [29]	Canada	241	119	122	3-4	Mod	22 w	Sup	40 min	NR	GWG	Depression, level of physical activity, demographic and obstetrical outcomes
Babbar et al., 2016 [30]	USA	46	23	23	3	Mod	8 w	Sup	60 min	NR	Umbilical artery Doppler results	Maternal blood pressure, heart rate, uterine contraction, foetal heart rate and weight gain
Bacchi et al., 2018 [31]	Argentina	111	49	62	3	Low-Mod	25.8 ± 3.3 w	Sup	55-60 min	80%	GWG and birth weight	Gestational age, birth weight categories, and newborn outcomes
Barakat et al., 2011 [32]	Spain	67	34	33	3	Low-Mod	28 w	Sup	35-45 min	85%	Urinary incontinence and health status	GWG, gestational age, type of delivery, delivery lacerations, blood pressure, etc.
Barakat et al., 2012a [33]	Spain	83	40	43	3	Low-Mod	28 w	Sup	35-45 min	85%	Maternal glucose screening, weight gain, and gestational diabetes mellitus	Maternal characteristics and other pregnancy outcomes
Barakat et al., 2012b [18]	Spain	290	138	152	3	Low-Mod	28 w	Sup	40-45 min	87%	Type of delivery, pregnancy outcomes (including GWG)	Maternal characteristics
Barakat et al., 2013 [34]	Spain	428	210	218	3	Low-Mod	28 w	Sup	50-55 min	95%	Glycemia and gestational diabetes mellitus	Gestational body weight gain, birth weight, Apgar scores and delivery outcomes
Barakat et al., 2014 [35]	Spain	200	107	93	3	Low-Mod	28 w	Sup	55-60 min	95%	Gestational age, weight gain, type of delivery, blood pressure, gestational diabetes mellitus	Birth weight, head circumference, Apgar score, pH of umbilical cord
Barakat et al., 2016 [36]	Spain	765	382	383	3	Mod	28 w	Sup	50-55 min	80%	Diastolic and systolic arterial blood pressure, and hypertension	Type of delivery, total GWG, birth weight
Barakat et al., 2018a [37]	Spain	429	227	202	3	Mod	28 w	Sup	55-60 min	80%	Duration of labour stages, type of delivery, and use of epidural	GWG, maternal gestational age, birth weight, Apgar scores, and pH of the umbilical cord blood
Barakat et al., 2018b [38]	Spain	65	33	32	3	Mod	28 w	Sup	55-60 min	85%	Placental weight	Gestational age, type of delivery, gestational diabetes, hypertension, and GWG

Table 1 (continued)

Authors, year	Country	N	IG	CG	Intervention			Super	Dur	Adh	Main variables	Secondary variables	
					Freq	Inten	Time						
Barakat et al., 2019 [39]	Spain	456	234	222	3	Mod	28 w	Aerobic, light muscle strengthening, coordination and balance, stretching, pelvic floor, and relaxation exercises	Sup	55–60 min	80%	Weight gain and prevalence of gestational diabetes	Maternal gestational age at delivery, type of delivery and birth weight
Bhartia et al., 2019 [40]	India	78	38	40	3	Mod	12 w	Yoga	Sup and unsup	50 min	NR	Perceived Stress Score and heart rate variability	Weight gain, birth weight, type of delivery
Bojanić et al., 2022 [41]	Bosnia and Herzegovina	70	35	35	3	Mod	8 w	Walking, strength and stretching exercises	Sup	45 min	NR	GWG, blood pressure, and nailfold capillary density	NR
Brik et al., 2019 [42]	Spain	85	42	43	3	Low-Mod	28 w	Cardiovascular, strengthening, coordination and balance, pelvic floor, and stretching exercises	Sup	60 min	70%	GWG and postpartum weight loss	Type of delivery, gestational age, and perinatal outcomes
Clark et al., 2019 [43]	USA	36	14	22	3	Mod	22 w	Aerobic exercises	Sup	50 min	79%	Maternal body mass index, lipid levels, and GWG	Birth weight
Cordero et al., 2012 [44]	Spain	55	25	30	3	Mod	28 w	Aerobic, strengthening, and pelvic floor exercises in land and water-based activities	Sup	50 min	NR	GWG and oral glucose	Sociodemographic maternal variables, delivery and neonatal outcomes
Cordero et al., 2015 [45]	Spain	342	122	220	3	Mod	28 w	Aerobic, strengthening, and pelvic floor exercises in land and water-based activities	Sup	50–60 min	80%	Gestational diabetes mellitus	Weight gain, gestational age at delivery, type of delivery, birthweight, and maternal characteristics
Daly et al., 2017 [46]	Ireland	88	44	44	3	Mod	20 w	Aerobics, strength, and pelvic floor exercises	Sup	50–60 min	78.9%	Maternal fasting plasma glucose	Excessive weight gain.
da Silva et al., 2017 [47]	Brazil	612	205	407	3	Mod	16 w	Aerobic, strength, and stretching exercises	Sup	60 min	70%	Preterm birth, pre-eclampsia, and gestational age	GWG, gestational diabetes, birth weight, infant length, and head circumference
Fernández-Buhigas et al., 2020 [48]	Spain	92	41	51	2	Mod	27 w	Cardiovascular, strengthening, coordination and balance, pelvic floor, and relaxation exercises	Sup	60 min	70%	Maternal systolic and diastolic blood pressure	GWG, fasting blood glucose levels, and other hepatic and renal outcomes
Garnæs et al., 2016 [49]	Norway	74	38	36	3	Mod-High	22–28 w	Treadmill walking/jogging, resistance, and pelvic floor exercises	Sup	60 min	50%	GWG	Body mass index, body composition, physical activity level, skinfold thickness, etc.
Garnæs et al., 2018 [50]	Norway	70	36	34	3	Mod	22–28 w	Walking on the treadmill, resistance, and pelvic floor strengthening exercises	Sup	60 min	NR	Pregnancy and postpartum weight retention	Blood pressure, fasting glucose, and sociodemographic data
Ghodsí & Asitoghiri, 2014 [51]	Iran	80	40	40	3	Mod	22–28 w	Cycling programme	Unsup	15 min	NR	Demographic characteristics and maternal outcomes (including GWG)	Neonatal outcomes

Table 1 (continued)

Authors, year	Country	N	IG	CG	Intervention			Main variables			Secondary variables			
					Freq	Inten	Time	Type	Super	Dur		Adh		
Haakstad et al., 2011 [52]	Norway	105	52	53	2	Mod	12 w	Aerobic and strength exercises	Sup and unsup	60 min	60%	GWG	Mean skin fold thickness and postpartum weight retention	
Haakstad et al., 2016 [53]	Norway	61	35	26	2	Mod	12 w	Aerobic and strength exercises	Sup and unsup	60 min	>80%	Mean adjusted difference in change in resting systolic and diastolic blood pressure	Mean adjusted difference in the change in systolic blood pressure during walking on the uphill treadmill at critical power, and other outcomes (including GWG)	
Hopkins et al., 2011 [54]	New Zealand	84	47	37	5	Mod	20 w	Aerobic exercises (at home)	Unsup	40 min	NR	Maternal outcomes (blood samples, GWG, and anthropometric variables)	Neonatal outcomes (birth size, birth weight, head circumference, etc).	
Kong et al., 2014 [55]	USA	37	18	19	5	Mod	20 w	Walking	Unsup	30 min	NR	Height, GWG, body mass index	Type of delivery, birth weight, and sociodemographic data	
McDonald et al., 2021 [56]	USA	74	42	32	3	Mod	24 w	Aerobic exercise in treadmill	Sup	60 min	80%	Neonatal weight, skinfold thickness, circumferences, and fat-free mass	GWG, gestational diabetes mellitus	
McDonald et al., 2022 [57]	USA	192	131	61	3	Mod	24 w	Aerobic and resistance exercises	Sup	60 min	80%	Maternal demographic and pregnancy-related characteristics and gestational weight gain	Type of delivery, gestational age and birth weight	
Menek & Kaya, 2024 [58]	Turkey	45	15	15	3	Low-mod	8 w	Stretching, aerobic, coordination and resistive exercises	Sup and unsup	NR	NR	Blood sample and quality of life	Demographic information (including weight gain)	
Nagal et al., 2020 [59]	Canada	43	23	20	3	Mod	16 w	Walking programme	Sup	40 min	80.2 ± 14.7%	Adherence	GWG and birth weight	
Nascimento et al., 2011 [60]	Brazil	80	39	41	1	Low-mod	14 w	Strengthening exercises	Sup	40 min	62.5% (Home exercises)	GWG	Arterial blood pressure, perinatal outcomes and quality of life	
Nobles et al., 2018 [61]	USA	241	118	123	7	Low-mod	12 w	Depending on participant preferences	Unsup	30 min	NR	GWG	Sociodemographic factors	
Oostdam et al., 2012 [62]	The Netherlands	121	62	59	2	Mod	25 w	Aerobic and strength exercises	Sup	60 min	NR	Fasting glucose, fasting insulin, and HbA1c, body weight, BMI, weight gain, and daily physical activity	Offspring measures and demographics variables	
Pelaez et al., 2019 [63]	Spain	345	230	115	3	Mod	24 w	Aerobic and major muscle groups resistance exercises	Sup	60–65 min	95.6%	GWG	Gestational diabetes, foetal macrosomia, and type of delivery	GWG, type of delivery, birth weight, and other pregnancy outcomes
Perales et al., 2015a [64]	Spain	167	90	77	3	Low-Mod	28 w	Aerobic, strengthening, pelvic floor, balance, and relaxation exercises	Sup	55–60 min	NR	Prenatal depression		

Table 1 (continued)

Authors, year	Country	N	IG	CG	Intervention			Super	Dur	Adh	Main variables	Secondary variables
					Freq	Inten	Time					
Perales et al., 2015b [65]	Spain	63	38	25	3	Mod	28 w	Aerobic, strengthening, pelvic floor, balance, and relaxation exercises	Sup	55–60 min	80%	Foetal heart rate Maternal and foetal recovery time to rest levels, maternal rate of perceived exertion, GWG, and other pregnancy outcomes Demographic data
Perales et al., 2016a [66]	Spain	166	83	83	3	Low-Mod	28 w	Aerobic, strengthening, pelvic floor, balance, and relaxation exercises	Sup	55–60 min	NR	Duration of labour, GWG, and other pregnancy outcomes
Perales et al., 2016b [67]	Spain	241	120	121	3	Low-mod	28 w	Aerobic, strength, pelvic floor and balance exercises	Sup	55–60 min	70%	Maternal cardiac adaptations Prevalence of maternal cardiovascular disease risk factors (including excessive weight gain) GWG and other pregnancy outcomes
Ramírez-Vélez et al., 2011 [68]	Colombia	50	26	24	3	Mod	16 w	Aerobic exercise	Sup	45 min	NR	Maximum oxygen consumption capacity, blood pressure Maternal demographic and pregnancy-related characteristics (including GWG)
Raper et al., 2021 [69]	USA	125	58	67	3	Mod	24 w	Aerobic exercise	Sup	50 min	80%	Neonatal birth measures
Rodríguez-Blanque et al., 2020 [70]	Spain	129	65	64	3	Mod	17 w	Aerobic, strength-endurance, and relaxation exercises	Sup	60 min	80%	Sociodemographic and anthropometric variables (including GWG) Intrapartum and neonatal outcomes
Roland et al., 2023 [71]	Denmark	219	87	45	3	Mod-Vig		Aerobic and resistance (in the gym). Swimming and water exercises (in pool)	Sup	60 min	NR	Obstetric and neonatal outcomes
Ruchat et al., 2012 [72]	Canada	94	49	45	3–4	Low-mod	16 w	Walking	Unsup	25–40 min	NR	Body mass index, birth weight, and other newborn outcomes
Ruiz et al., 2013 [73]	Spain	962	481	481	3	Low-mod	28 w	Aerobic and resistance exercises	Sup	50–55 min	97%	Maternal and foetal outcomes
Seneviratne et al., 2015 [74]	New Zealand	74	37	37	4–5	Mod	16 w	Stationary cycling programme	Unsup	15–30 min	33%	Maternal and paternal socio-demographic variables
Silva-Jose et al., 2022a [75]	Spain	139	69	70	3	Mod	30 w	Aerobic, strengthening, coordination and balance, pelvic floor, and relaxation	Sup	55–60 min	80%	Body mass index, GWG
Silva-Jose et al., 2022b [76]	Spain	157	78	79	3	Mod	30 w	Aerobic, strengthening, coordination and balance, pelvic floor, and relaxation exercises	Sup	55–60 min	80%	Maternal gestational age, type and mode of delivery, birth weight, birth length, Apgar scores and umbilical cord pH of the umbilical cord
Taniguchi et al., 2016 [77]	Japan	107	54	53	3	Mod	8 w	Walk briskly	Unsup	30 min	80%	Pregnancy outcomes (GWG) mood states

Table 1 (continued)

Authors, year	Country	N	IG	CG	Intervention			Super	Dur	Adh	Main variables	Secondary variables
					Freq	Inten	Time					
Uria-Minguito et al., 2022 [13]	Spain	260	130	130	3	Mod	30 w	Sup	50-60 min	NR	Diagnosis of gestational diabetes mellitus	Maternal characteristics (including GWG), and childbirth data
Ussher et al., 2015 [78]	UK	140	74	66	3-4	Low	4 w	Sup	20 min	NR	Continuous smoking abstinence	GWG, depression, birth outcomes, withdrawal symptoms and urges to smoke
Wang et al., 2017 [79]	China	265	132	133	3	Low - Mod	18 w	Sup	60 min	75%	Gestational diabetes mellitus	GWG, mode of delivery, gestational age at delivery, Apgar score, birthweight

IG (Intervention Group), CG (Control Group), Freq (Weekly frequency of sessions), Inten (Intensity), Time (Duration of the intervention programme), Super (Supervision of sessions by a qualified exercise professional), Dur (Session duration), Adh (Adherence to the programme), Mod (Moderate), Vig (Vigorous), Sup (Supervised), Unsup (Unsupervised), NR Not reported

carrying a physical activity intervention programme during their pregnancies, were evaluated for eligibility.

Intervention

Physical activity interventions were searched, excluding those interventions based only on advising or not performing quantifiable physical activity, necessarily including at least two comparable study groups (normally intervention and control groups, the first group performing the intervention and the other group not performing it). The intervention programmes were descriptively analysed in Table 1, including intensity, duration, developed exercises, and weekly frequency of sessions, but also supervision and participation in the full intervention.

Comparison

Study-randomised participants whose result is a control group (CG), not developing the intervention programme, but also not involving other types of physical activity during pregnancy, generally receiving the usual obstetric follow-up or counselling, were compared to the participants in the Intervention Group (IG).

Outcomes

GWG during pregnancy and weight gain were searched based on pregestational BMI measured at the end of gestation. Participants in the underweight index were not independently analysed in a specific meta-analysis due to the lack of published articles.

Information sources, search strategy, and selection process

Academic Search Premier, Education Resources Information Center, MEDLINE, SPORTDiscus, OpenDissertations (all included in EBSCO), Clinicaltrials.gov, Web of Science, Scopus, Cochrane Database of Systematic Reviews and Physiotherapy Evidence Database (PEDro) were used to search articles published between January 2010 and May 2024 and written in English and Spanish, retrieving articles from October 2022 to May 2024 The search terms were:

- English: [Gestational weight gain OR maternal weight gain OR weight gain OR weight retention] AND [pregnancy OR pregnant OR prenatal OR antenatal OR perinatal OR maternal] AND [exercise OR physical activity OR fitness OR sport aerobic training OR strength training OR cardiovascular training] AND [randomized controlled trials OR RCT OR randomised control trials or randomized AND intervention.
- Spanish: Ganancia de peso gestacional o ganancia de peso materno o ganancia de peso o retención de peso Y embarazo o embarazada o prenatal o antenatal o perinatal o materno Y ejercicio o

actividad física o fitness o deporte o entrenamiento aeróbico o entrenamiento de fuerza o entrenamiento cardiovascular Y ensayo clínico aleatorizado o eca o ensayo controlado aleatorizado o aleatorizado Y intervención.

Data collection process

Randomised controlled trials (RCT) with the result of the GWG measure were searched (excluding articles without this measure despite having a weight mean at the end of pregnancy). Weight gain was evaluated (as possible) as a continuous variable, but also if it was reported as a categorical variable (presence of excessive gestational weight gain, generally following international guidelines on gestational weight gain with respect to pregestational BMI) [2]. Systematic reviews were also searched to compare the results of these articles with ours.

Data were extracted directly by writing the search results of retrieved abstracts in a Word file, and after the screening, publications were filtered to discard those articles that did not meet our inclusion criteria, first performed by one researcher, then extracted and supervised by two more researchers (discrepancies between researchers, when exist, were handled by having consensus between two researchers). The characteristics are reported in Table 1, including the author(s), year of publication, country, sample sizes of the study group, characteristics of the intervention and variables.

characteristics (previously described), main and secondary outcomes analysed in the retrieved studies, and, if included, cointervention. Duplicated articles were automatically removed after adding the references to a specific folder in the Mendeley reference manager software. To assess multiple reports from the same study (if there are), we decided to extract data from each report separately and then combine all the information.

After screening (performed by two independent researchers), data from the results sections (measured as the number of events or the mean and standard deviation of the selected outcomes), generally reported in the text or in the tables displayed in each article, were searched and extracted to perform the subsequent analyses. Characteristics on intervention, study groups, study design, and results of the articles to be systematically summarised were commonly selected in the Methods section.

Certainty assessment

As previously described and to provide high quality to the search of articles, we only chose randomised controlled trials published with selected outcomes and interventions. To assess the certainty of evidence and the importance of the results, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) guidelines was used in its version of the online guideline

development tool version available on the GRADEpro website [23, 24]. This assessment provides certainty of evidence based on the inconsistencies of the articles analysed for each outcome and allows researchers to give three scales of importance (i.e., ‘not important’, ‘important’, and ‘critical’) to the selected variables. This evaluation was performed independently by two researchers.

Study risk of bias and reporting bias assessments

To evaluate the risk of bias (RoB), the RoB version 2 through 5.4. version of RevMan (Review Manager) software, and based on the Cochrane Handbook [25] was used to determine potential sources of bias in the studies that were finally included in the study, involving selection (evaluating both random sequence generation and allocation concealment), performance (blinding of participants), attrition (incomplete outcome data), detection (blinding of outcome assessment) and reporting (selective reporting, evaluating discrepancies between the outcomes reported in protocol registration and described in the article) sources of bias, with low, high or unclear risk of bias determined in each source and article. Three different members of the team were involved in both assessments to reach a consensus on the statements. To quantify the potential publication bias in the analyses performed, the Egger regression test was used, as this measure could detect publication bias under conditions of low or moderate heterogeneity, which is commonly significant when test results are $p < 0.1$ [26].

Effect measurements and synthesis methods

In this systematic review, five meta-analyses were performed with the aim of synthesising existing evidence on the effect of physical activity on gestational weight gain according to BMI prior to pregnancy. First, a meta-analysis was performed that considered all women who participated in the RCTs included in the review, regardless of their pre-pregnancy BMI. The second meta-analysis also considered general gestational weight gain during pregnancy, dividing the articles into subgroups depending on the supervision or its absence, of PA programme during pregnancy, with the same evaluation as the first analysis performed. In the third, the articles were divided into two subgroups according to the number of PA performed during the intervention (one or more than one). For both meta-analyses to compare subgroup differences, the Chi-square (χ^2) test (2) was used. The confidence interval (CI) and mean differences (MD) were calculated for these analyses, assessing the effects sizes through the inverse variance (IV) analysis.

For the fourth meta-analysis, excessive gestational weight gain was searched as a dichotomous categorical result (yes/no) created following international guidelines to determine excessive weight gain. In this analysis, all

women who made up the sample of included studies were also included. In this case, the number of present events and the odds ratio (OR) of each study group were evaluated, with a Mantel-Haenszel (M-H) analysis to know the effect sizes. Subsequently, three independent meta-analyses were performed to assess the effect of physical activity on gestational weight gain in women of normal weight, overweight, and obese women (measures taken before pregnancy). The analysis approach used in these three meta-analyses was the same as in the first, second, and third meta-analyses. The effects sizes were calculated considering the following ranges: < 0.4 indicates a small effect; $0.4-0.7$ indicates a medium effect; > 0.75 indicates a large effect [27]. For all meta-analyses, the random effects model was selected due to the large differences observed between sample sizes (generally and per study groups) and characteristics observed in the analysed articles.

In all meta-analyses, a relative weight was assigned according to the sample size of the study groups per article, taking into account all articles and weights per analysis. The I^2 statistic was used to measure the presence of heterogeneity in each analysis, also providing a percentage of it, and managing the next levels of heterogeneity as: low $< 25\%$ moderate = 50% ; high $> 75\%$. Analyses were performed using Review Manager.

Results

Study selection

In this review, 1356 articles were first identified through six different databases, excluding 438 articles before screening. During the selection process, 804 articles were excluded because they did not meet the inclusion criteria or were nonrandomised controlled trials. 114 articles were evaluated in the full text search process, finally 54 [13, 18, 28–79] articles with 9,427 women involved in their interventions (Fig. 1).

Study characteristics

Throughout the intervention articles retrieved, the weeks ranged from four to thirty, also from low (or light) to moderate intensity (only with two articles archiving high intensity) [49, 71], performing weekly sessions in a range that varied between one and seven days per week. Most of the sessions were supervised (11 articles with unsupervised sessions or containing both types in their programme approach), with a duration between 15 and 65 min per session (Table 1).

Results of individual studies and syntheses

Effects of physical activity on gestational weight gain

Regarding the measurement of general gestational weight gain, 52 articles [13, 18, 28–44, 46–66, 68–79] were included in this meta-analysis that found significant

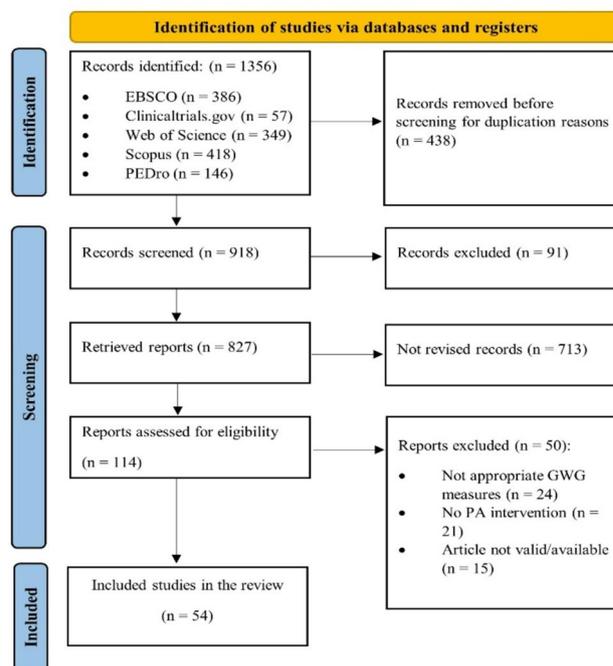


Fig. 1 Flow diagram of the searches performed

differences with large effects sizes ($z = 4.73$, $p < 0.001$; MD = -1.20 , 95% CI = $-1.70, -0.70$; $I^2 = 90\%$, $P_{\text{heterogeneity}} < 0.001$) between intervention and control groups, showing lower gestational weight gain in physically active pregnant women, as described in Fig. 2. In general, women who exercised during pregnancy reported a weight gain of 1.20 kg on average than women assigned to control groups. The analysis of potential publication bias did not result in a significant bias ($p = 0.790$) in the articles analysed.

Effects of supervised and unsupervised physical activity on gestational weight gain

52 articles [13, 18, 28–44, 46–66, 68–79] were selected (showing previously the general result in Fig. 2, and the result of the general bias of the publication) to evaluate the effects of physical activity by qualified exercise professionals on general gestational weight gain. This analysis showed a significant decrease in women who carried out a supervised physical activity programme [13, 18, 28–39, 41–50, 56–60, 62–71, 73, 75, 76, 78, 79] with large effects sizes ($z = 4.39$, $p < 0.001$; MD = -1.30 , 95% CI = $-1.88, -0.72$; $I^2 = 92\%$, $P_{\text{heterogeneity}} < 0.001$). However, significant differences were observed in unsupervised [40, 51–55, 58, 61, 72, 74, 77] physical activity programmes, also reporting moderate effect sizes ($z = 2.47$, $p = 0.01$; MD = -0.77 , 95% CI = $-1.38, -0.16$; $I^2 = 25\%$, $P_{\text{heterogeneity}} = 0.20$). Both results are represented in Fig. 3.

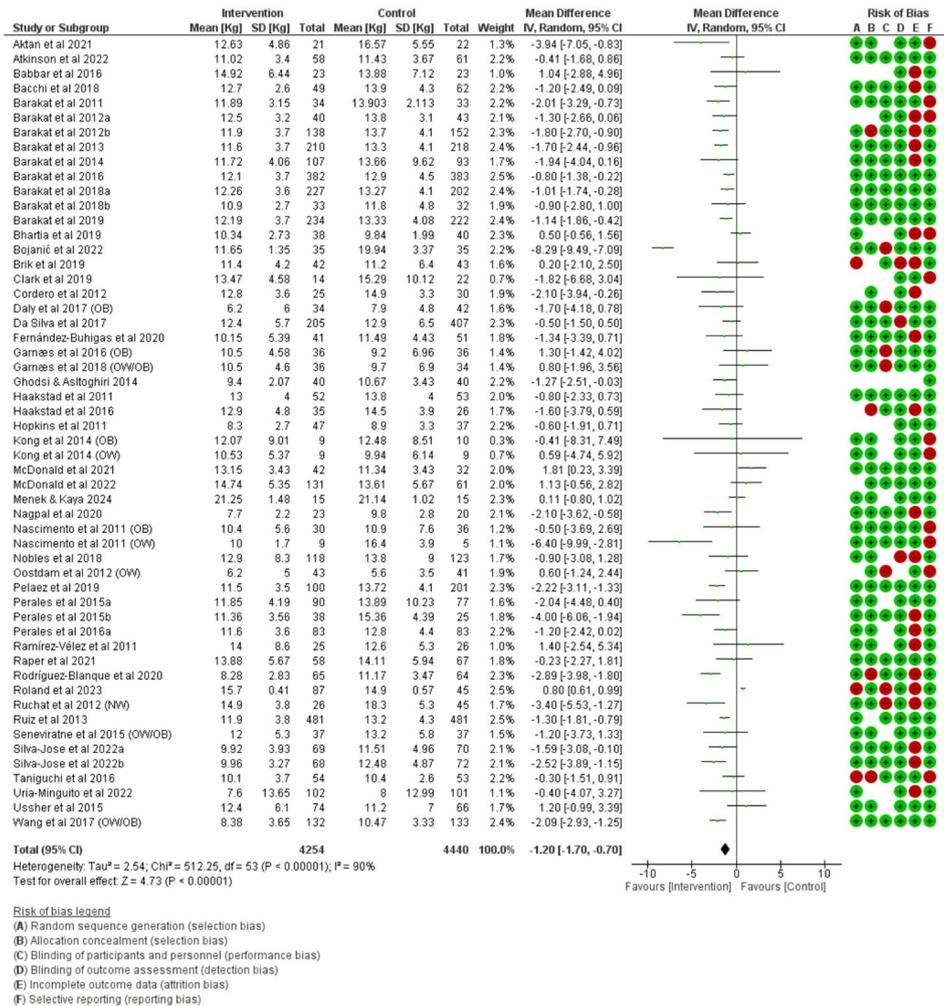


Fig. 2 Effects of physical activity on gestational weight gain [13, 18, 28–44, 46–66, 68–79]. OB, Obese; OW, Overweight

The test for subgroup differences did not reveal significant differences between subgroups ($\chi^2 (1) = 1.51; p = 0.22$). Potential publication bias was not observed in the overall analysis ($p = 0.675$) or in the first ($p = 0.356$) and second subgroups ($p = 0.599$).

Effects of physical activity on the number of physical activities developed through the intervention

In this analysis (Fig. 4), 52 articles [13, 18, 28–44, 46–66, 68–79] were included (overall result in Fig. 2) that evaluated the effects of the number of physical activities performed during the intervention (one or more than one type, i.e., multicomponent exercise), showing a significant reduction in gestational weight gain in women who performed only one type of physical activity during pregnancy [28–30, 40, 43, 51, 54, 55, 60, 68, 69, 72, 74, 77, 78] with large effect sizes ($z = 2.25, p = 0.02; MD = -0.85, 95\% CI = -1.59, -0.11; I^2 = 65\%, P_{\text{heterogeneity}} < 0.001$). However, a significant (and higher) reduction in weight gain during pregnancy in women who performed more than

one type of physical activity (multicomponent) during pregnancy [13, 18, 31–39, 41, 42, 44, 46–50, 52, 53, 57, 58, 61–66, 70–73, 75–77], with also large effect sizes ($z = 4.21, p < 0.001; MD = -1.35, 95\% CI = -1.98, -0.72; I^2 = 93\%, P_{\text{heterogeneity}} < 0.001$) was observed.

Analysis of subgroup differences did not find significant differences ($\chi^2 (1) = 1.03; p = 0.31$). After the Egger regression test, no significant publication bias was observed in the overall results ($p = 0.694$), in the first subgroup ($p = 0.971$), and in the second subgroup ($p = 0.718$).

Effects of physical activity on excessive weight gain

Twenty-three articles [13, 18, 29, 31, 35–39, 45, 47, 49, 52, 59, 61, 63–67, 73, 76, 78] evaluated excessive gestational weight gain (Yes/No), showing significantly more cases of excessive gestational weight gain in the control group ($z = 6.09, p < 0.001; OR = 0.59, 95\% CI = 0.49, 0.70; I^2 = 46\%, P_{\text{heterogeneity}} = 0.009$) than in the intervention group at the end of pregnancy, as shown in Fig. 4. According to

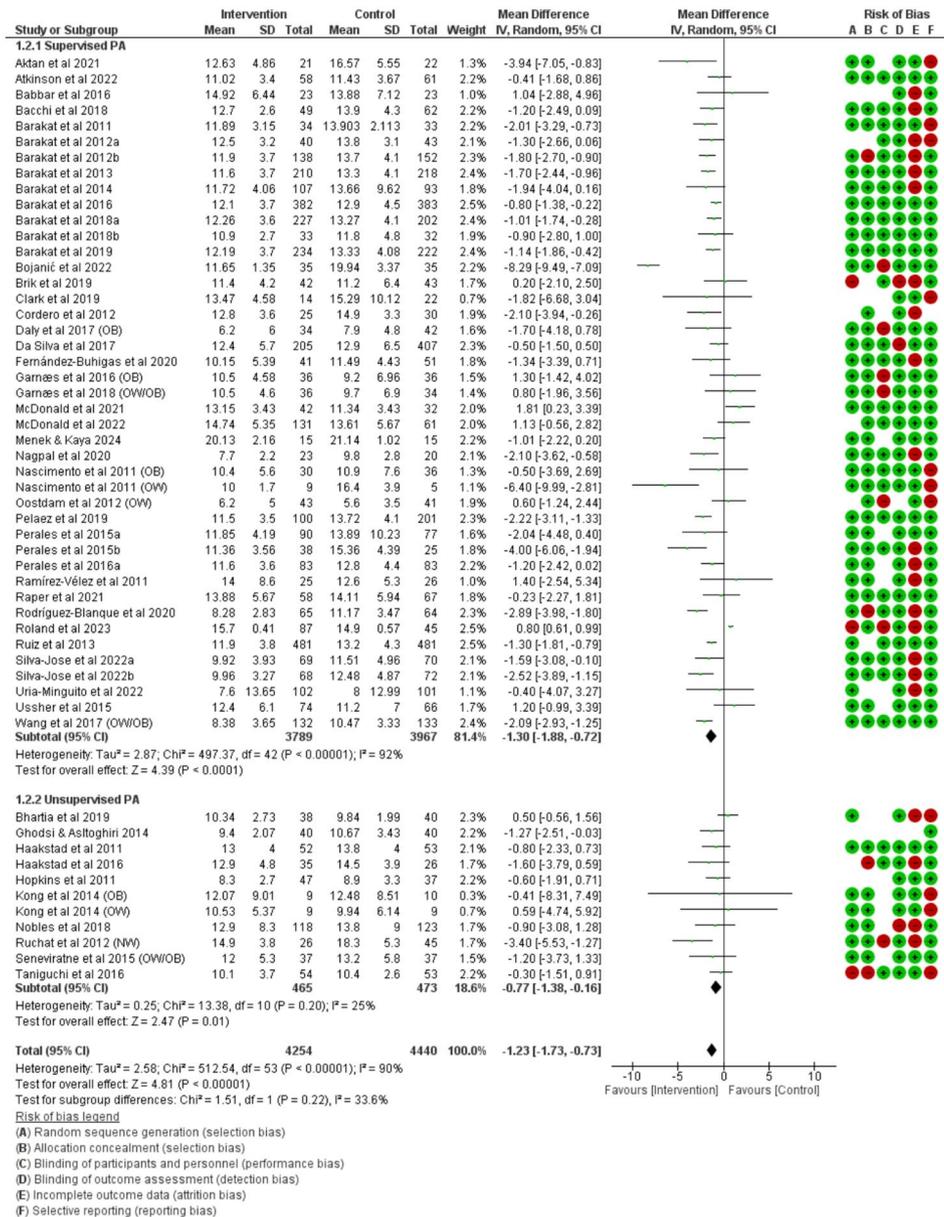


Fig. 3 Effects of supervised and unsupervised physical activity on gestational weight gain [13, 18, 28–44, 46–66, 68–79]. OB, Obese; OW, Overweight

the results, women in the CG showed 1.69 times higher odds of experiencing excessive gestational weight gain compared to women in the IG (Fig. 5). After the Egger regression test, no significant publication bias ($p = 0.818$) was observed in the selected articles.

Effects of physical activity on gestational weight gain in women of normal weight, overweight, and obese women

In Fig. 6, three meta-analyses were included. The first included six articles [29, 57, 72, 73, 75, 76] that showed significant differences and large effects sizes ($z = 3.58$, $p < 0.01$; MD = -1.36, 95% CI = -2.10, -0.62; $I^2 = 37%$, $P_{\text{heterogeneity}} = 0.16$) in gestational weight gain between

intervention and control groups (Fig. 6). In general, women who participated in IG reported an average weight gain of 1.36 kg less than women in CG. Quantification of publication bias did not reveal potential bias ($p = 0.287$). Regarding the second analysis, six articles [29, 55, 60, 62, 75, 76] were recovered without significant differences ($z = 1.94$, $p = 0.05$; MD = -1.93, 95% CI = -3.87, 0.02; $I^2 = 68%$, $P_{\text{heterogeneity}} = 0.008$) between participants in the control and intervention group, with significant publication bias ($p = 0.097$) reported. Finally, in the third meta-analysis, seven articles [29, 46, 49, 55, 60, 75, 76] were evaluated and did not show statistical differences with medium effect sizes ($z = 0.68$, $p = 0.50$; MD = -0.56, 95% CI = -2.18, 1.06; $I^2 = 56%$, $P_{\text{heterogeneity}} =$

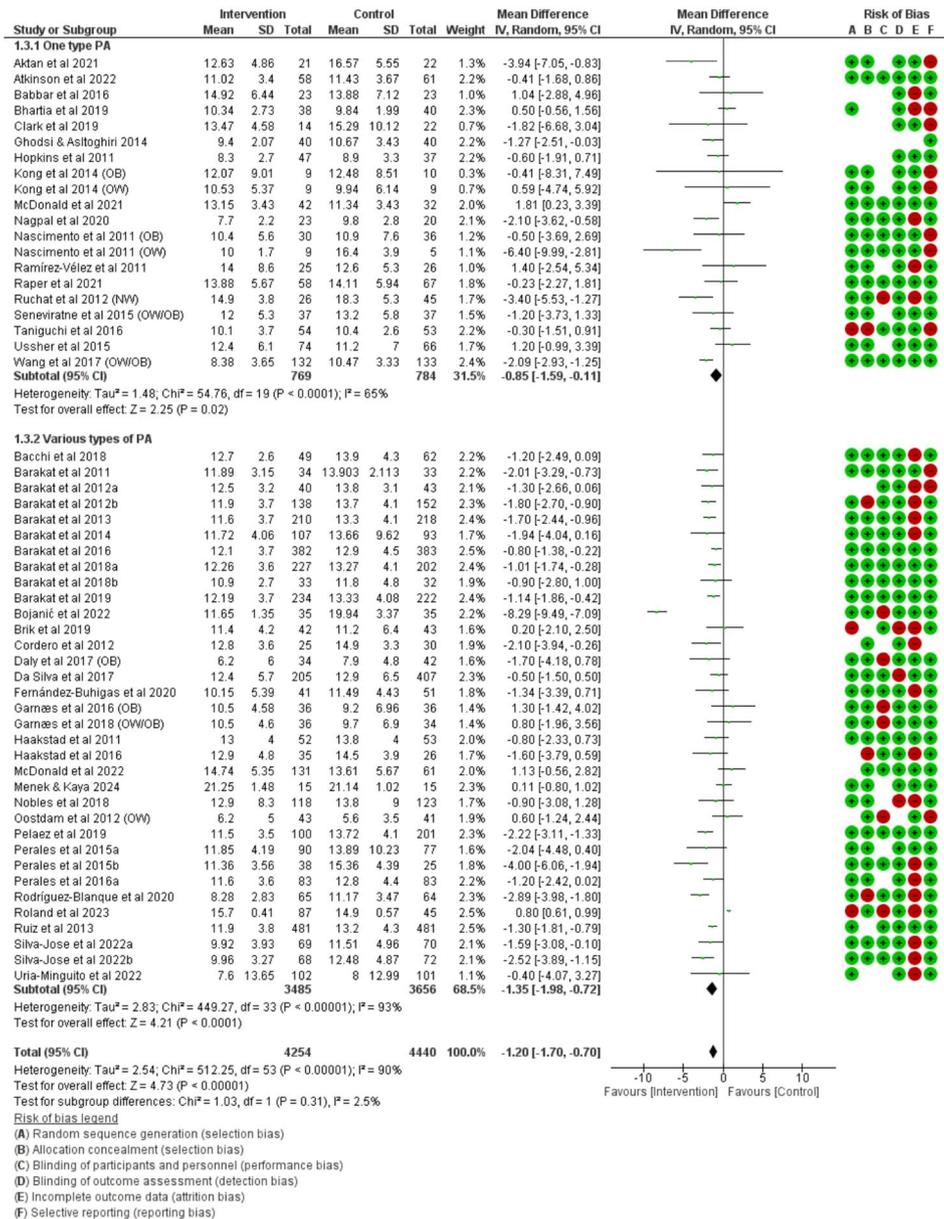


Fig. 4 Effects of physical activity on the number of physical activities developed through the intervention [13, 18, 28–44, 46–66, 68–79]. OB, Obese; OW, Overweight

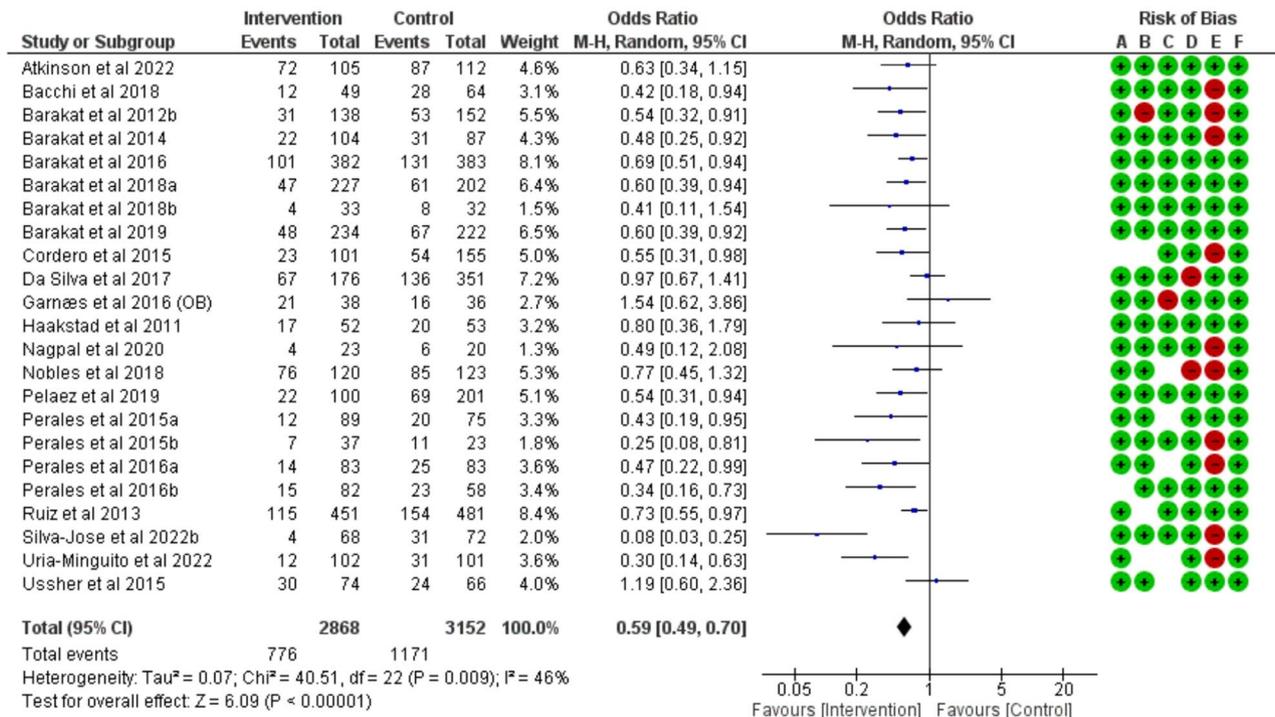
0.03) between study groups, also did not report statistically significant publication bias in selected articles ($p = 0.227$).

Risk of bias in studies, reporting biases, and certainty of evidence

In the present study, only randomised controlled trials were included, resulting in high certainty (since the articles did not show an overall high risk of bias, inconsistencies, indirectness, or imprecisions in their results) and high to critical importance of the analysed results (depending on the effect size evaluated by the GRADEpro

tool for each outcome, we decided to downgrade or not the importance).

No serious risk of bias was identified among the recovered articles. The most common risk of bias observed was related to performance or sources of attrition, where some articles had an unclear risk of bias due to not reporting the inclusion of participants after randomisation or the inability to blind the participants. Furthermore, certain articles showed a high risk of sources of bias in terms of attrition due to a significant dropout rate between study groups and also unclear selection bias due to the randomisation sequence or allocation procedure, as depicted in Figs. 2, 3, 4, 5 and 6.



Risk of bias legend

- (A) Random sequence generation (selection bias)
- (B) Allocation concealment (selection bias)
- (C) Blinding of participants and personnel (performance bias)
- (D) Blinding of outcome assessment (detection bias)
- (E) Incomplete outcome data (attrition bias)
- (F) Selective reporting (reporting bias)

Fig. 5 Effects of physical activity on excessive weight gain [13, 18, 29, 31, 35–39, 45, 47, 49, 52, 59, 61, 63–67, 73, 76, 78]. OB, Obese

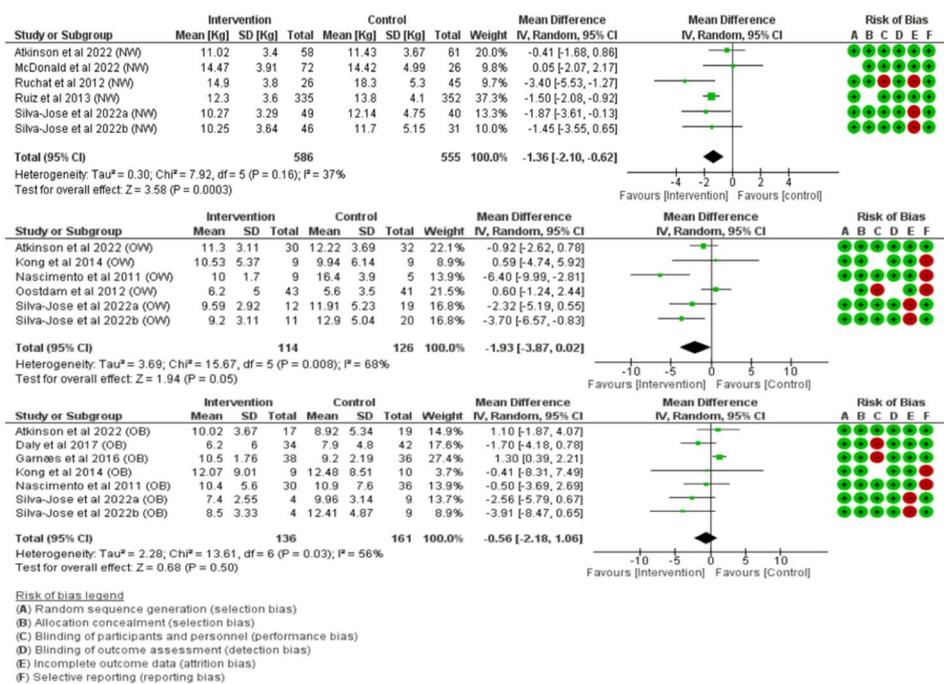


Fig. 6 Effects of physical activity on gestational weight gain in women of normal weight [29, 57, 72, 73, 75, 76], overweight [29, 55, 60, 62, 75, 76], and obese [29, 46, 49, 55, 60, 75, 76]. NW, Normal weight; OW, Overweight; OB, Obese

Discussion

This systematic review evaluated the effects of physical activity during pregnancy on total gestational weight gain, excessive gains, and weight gain depending on BMI before pregnancy, obtaining 54 RCTs and five different meta-analyses. From a scientific perspective, this approach has allowed comparison of data from IG (includes regular obstetric care and physical activity) with CG (involves only regular obstetric care) in all meta-analyses. This has been essential in assessing the true impact of physical activity during pregnancy with a high level of reliability.

In a general analysis, the results provided by the different meta-analyses show a positive association of physical activity during pregnancy with improved control of maternal weight gain. From a health point of view, these findings confirm the recommendations of international organisations on a minimum burden of 150 min per week of moderate physical activity throughout pregnancy as a promoter of favourable maternal, foetal, and neonatal outcomes [11, 21, 80, 81], with 37 of the included articles achieving this recommendation in their interventions [13, 29–31, 34–40, 42–47, 49, 50, 54–57, 61, 63–67, 69–76, 79]. Specifically, supervised physical activity interventions were found to potentially increase the effect of physical activity performance by allowing pregnant women to gain less weight than unsupervised interventions, despite the absence of significant differences between subgroups ($p > 0.05$). This result supports the ACOG guideline on physical activity during pregnancy [11].

Furthermore, it is crucial to have involved a multi-disciplinary team in which obstetrician, gynaecologists and other obstetric care providers encourage pregnant women to continue or begin exercise as an important component of optimal health [11], and physical activity and exercise professionals supervise and guide customised exercise sessions, as this supervision could also increase participant adherence to the programme [82].

On a specific examination of each meta-analysis, quantitative data demonstrate a lower mean maternal weight gain in pregnant women who participate in active pregnancy groups (IG) compared to those who do not (CG). The same trend is observed when analysing the normal weight subgroup classified by BMI at the beginning of pregnancy.

Furthermore, in terms of cases of excessive weight gain during pregnancy, the data reveal a lower percentage of IG compared to CG, and pregnant women in IG have a 41% lower probability of developing excessive weight gain during pregnancy.

This study may have important clinical implications. GWG is one of the main concerns that healthcare professionals must manage during pregnancy, because it could have adverse consequences, such as postpartum weight

retention or increased caesarean rates, combined with the risks of childhood overweight or obesity [1], but even for pregnant women who perceived this result as critical, avoidable, and commonly related to environmental factors [83]. By assuming that low to moderate PA following recommendations is safe and effective in reducing GWG, it may seem a powerful tool to promote PA in obstetric consultations, but also considering as essential the role of physical activity and sports science professionals who supervise the PA programme.

Other review studies have explored this scientific topic, indicating that physical activity can serve as an effective tool to reduce gestational weight gain [84–87]. Furthermore, physical activity has been suggested to help prevent excessive weight gain during pregnancy [86, 88]. These findings demonstrate a significant alignment with the results of the present study.

The review by Ruchat et al. [88] revealed that prenatal exercise has the potential to reduce the odds of excessive GWG and postpartum weight retention. However, it also indicated an increased risk of inadequate gestational weight gain. It is important to note that the authors themselves acknowledged that this finding should be interpreted with caution due to its reliance on a limited number of studies (five RCT) and may be the combination of an imbalance of several factors, such as caloric intake, energy expenditure, or medical reasons.

The study by Bennett et al. [89] aimed to assess the overall impact of interventions that aim to prevent excessive GWG on the incidence of gestational diabetes mellitus (GDM). Furthermore, the authors examined whether these effects varied according to maternal BMI or ethnicity. The results indicated that diet, PA, and lifestyle interventions (diet + PA) that focus on mitigating excessive GWG by targeting individual behaviours effectively reduced the incidence of GDM in women with varying levels of BMI better than standard care. However, the effectiveness of these interventions was relatively lower in women with a high pre-pregnancy BMI. These findings align closely with the results obtained in the present study.

Based on the findings of the meta-analyses conducted, it becomes evident that physical activity should be considered a mandatory and essential requirement for pregnant women who want to achieve adequate weight gain during gestation. However, more research is needed to identify more effective interventions for pregnant women with a high BMI at the beginning of pregnancy.

Evidence collected from articles and interventions suggests that a physical activity programme that includes multiple types of exercise [13, 18, 31–39, 41, 42, 44, 46–50, 52, 53, 57, 58, 61–66, 70–73, 75, 76] could produce better results compared to a programme with only one type, with a predominant focus on aerobic exercises

[28–30, 40, 43, 51, 54, 55, 60, 68, 69, 72, 74, 77, 78]. However, this should be taken with caution due to the absence of significant differences between both subgroups, hypothesising that by increasing the number of articles reporting this variable, the differences could be effective. Such multicomponent programmes appear to better meet the physiological demands of the maternal organism during pregnancy.

Furthermore, additional randomised controlled trials are warranted to confirm which types of physical activity interventions are more effective in reducing or preventing excessive gestational weight gain. This would further strengthen the evidence supporting the role of physical activity in promoting healthier pregnancy outcomes.

Strengths and limitations

Despite the large number of articles that were searched and included in this systematic review, it was possible to assume that due to the scarcity of published articles that specified weight gain depending on pregestational weight gain, underweight women were not included in this analysis. Additionally, a specific analysis of excessive GWG was not included depending on each pregestational BMI category, which is the biggest limitation of this study. Another limitation was that it was not possible to analyse subgroups of studies on the characteristics of diet or nutrition pattern during pregnancy due to the lack of articles that included or reported this assessment. Therefore, nutrition was not included in the analyses, as an outcome variable, because it was not possible to have enough articles having co-interventions based on nutrition. Furthermore, a significantly high publication risk of bias was observed in analyses related to overweight maternal weight gain. Although publication bias could be influenced by random effects analysis [90], we opted to include these articles with random effects analysis due to the large differences observed in study group sizes, so this analysis could effectively account for variabilities and differences between groups better than a fixed model. Another limitation was that we did not use a citation tracking assessment to ensure that all available references in the literature were selected.

The main strength of this systematic review lies in its exclusive inclusion of high-quality randomised controlled trials. This article provides evidence that physical activity is an effective strategy to reduce weight gain during pregnancy and may help prevent excessive GWG.

Furthermore, another strength is the number of studies analysed with five meta-analyses conducted. Using meta-analysis, a statistical method that combines the results of several trials to generate an average result, adds value because it produced a more precise estimate of the effect of an intervention than considering each study individually. Our meta-analyses suggest that supervised physical

activity interventions, an important role for qualified exercise professionals, are more effective in controlling weight gain during pregnancy than unsupervised programmes.

According to de Castro et al. [91], physical activity and exercise interventions lack standardised methodologies in the development, delivery and evaluation of such programmes due to their complexity, with respect to the different interacting components, interprofessional and intervention contexts. Moreover, the non-compliance with the Consensus on Exercise Reporting Template (CERT) [92] in all identified RCTs is a limitation to the replication and precision of the exercise programmes. However, using part of this template in Table 1 was useful in describing the characteristics of exercise programmes and detecting some gaps in interventions. Furthermore, this template also allowed comparisons between supervised and unsupervised interventions, in line with ACOG recommendations [11].

Conclusions

PA interventions based on prenatal exercise programmes, comprising a wide range of activities (multicomponent, mainly aerobic and strength exercises), showed promising potential to regulate total gestational weight gain within normal values and effectively manage weight gain, reducing the likelihood of developing excessive weight gain. Supervised physical activity interventions by qualified exercise professionals could suppose a more effective trend in gaining less weight during pregnancy than unsupervised PA. Sustained physical activity during pregnancy has been shown to be particularly beneficial for expectant mothers with a pre-pregnancy BMI that falls within the normal weight range, as it helps prevent excessive weight gain during pregnancy.

Abbreviations

ACOG	American College of Obstetricians and Gynecologists
Adh	Adherence
BMI	Body Mass Index
CERT	Consensus on Exercise Reporting Template
CG	Control Group
CI	Confidence Interval
Dur	Session duration
Freq	Weekly frequency of sessions
GDM	Gestational Diabetes Mellitus
GRADE	the Grading of Recommendations Assessment, Development and Evaluation
GWG	Gestational Weight Gain
IG	Intervention Group
Inten	Intensity
IoM	Institute of Medicine
IV	Inverse Variances
M-H	Mantel-Haenszel
MD	Mean Differences
Mod	Moderate
NR	Not reported
OR	Odds Ratio
PA	Physical Activity
PEdRo	Physiotherapy Evidence Database

PRISMA	the Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic reviews
RCT	Randomised Controlled Trials
RoB	Risk of Bias
SR + MA	Systematic Review + Meta-Analysis
Sup	Supervised
Super	Supervision of sessions by a qualified exercise professional
Time	Duration of the intervention programme
Unsup	Unsupervised
Vig	Vigorous
W	Week
WHO	World Health Organisation

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12884-026-08713-1>.

Supplementary Material 1
 Supplementary Material 2
 Supplementary Material 3
 Supplementary Material 4
 Supplementary Material 5
 Supplementary Material 6
 Supplementary Material 7
 Supplementary Material 8

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Authors' contributions

Conceptualization, M.S.-P., R.S.-R., E.F., and R.B.; methodology, M.S.-P., D.Z., and R.B.; software, M.S.-P., and C.S.-J.; validation, M.S.-P., R.S.-R., D.Z., and E.F.; formal analysis, M.S.-P., D.Z., C.S.-J., and R.B.; investigation, M.S.-P., R.S.-R., and R.B.; resources, E.F.; data curation, C.S.-J.; writing—original draft preparation, M.S.-P., R.S.-R., and R.B.; writing—review and editing, M.S.-P., R.S.-R., and R.B.; visualization, C.S.-J.; supervision, E.F. and R.B.; project administration, R.B.; funding acquisition, R.S.-R. All authors have read and agreed to the published version of the manuscript.

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Data availability

The datasets generated and/or analysed during the current study are available in the OSF repository, ([https://osf.io/vdn4j/?view_only=3bf1af8ff98445378d5af56e9000541d] ([https://osf.io/vdn4j/?view_only=3bf1af8ff98445378d5af56e9000541d])). The authors reserve the rights to reuse access to the information uploaded to the repository.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

- ¹GICAF Research Group, Department of Education, Research and Evaluation Methods, Universidad Pontificia Comillas, Madrid, Spain
- ²ESDRM - Department of Physical Activity and Health, Sport Sciences School of Rio Maior, Santarém Polytechnic University, Rio Maior, Portugal
- ³SPRINT – Sport Physical Activity and Health Research & Innovation Center, Rio Maior, Portugal
- ⁴AFIPE Research Group, Faculty of Physical Activity and Sport Sciences-INEF, Universidad Politécnica de Madrid, Madrid, Spain
- ⁵Departamento de Comunicación y Educación, Universidad Loyola Andalucía, Seville, Spain

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References

- Kominiarek MA, Peaceman AM. Gestational weight gain. *Am J Obstet Gynecol.* 2017;217(6):642–51.
- Rasmussen KM, Yaktine AL, Institute of Medicine (US), National Research Council (US). Committee to reexamine IOM pregnancy weight guidelines. *Weight Gain Dur Pregnancy: Reexamining Guidelines.* 2009;10:12584.
- Kent L, McGirr M, Eastwood KA. Global trends in prevalence of maternal overweight and obesity: A systematic review and meta-analysis of routinely collected data retrospective cohorts. *Int J Popul Data Sci.* 2024;9(2):2401.
- World Health Organization. Obesity and Overweight [online]. 2021. <https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight> (accessed 20 July 2023).
- World Health Organization. WHO European regional obesity report 2022. World Health Organization. Regional Office for Europe; 2022. <https://www.who.int/europe/publications/i/item/9789289057738>.
- Whitaker KM, Becker C, Healy H, Wilcox S, Liu J. Women's report of health care provider advice and gestational weight gain: a systematic review. *J Women's Heal.* 2021;30(1):73–89.
- Bodnar LM, Wisner KL, Moses-Kolko E, Sit D, Hanusa BH. Prepregnancy body mass index, gestational weight gain, and the likelihood of major depressive disorder during pregnancy. *J Clin Psychiatry.* 2009;70(9):15274.
- Samura T, Steer J, Michelis LD, Carroll L, Holland E, Perkins R. Factors associated with excessive gestational weight gain: review of current literature. *Glob Adv Heal Med.* 2016;5(1):87–93.
- Siega-Riz AM, Viswanathan M, Moos M-K, Deierlein A, Mumford S, Knaack J, et al. A systematic review of outcomes of maternal weight gain according to the Institute of medicine recommendations: birthweight, fetal growth, and postpartum weight retention. *Am J Obstet Gynecol.* 2009;201(4):339–e1.
- Koh H, Ee TX, Malhotra R, Allen JC, Tan TC, Østbye T. Predictors and adverse outcomes of inadequate or excessive gestational weight gain in an Asian population. *J Obstet Gynaecol Res.* 2013;39(5):905–13.
- American College of Obstetricians and Gynecologists (ACOG). Physical activity and exercise during pregnancy and the postpartum period: ACOG committee Opinion, number 804. *Obstet Gynecol.* 2020;135(4):e178–88.
- Silva-Jose C, Sánchez-Polán M, Díaz-Blanco Á, Coterón J, Barakat R, Refoyo I. Effectiveness of a virtual exercise program during COVID-19 confinement on blood pressure control in healthy pregnant women. *Front Physiol.* 2021;12:645136.
- Uriá-Minguito A, Silva-José C, Sánchez-Polán M, Díaz-Blanco Á, García-Benasach F, Carrero Martínez V, et al. The effect of online supervised exercise throughout pregnancy on the prevention of gestational diabetes in healthy pregnant women during COVID-19 pandemic: A randomized clinical trial. *Int J Environ Res Public Health.* 2022;19(21):14104.
- Moyer C, May L. Influence of exercise mode on maternal and fetal health outcomes (886.3). *FASEB J.* 2014;28:883–6.
- Michalek IM, Comte C, Desseauve D. Impact of maternal physical activity during an uncomplicated pregnancy on fetal and neonatal well-being parameters: a systematic review of the literature. *Eur J Obstet Gynecol Reprod Biol.* 2020;252:265–72.
- Vargas-Terrones M, Nagpal TS, Barakat R. Impact of exercise during pregnancy on gestational weight gain and birth weight: an overview. *Brazilian J Phys Ther.* 2019;23(2):164–9.
- Muktabhant B, Lawrie TA, Lumbiganon P, Laopaiboon M. Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *Cochrane Database Syst Rev.* 2015;2015(6):CD007145.

18. Barakat R, Pelaez M, Lopez C, Montejó R, Coteron J. Exercise during pregnancy reduces the rate of Cesarean and instrumental deliveries: results of a randomized controlled trial. *J Matern Neonatal Med.* 2012b;25(11):2372–6.
19. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. *J Clin Epidemiol.* 2021;134:103–12.
20. Sánchez-Polán M, Santos-Rocha R, Zhang D, Silva-Jose C, Franco E, Barakat R. Physical activity during pregnancy and gestational weight gain depending on pre-pregnancy body mass Index. Systematic review and meta-analysis. PROSPERO [Protocol]. 2022. CRD42022374014. https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022374014.
21. Mottola MF, Davenport MH, Ruchat SM, Davies GA, Potras VJ, Gray CE, et al. 2019 Canadian guideline for physical activity throughout pregnancy. *Br J Sports Med.* 2018;52(21):1339–46.
22. Barakat R, Díaz-Blanco A, Franco E, Rollán Malmierca A, Brik M, Vargas M, et al. Guías clínicas Para El ejercicio físico Durante El Embarazo [Clinical guidelines for exercise during pregnancy; Spanish]. *Progresos Obstet Y Ginecol.* 2019;62(5):464–71.
23. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE an emerging consensus on rating quality of evidence and strength of recommendations. *Br Med J.* 2008;336(7650):924–6.
24. GRADEpro. Guideline Development Tool [Software]. McMaster University and Evidence Prime. 2022. Available from <https://gradepro.org>.
25. Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JAC. Chapter 8: Assessing risk of bias in a randomized trial [last updated October 2019]. In: Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al, editor(s). *Cochrane Handbook for Systematic Reviews of Interventions version 6.5.* Cochrane, 2024. Available from [cochrane.org/handbook](https://www.cochrane.org/authors/handbooks-and-manuals/handbook/current/chapter-08). <https://www.cochrane.org/authors/handbooks-and-manuals/handbook/current/chapter-08>.
26. Lin L, Chu H. Quantifying publication bias in meta-analysis. *Biometrics.* 2018;74(3):785–94.
27. Deeks JJ, Higgins JP, Altman DG, McKenzie JE, Veroniki AA (editors). Chapter 10: Chapter 10: Analysing data and undertaking meta-analyses [last updated November 2024]. In: Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al, editor(s). *Cochrane Handbook for Systematic Reviews of Interventions version 6.5.* Cochrane, 2024. Available from [cochrane.org/handbook](https://www.cochrane.org/authors/handbooks-and-manuals/handbook/current/chapter-10). <https://www.cochrane.org/authors/handbooks-and-manuals/handbook/current/chapter-10>.
28. Aktan B, Kayıkçıoğlu F, Akbayrak T. The comparison of the effects of clinical pilates exercises with and without childbirth training on pregnancy and birth results. *Int J Clin Pract.* 2021;75(10):e14516.
29. Atkinson SA, Maran A, Dempsey K, Perreault M, Vanniyasingam T, Phillips SM, et al. Be healthy in pregnancy (BHIP): a randomized controlled trial of nutrition and exercise intervention from early pregnancy to achieve recommended gestational weight gain. *Nutrients.* 2022;14(4):810.
30. Babbar S, Hill JB, Williams KB, Pinon M, Chauhan SP, Maulik D. Acute fetal behavioral response to prenatal yoga: a single, blinded, randomized controlled trial (TRY yoga). *Am J Obstet Gynecol.* 2016;214(3):399–e1.
31. Bacchi M, Mottola MF, Perales M, Refoyo I, Barakat R. Aquatic activities during pregnancy prevent excessive maternal weight gain and preserve birth weight: A randomized clinical trial. *Am J Heal Promot.* 2018;32(3):729–35.
32. Barakat R, Pelaez M, Montejó R, Luaces M, Zakyntinkaki M. Exercise during pregnancy improves maternal health perception: A randomized controlled trial. *Am J Obstet Gynecol.* 2011;204(5):e4021–7.
33. Barakat R, Cordero Y, Coteron J, Luaces M, Montejó R. Exercise during pregnancy improves maternal glucose screen at 24–28 weeks: A randomised controlled trial. *Br J Sports Med.* 2012a;46(9):656–61.
34. Barakat R, Pelaez M, Lopez C, Lucia R, Ruiz JR. Exercise during pregnancy and gestational diabetes-related adverse effects: a randomised controlled trial. *Br J Sports Med.* 2013;47(10):630–6.
35. Barakat R, Perales M, Bacchi M, Coteron J, Refoyo I. A program of exercise throughout pregnancy. Is it safe to mother and newborn? *Am J Heal Promot.* 2014;29(1):2–8.
36. Barakat R, Pelaez M, Cordero Y, Perales M, Lopez C, Coteron J, et al. Exercise during pregnancy protects against hypertension and macrosomia: randomized clinical trial. *Am J Obstet Gynecol.* 2016;214(5):e6491–8.
37. Barakat R, Franco E, Perales M, López C, Mottola MF. Exercise during pregnancy is associated with a shorter duration of labor. A randomized clinical trial. *Eur J Obstet Gynecol Reprod Biol.* 2018a;224:33–40.
38. Barakat R, Vargas M, Brik M, Fernandez I, Gil J, Coteron J, et al. Does exercise during pregnancy affect placental weight? A randomized clinical trial. *Eval Health Prof.* 2018b;41(3):400–14.
39. Barakat R, Refoyo I, Coteron J, Franco E. Exercise during pregnancy has a preventative effect on excessive maternal weight gain and gestational diabetes. A randomized controlled trial. *Brazilian J Phys Ther.* 2019;23(2):148–55.
40. Bhartiya N, Jain S, Shankar N, Rajaram S, Gupta M. Effects of antenatal yoga on maternal stress and clinical outcomes in North Indian women: a randomised controlled trial. *J Indian Acad Clin Med.* 2019;20(1):11.
41. Bojanić V, Ljubojević V, Nožica-Radulović T, Lazović M. Research on the influence of prenatal exercises on anthropometric and vascular parameters in pregnant women. *Srp Arh Celok Lek.* 2022;150(5–6):330–5.
42. Brik M, Fernández-Buhigas I, Martín-Arias A, Vargas-Terrones M, Barakat R, Santacruz B. Does exercise during pregnancy impact on maternal weight gain and fetal cardiac function? A randomized controlled trial. *Ultrasound Obstet Gynecol.* 2019;53(5):583–9.
43. Clark E, Isler C, Strickland D, McMillan AG, Fang X, Kuehn D, et al. Influence of aerobic exercise on maternal lipid levels and offspring morphometrics. *Int J Obes.* 2019;43(3):594–602.
44. Cordero Rodríguez Y, Peláez Puente M, Miguel Abad MD, Perales Santaella M, Barakat Carballo R. ¿Puede El ejercicio físico moderado Durante El Embarazo actuar Como Un factor de prevención de La diabetes gestacional? *RICYDE Rev Int Cienc Deporte.* 2012;8(27):3–19.
45. Cordero Y, Mottola MF, Vargas J, Blanco M, Barakat R. Exercise is associated with a reduction in gestational diabetes mellitus. *Med Sci Sport Exerc.* 2015;47(7):1328–33.
46. Daly N, Farren M, McKeating A, O’Kelly R, Stapleton M, Turner MJ. A medically supervised pregnancy exercise intervention in obese women: a randomized controlled trial. *Obstet Gynecol.* 2017;130(5):1001–10.
47. da Silva SG, Hallal PC, Domingues MR, Bertoldi AD, Silveira MFD, Bassani D, et al. A randomized controlled trial of exercise during pregnancy on maternal and neonatal outcomes: results from the PAMELA study. *Int J Behav Nutr Phys Act.* 2017;14(1):1–11.
48. Fernández-Buhigas I, Brik M, Martín-Arias A, Vargas-Terrones M, Varillas D, Barakat R, et al. Maternal physiological changes at rest induced by exercise during pregnancy: A randomized controlled trial. *Physiol Behav.* 2020;220:112863.
49. Garnæs KK, Mørkved S, Salvesen Ø, Moholdt T. Exercise training and weight gain in obese pregnant women: a randomized controlled trial (ETIP trial). *PLoS Med.* 2016;13(7):e1002079.
50. Garnæs KK, Mørkved S, Salvesen Ø, Moholdt T. Exercise training during pregnancy reduces Circulating insulin levels in overweight/obese women postpartum: secondary analysis of a randomised controlled trial (the ETIP trial). *BMC Pregnancy Childbirth.* 2018;18:1–11.
51. Ghodsi Z, Asltooghiri M. Effects of aerobic exercise training on maternal and neonatal outcome: a randomized controlled trial on pregnant women in Iran. *JPMA J Pak Med Assoc.* 2014;64(9):1053–6.
52. Haakstad LAH, Bø K. Effect of regular exercise on prevention of excessive weight gain in pregnancy: a randomised controlled trial. *Eur J Contracept Reprod Heal Care.* 2011;16(2):116–25.
53. Haakstad LA, Edvardsen E, Bø K. Effect of regular exercise on blood pressure in normotensive pregnant women. A randomized controlled trial. *Hypertens Pregnancy.* 2016;35(2):170–80.
54. Hopkins SA, Baldi JC, Cutfield WS, McCowan L, Hofman PL. Effects of exercise training on maternal hormonal changes in pregnancy. *Clin Endocrinol.* 2011;74(4):495–500.
55. Kong KL, Campbell CG, Foster RC, Peterson AD, Lanningham-Foster L. A pilot walking program promotes moderate-intensity physical activity during pregnancy. *Med Sci Sports Exerc.* 2014;46(3):462–71.
56. McDonald SM, Isler C, Haven K, Newton E, Kuehn D, Kelley G, et al. Moderate intensity aerobic exercise during pregnancy and 1-month infant morphology. *Birth Defects Res.* 2021;113(3):238–47.
57. McDonald SM, Mouro S, Wisseman B, Isler C, DeVente J, Newton E, et al. Influence of prenatal exercise on the relationship between maternal overweight and obesity and select delivery outcomes. *Sci Rep.* 2022;12(1):17343.
58. Menek MY, Kaya AK. Comparison of home exercise under supervision and self home exercise in pregnant women with gestational diabetes: randomized controlled trial. *Arch Gynecol Obstet.* 2024;309:1075–82.
59. Nagpal TS, Prapavessis H, Campbell CG, de Vrijer B, Bgeginski R, Hosein K, et al. Sequential introduction of exercise first followed by nutrition improves program adherence during pregnancy: a randomized controlled trial. *Int J Behav Med.* 2020;27:108–18.
60. Nascimento SL, Surita FG, Parpinelli MA, Siani S, Pinto e Silva JL. The effect of an antenatal physical exercise programme on maternal/perinatal outcomes

- and quality of life in overweight and obese pregnant women: a randomised clinical trial. *BJOG: Int J Obstet Gynaecol.* 2011;118(12):1455–63.
61. Nobles C, Marcus BH, Stanek EJ III, Braun B, Whitcomb BW, Manson JE, et al. The effect of an exercise intervention on gestational weight gain: the behaviors affecting baby and you (BABY) study: a randomized controlled trial. *Am J Health Promot.* 2018;32(3):736–44.
 62. Oostdam N, Van Poppel MNM, Wouters MGAJ, Eekhoff EMW, Bekedam DJ, Kuchenbecker WKH, et al. No effect of the FitFor2 exercise programme on blood glucose, insulin sensitivity, and birthweight in pregnant women who were overweight and at risk for gestational diabetes: results of a randomised controlled trial. *BJOG-INT J OBSTET GY.* 2012;119(9):1098–107.
 63. Pelaez M, Gonzalez-Cerron S, Montejo R, Barakat R. Protective effect of exercise in pregnant women including those who exceed weight gain recommendations: A randomized controlled trial. *Mayo Clin Proc.* 2019;94(10):1951–9.
 64. Perales M, Refoyo I, Coteron J, Bacchi M, Barakat R. Exercise during pregnancy attenuates prenatal depression: a randomized controlled trial. *Eval Health Prof.* 2015a;38(1):59–72.
 65. Perales M, Mateos S, Vargas M, Sanz I, Lucia A, Barakat R. Fetal and maternal heart rate responses to exercise in pregnant women. A randomized controlled trial. *Arch Med Del Deport.* 2015b;32(6):361–7.
 66. Perales M, Calabria I, Lopez C, Franco E, Coteron J, Barakat R. Regular exercise throughout pregnancy is associated with a shorter first stage of labor. *Am J Heal Promot.* 2016a;30(3):149–57.
 67. Perales M, Santos-Lozano A, Sanchis-Gomar F, Luaces M, Pareja-Galeano H, Garatachea N, et al. Maternal cardiac adaptations to a physical exercise program during pregnancy. *Med Sci Sports Exerc.* 2016b;48(5):896–906.
 68. Ramírez-Vélez R, Aguilar de Plata AC, Mosquera-Escudero M, Ortega JG, Salazar B, Echeverri I, et al. Efecto Del ejercicio físico aeróbico sobre El Consumo de oxígeno de mujeres primigestantes saludables: estudio clínico Aleatorizado. *Rev Colomb Obstet Ginecol.* 2011;62(1):15–23.
 69. Raper MJ, McDonald S, Johnston C, Isler C, Newton E, Kuehn D, et al. The influence of exercise during pregnancy on racial/ethnic health disparities and birth outcomes. *BMC Pregnancy Childbirth.* 2021;21(1):1–9.
 70. Rodríguez-Blanque R, Aguilar-Cordero MJ, Marín-Jiménez AE, Núñez-Negrillo AM, Sánchez-López AM, Sánchez-García JC. Influence of a water-based exercise program in the rate of spontaneous birth: a randomized clinical trial. *Int J Environ Res Public Health.* 2020;17(3):795.
 71. Roland CB, Knudsen SD, Alomairah SA, Jessen AD, Jensen IK, Brændstrup N. Effects of prenatal exercise on gestational weight gain, obstetric and neonatal outcomes: fitmum randomized controlled trial. *BMC Pregnancy Childbirth.* 2023;23(1):214.
 72. Ruchat S-M, Davenport MH, Giroux I, Hillier M, Batada A, Sopper MM, et al. Nutrition and exercise reduce excessive weight gain in normal-weight pregnant women. *Med Sci Sport Exerc.* 2012;44(8):1419–26.
 73. Ruiz JR, Perales M, Pelaez M, Lopez C, Lucia A, Barakat R. Supervised exercise-based intervention to prevent excessive gestational weight gain: a randomized controlled trial. *Mayo Clin Proc.* 2013;88(12):1388–97.
 74. Seneviratne SN, Jiang Y, Derraik JGB, McCowan LME, Parry GK, Biggs JB, et al. Effects of antenatal exercise in overweight and obese pregnant women on maternal and perinatal outcomes: a randomised controlled trial. *BJOG.* 2016;123(4):588–97.
 75. Silva-Jose C, Sánchez-Polán M, Barakat R, Díaz-Blanco Á, Mottola MF, Refoyo I. A virtual exercise program throughout pregnancy during the COVID-19 pandemic modifies maternal weight Gain, smoking habits and birth weight—Randomized clinical trial. *J Clin Med.* 2022a;11(14):4045.
 76. Silva-Jose C, Sánchez-Polán M, Barakat R, Diaz-Blanco Á, Carrero Martínez V, García-Benasach F, et al. Exercise throughout pregnancy prevents excessive maternal weight gain during the COVID-19 pandemic: A randomized clinical trial. *J Clin Med.* 2022b;11(12):3392.
 77. Taniguchi C, Sato C. Home-based walking during pregnancy affects mood and birth outcomes among sedentary women: a randomized controlled trial. *Int J Nurs Pract.* 2016;22(5):420–6.
 78. Ussher M, Lewis S, Aveyard P, Manyonda I, West R, Lewis B, et al. The London exercise and pregnant smokers (LEAP) trial: a randomised controlled trial of physical activity for smoking cessation in pregnancy with an economic evaluation. *Health Technol Assess.* 2015;19(84):vii.
 79. Wang C, Wei Y, Zhang X, Zhang Y, Xu Q, Sun Y, et al. A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. *Am J Obstet Gynecol.* 2017;216(4):340–51.
 80. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World health organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med.* 2020;54(24):1451–62.
 81. Barakat R, Sánchez-Polán M, Silva-Jose C, Uria-Minguito A, Zhang D, et al. Guía de Práctica Clínica sobre la actividad física durante el embarazo. Universidad Politécnica de Madrid, Instituto de las Mujeres y Consejo Superior de Deportes, Madrid. 2023.ISBN: 978-84-09-49262-6 https://federacionmatronas.org/wp-content/uploads/2024/01/gpc_623_actividad_fisica_embarazo_up_m_compl-1.pdf.
 82. Sánchez-Polán M, Nagpal T, Barakat R. Knowledge into action: proposing an evidence-based group prenatal exercise prescription. *Perspect Public Health.* 2023;143(1):29–33.
 83. Vanstone M, Kandasamy S, Giacomini M, DeJean D, McDonald SD. Pregnant women's perceptions of gestational weight gain: A systematic review and meta-synthesis of qualitative research. *Matern Child Nutr.* 2017;13(4):e12374.
 84. Díaz-Burruero JR, Cano-Ibáñez N, Martín-Peláez S, Khan KS, Amezcua-Prieto C. Effects on the maternal-fetal health outcomes of various physical activity types in healthy pregnant women. A systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol.* 2021;262:203–15.
 85. Lamina S, Agbanusi EC. Effect of aerobic exercise training on maternal weight gain in pregnancy: a meta-analysis of randomized controlled trials. *Ethiop J Health Sci.* 2013;23(1):59–64.
 86. Sanabria-Martínez G, García-Hermoso A, Poyatos-León R, Álvarez-Bueno C, Sánchez-López M, Martínez-Vizcaino V. Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: a meta-analysis. *BJOG Int J Obstet Gynaecol.* 2015;122(9):1167–74.
 87. Wang J, Wen D, Liu X, Liu Y. Impact of exercise on maternal gestational weight gain: an updated meta-analysis of randomized controlled trials. *Med Baltim.* 2019;98(27):e16199.
 88. Ruchat S-M, Mottola MF, Skow RJ, Nagpal TS, Meah VL, James M, et al. Effectiveness of exercise interventions in the prevention of excessive gestational weight gain and postpartum weight retention: a systematic review and meta-analysis. *Br J Sports Med.* 2018;52(21):1347–56.
 89. Bennett CJ, Walker RE, Blumfield ML, Gwini SM, Ma J, Wang F, et al. Interventions designed to reduce excessive gestational weight gain can reduce the incidence of gestational diabetes mellitus: A systematic review and meta-analysis of randomised controlled trials. *Diabetes Res Clin Pract.* 2018;141:69–79.
 90. Henmi M, Copas JB. Confidence intervals for random effects meta-analysis and robustness to publication bias. *Stat Med.* 2010;29:2969–83.
 91. de Castro R, Antunes R, Mendes D, Szumilewicz A, Santos-Rocha R. Can group exercise programs improve health outcomes in pregnant women? An updated systematic review. *Int J Environ Res Public Health.* 2022;19(8):4875.
 92. Slade SC, Dionne CE, Underwood M, Buchbinder R. Consensus on exercise reporting template (CERT): explanation and elaboration statement. *Br J Sports Med.* 2016;50(23):1428–37.

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