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REVIEW ARTICLE

Obstetrics

An umbrella review of systematic reviews on interventions of physical activity before pregnancy, during pregnancy, and postpartum to control and/or reduce weight gain

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Abstract

Background: The increasing prevalence of overweight and obesity worldwide represents a (chronic) complex public health problem. This is also seen among women of childbearing age despite increased efforts to promote physical activity (PA) interventions. Excessive gestational weight gain (GWG) is associated with negative health outcomes for both mothers and offspring.

Objectives: To summarize current systematic reviews (SRs) on PA interventions during pregnancy and postpartum to prevent excessive GWG and identify the most effective approaches.

Search Strategy: A literature search was conducted on major electronic databases (MEDLINE/Pubmed, Cochrane, Web of Science, Epistemonikos) from inception to March 2023.

Selection Criteria: This study included SRs and meta-analyses of studies involving women aged 18 years or older from diverse ethnic backgrounds, who were either in the preconception period, pregnant, or within 1 year postpartum and who had no contraindications for exercise. Women with chronic diseases, such as pre-existing diabetes (type 1 or type 2) were excluded.

Data Collection and Analysis: Two reviewers extracted data from selected studies assessing the impact of PA in preconception, pregnancy, and postpartum. Methodologic quality was assessed with the AMSTAR-2 tool. A narrative summary of results addresses relationships between PA and weight before, during, and after pregnancy, informing future research priorities for preventing excessive weight gain. This study is registered on PROSPERO (CRD420233946666).

Main Results: Out of 892 identified articles, 25 studies were included after removing duplicates, unrelated titles, and screening titles and abstracts for eligibility.

Andrea Grau González and Ana Sánchez del Pino have equal authorship.

The results demonstrate that PA can help prevent excessive GWG and postpartum weight retention. Structured and supervised moderate-intensity exercise, at least twice a week, and each session lasting a minimum of 35 min seems to provide the greatest benefits.

Conclusions: Women who comply with the PA program and recommendations are more likely to achieve adequate GWG and return to their pre-pregnancy body mass index after delivery. Further research is warranted to explore how preconception PA influences pregnancy and postpartum outcomes given the absence of identified preconception-focused interventions.

KEYWORDS
gestational weight gain, physical activity, postpartum body mass index (BMI), pregnancy, intervention

1 | INTRODUCTION

The increasing prevalence of overweight and obesity worldwide represents a chronic complex public health problem.[1,2] Statistical data corroborate that overweight and obesity increasingly affect younger people.[3] Additionally, the prevalence of overweight and obesity in women of childbearing age has significantly increased, with about half of US women falling into this category.[4]

Women with obesity have a much higher risk of poor reproductive and obstetric outcomes, such as reduced fertility, abortion, pregnancy complications (gestational diabetes mellitus, preeclampsia, cesarean section), and adverse postpartum events.[5] Moreover, it is associated with high birth weight, infant adiposity, and an increased risk of metabolic syndrome and childhood obesity.[6]

Physical activity (PA), defined as any bodily movement produced by the contraction of skeletal muscles, maintains and improves cardiorespiratory fitness, and reduces the risk of obesity and associated comorbidities.[7] The Preventive Activities and Health Promotion Program (PAPPS) expert suggests doing PA on a regular basis at a moderate-high intensity.[8] This also produces benefits for society and the health system.[9] World Health Organization (WHO) 2020 guidelines recommend types and intensity of PA for the population, including pregnant women.[10] However, in high-income countries, around 50% of women enter pregnancy above the recommended weight[11–13] and in low- and middle-income countries, obesity is a major health burden, coexisting alongside undernutrition.[14]

Pregnancy is a key driver of obesity in women. Compared with other age groups, US women aged 35–44 years have the greatest increase in obesity prevalence.[15] High preconception body mass index (BMI; calculated as weight in kilograms divided by the square of height in meters), excessive gestational weight gain (GWG) and postpartum weight retention are all independent factors that significantly contribute to adverse maternal outcomes,[16,17] such as gestational diabetes, gestational hypertension, or cesarean delivery, as well as adverse offspring outcomes,[18] including a greater risk of macrosomia, preterm birth, and large-for-gestational-age neonates.

The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women achieve at least 150 weekly minutes of moderate-intensity aerobic activity, such as brisk walking during and after pregnancy.[19] In the absence of obstetric or medical complications or contraindications, PA is safe.[20] Moreover, physical inactivity and excessive GWG have been recognized as independent risk factors for maternal obesity and related pregnancy complications.[19,21,22]

Improving healthy habits in pregnancy involves the practice of PA from the preconception stage. The preconception period provides an opportunity to encourage and support healthy behavior change.[23] Prenatal interventions designed to prevent excessive GWG resulted in an average risk reduction of 20%.[24] Many studies have shown that women do not exercise enough before pregnancy and reduce the level further once they become pregnant.[25–30] Only 26.2% of women in the European Union meet the WHO activity recommendation of at least 150 min of moderate-intensity aerobic exercise per week,[26] and around 9%–15% of pregnant women meet the current PA recommendations, with some women concerned that prenatal exercise may harm the fetus.[25]

Preconceptionally lifestyle interventions have not been implemented or incorporated into routine care to effectively prevent excessive GWG, partly because approximately 50% of pregnancies are unplanned.[31] More quality studies are needed that define the type, frequency, duration, and intensity of PA, and how best to implement it to achieve beneficial outcomes during preconception, pregnancy, and postpartum.[32]

The aim of this research was to overview systematic reviews (SRs) to summarize the current evidence on the effectiveness of PA-based interventions before, during, and after pregnancy to prevent and/or reduce excessive weight gain. In addition, it is proposed to find out which of these interventions has turned out to be more effective.

2 | METHODS

2.1 | Eligibility criteria

An inclusion/exclusion criteria list framework, based on PICOS questions was made to identify all the pertinent SRs: *Population*: Women planning pregnancy (3 months before conception), during pregnancy, or during the postpartum period (12 months after delivery); with normal weight, overweight and obesity; equal or over 18 years of age; *Intervention*: PA, exercise, fitness, sports. SRs with diet and PA intervention were included if in the randomized controlled trial (RCT) involved there was an intervention group receiving PA but not diet intervention; *Comparison*: Women planning pregnancy, during pregnancy, or during the postpartum period with standard antenatal care; *Outcome*: Prevention of excessive weight gain before, during, and after pregnancy; *Study design*: SRs or meta-analyses.

2.2 | Information sources

A comprehensive search of the literature was conducted in MEDLINE/PubMed, Cochrane Library, Web of Science, and Epistemonikos, from inception to March 2023.

2.3 | Search strategy

Initially, a search was performed in PROSPERO to assess the existing research status to avoid duplication. No comparable studies were identified at that time. Subsequently, a research protocol was performed and registered in PROSPERO (CRD42023394666). Due to the variety of search platforms among databases, as a strategy, different combinations of the key words (pre-pregnancy OR preconception OR women OR pregnancy OR "Postpartum Period" OR postnatal OR gestation) AND (exercise OR "physical activity" OR fitness OR sports) AND ("weight gain" OR "weight control" OR "body weight changes" OR "weight loss" OR "pregnancy outcome") were used (Table S1).

2.4 | Study selection

The search located SRs or meta-analyses of all interventions based on PA designed to prevent or control excessive GWG. Following the PRISMA guidelines,[33] studies were selected by two reviewers (A.G.G. and A.S.d.P.) if they met the following inclusion criteria: SRs and meta-analyses including studies that involved women aged 18 years or older of all ethnicities that were in the preconception period (3 months before pregnancy), pregnant, and/or within 1 year postpartum, without absolute or relative contraindications to exercise as defined by the 2015 ACOG recommendations for PA and exercise during pregnancy and the postpartum period.[19] Study population samples including women with normal weight or overweight or obesity, of any gestational stage and interventions of any duration, frequency, and intensity were included.

Studies specifically designed for women with gestational diabetes mellitus, pre-existing diabetes (type 1 or type 2) or other chronic diseases (kidney disease, hyperthyroidism, hypertension, or autoimmune disease) were excluded because of the variation in their nutritional and medication requirements. Records were managed using Zotero reference manager.

2.5 | Data extraction

Two reviewers (A.G.G. and A.S.d.P.) extracted the data regarding preconception, pregnancy, and postpartum: (1) SRs or meta-analyses that evaluate the effect of PA in the preconception and postpartum period; (2) SRs or meta-analyses that evaluate the effect of PA during pregnancy.

Data about characteristics of the studies and the most relevant results of each SR were extracted in duplicate (A.G.G. and A.S.d.P.). A third and fourth author were consulted if there was a lack of consensus among the reviewers (L.G.-V. and C.A.-P.).

2.6 | Assessment of risk of bias

To assess the methodologic quality of the included reviews, the AMSTAR-2 tool,[34] available at http://amstar.ca/Amstar-2.php, was applied, grading the studies in four groups: high (zero or one non-critical weakness); moderate (more than one non-critical weakness); low (one critical flaw with or without non-critical weaknesses); and critically low (more than one critical flaw with or without non-critical weaknesses).

2.7 | Data synthesis

A narrative summary of the main results in each study will be provided to highlight the main relationships observed between PA and weight before, during, and after pregnancy and to address the current state of knowledge and priorities for future research in this field to create a conceptual framework for the prevention and/or reduction of excessive weight gain.

3 | RESULTS

Eligible intervention studies are summarized in Figure 1. First, we identified 892 articles from four databases. After removing duplicates and unrelated titles, as well as screening the titles and abstracts, 112 studies were accessed and analyzed for eligibility. Finally, 25 studies were included. According to the stage of pregnancy, these studies were classified into the following categories:

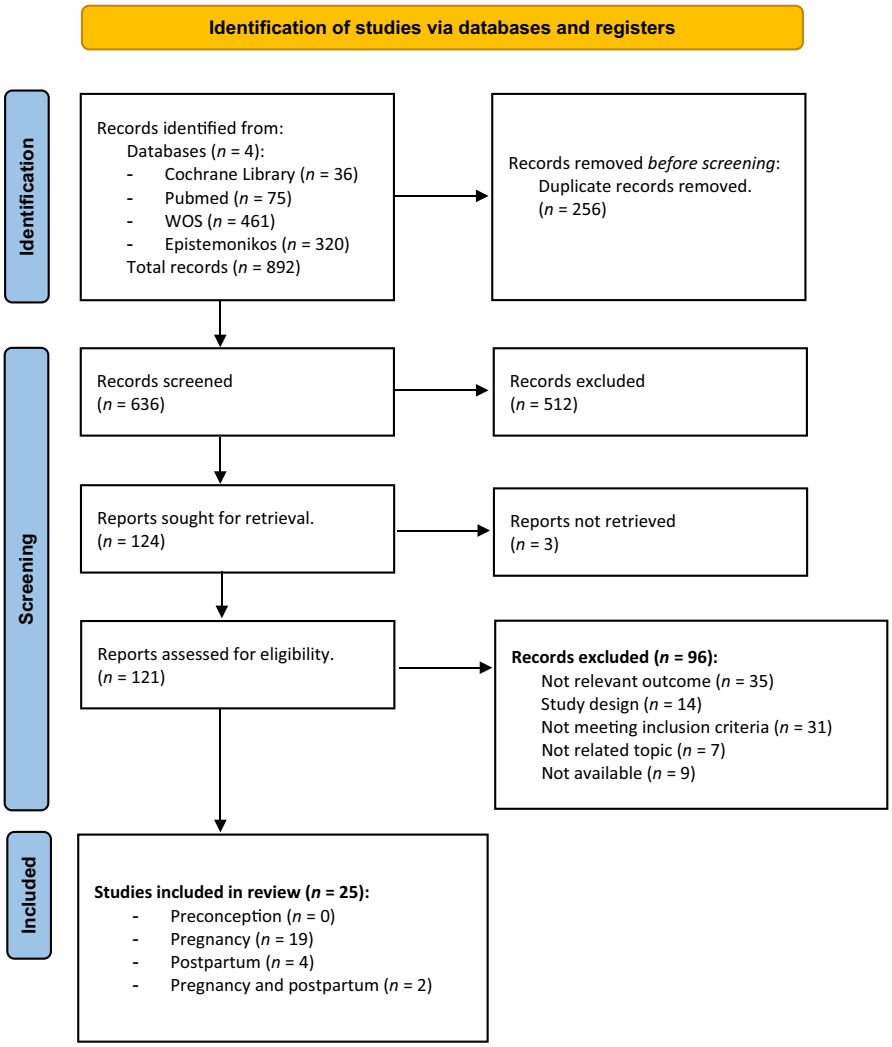

FIGURE 1 PRISMA flowchart.

preconception ($n=0$), pregnancy ($n=19$), pregnancy and postpartum ($n=2$), and postpartum ($n=4$).

The umbrella review included 13 SRs of clinical trials (RCTs or non-randomized clinical trials [NRCTs]), seven meta-analyses of exclusively RCTs, one SR of observational studies, one SR of RCTs and cohort studies, one SR that covered clinical trials (RCTs and NRCT) and cohort studies, one SR including RCTs, case–control studies, and cohort studies, and one SR of RCTs and quasi-experimental studies (Table 1).

3.1 | Characteristics of the included studies in pregnancy

Nineteen SRs included in this umbrella review analyzed various types of exercise interventions in pregnant women[35–53] without contraindications to exercise. SRs were published between 2011 and 2023 and conducted in Portugal (two), France (one), Spain (one), Brazil (three), Saudi Arabia (one), Indonesia (one), China (two), USA (two), Australia (one), Canada (one), South Africa (two), Thailand (one), and Germany (one) (Table 1).

Different approaches to weight categorization of pregnant women have been identified from the 19 articles mentioned. Specifically, two reviews were focused exclusively on pregnant women with a normal BMI[39,40] whereas four reviews focused on women with overweight or obesity.[37,45,50,53] These reviews specifically analyzed the effects of PA on high GWG, and the related implications for maternal health. The remaining 13 reviews included any type of BMI, thus covering pregnant women within different weight categories[35,36,38,41–44,46–49,51,52] (Table 1).

3.2 | Description of the interventions in pregnancy

The SRs and meta-analyses collected in this article included studies in which interventions vary in form, duration, and intensity. In general, women exercised two or three times a week for at least 20 min and up to 1 h performing aerobics, running, cycling, water aerobics, muscle resistance, or yoga. Seven of the reviews refer to studies based on interventions with supervised exercise programs.[37,40,41,45,49,50,53] One of the reviews focused on occupational

TABLE 1 General characteristics of the systematic reviews.

Author	Year	Country	Type of study	Inclusion criteria	Weight range	Stage of pregnancy	Gestational age	Intervention
Bernardo et al.	2023	Portugal	SR of RCTs	Adult pregnant women (≥18 years) with overweight and/or obesity, with singleton pregnancies and no medical contraindication to physical exercise	Overweight and/or obese women	Pregnancy	First and second trimesters	Structured physical exercise
de Castro et al.	2022	Portugal	SR of RCTs	Adult pregnant women without known pregnancy-related medical conditions	Normal weight women	Pregnancy	Any gestational age	Supervised group exercise programs
Hanley et al.	2022	UK	SR of RCTs	Healthy pregnant and postpartum women, aged ≥18 years and free from medication known to influence weight or exercise performance	Normal weight, overweight and obese women	Pregnancy and postpartum (12 months after delivery)	First and second trimester	Supervised groups (group and individual settings)
Hamann et al.	2022	France	SR of observational studies	Peer-reviewed articles written in English and published post-2000, limited to pregnant women and their PA	Any BMI (except underweight)	Pregnancy	Any gestational age	Self-reported PA
Díaz-Burrueco et al.	2021	Spain	SR and meta-analysis of RCTs	Healthy pregnant women without pathologies, with any BMI and with a single pregnancy	Any BMI (except underweight)	Pregnancy	Any gestational age	Various types of PA during pregnancy
Santos et al.	2021	Brazil	SR of RCTs	RCT that addressed the functional effects of water exercise in healthy women with singleton pregnancies	Any BMI (except underweight)	Pregnancy	Any gestational age	Physical exercises in the aquatic environment
Almalki et al.	2021	Saudi Arabia	SR of RCTs or NRCTs	Healthy, aged ≥18 years, pregnant with a singleton fetus and free from any medical problem	Any BMI (except underweight)	Pregnancy	Any gestational age	Occupational activity and leisure activity
Mullins et al.	2021	UK	SR of RCTs	RCTs that compared moderate and/or vigorous PA with no PA in postpartum	Any BMI (except underweight)	Postpartum (12 months after delivery)	Not mentioned	Postnatal PA interventions
Muhammad et al.	2021	Indonesia	SR and meta-analysis of RCTs	RCTs reporting physiologic and/or adherence outcomes in obesity/overweight pregnant women aged ≥18 years	Overweight and/or obese women	Pregnancy	Any gestational age	Supervised exercises

(Continues)

TABLE 1 (Continued)

Author	Year	Country	Type of study	Inclusion criteria	Weight range	Stage of pregnancy	Gestational age	Intervention
Chan et al.	2019	China	SR of RCTs and NRCTs	Healthy pregnant women aged ≥18 years, carrying a single pregnancy without medical or obstetrical contraindications to PA	Any BMI (except underweight)	Pregnancy	Any gestational age	Land-based PA interventions
Wang et al.	2019	China	SR of RCTs	(1) Published as RCTs; (2) pregnant women engaging in PA compared with conventional medical care; and (3) studies reporting maternal GWG during pregnancy	Any BMI (except underweight)	Pregnancy	Any gestational age	PA interventions (aerobic exercises, strength training, walking, cycling, or weight training)
Shieh et al.	2019	USA	SR of RCTs	Healthy overweight and/or obese pregnant adult women; GWG as a primary or secondary outcome	Overweight and obese women	Pregnancy	Any gestational age	Structured and supervised PA
Beetham et al.	2019	Australia	SR of RCTs and cohort studies	Studies reporting an intervention or reporting pregnant women (of any age) engaging in vigorous exercise	Any BMI (except underweight)	Pregnancy	Any gestational age	Vigorous (high-intensity) exercise
Ruchat et al.	2018	Canada	SR of RCTs, NRCTs and cohort studies	Pregnant women without contraindication to exercise	Any BMI (except underweight)	Pregnancy	Second and third trimester	Moderate-intensity exercise
Dodd et al.	2018	Australia	SR of RCTs	Women who had delivered a healthy singleton infant and were either overweight or obese, started pregnancy with a normal BMI but exceeded the IOM guidelines for GWG, or retained weight at the time of trial recruitment	Overweight or obese women	Postpartum	Not mentioned	Postpartum dietary and/or PA interventions
da Silva et al.	2017	Brazil	SR and meta-analysis of RCTs	Healthy pregnant women with normal weight, without comorbidities	Normal weight women	Pregnancy	Any gestational age	Structured exercise program and self-reported questionnaires
Watson et al.	2017	South Africa	SR of RCTs, case–control studies, and cohort studies	Studies conducted in developing countries that explored overweight/obesity in pregnant women and/or lifestyle interventions during pregnancy	Overweight and obese women	Pregnancy	Any gestational age	Supervised exercises

TABLE 1 (Continued)

Author	Year	Country	Type of study	Inclusion criteria	Weight range	Stage of pregnancy	Gestational age	Intervention
McDonald et al.	2016	USA	SR of RCTs and quasi-experimental studies	No restrictions placed on year of publication, country, pre-pregnancy BMI or gestational age at study entry	Any BMI (except underweight)	Pregnancy	From 8 weeks of pregnancy	Exercise interventions
Muktabhant et al.	2015	Thailand	SR of RCTs	Pregnant women of any BMI	Any BMI (except underweight)	Pregnancy	Any gestational age	Diet and/or exercise intervention
Lim et al.	2015	Australia	SR and meta-analysis of RCTs	Intervention studies involving modification of diet or PA, or both, for women in their first year postpartum	Any BMI (except underweight)	Postpartum	Not mentioned	Modification of diet and/or PA
Berger et al.	2014	USA	SR of RCTs	Women in the early postpartum period (up to 12 weeks following delivery) from any geographical and racial/ethnic background	Any BMI (except underweight)	Postpartum	Not mentioned	Interventions that included diet and/or exercise components
Lamina y Agbanusi	2013	Nigeria	SR and meta-analysis of RCTs	The study population defined was maternal weight with aerobic training	Any BMI (except underweight)	Pregnancy	Any gestational age	Moderate intensity aerobic exercise interventions
Choi et al.	2013	USA	SR and meta-analysis of RCTs	Overweight or obese pregnant women or after postpartum	Overweight and obese women	Pregnancy and postpartum	Any gestational age	PA and PA plus diet interventions
Nascimento et al.	2012	Brazil	SR of RCTs	Healthy pregnant women	Any BMI (except underweight)	Pregnancy	Any maternal age	Any form of physical exercise program
Streuling et al.	2011	Germany	SR and meta-analysis of RCTs	Healthy women with increased PA as the only intervention	Any BMI (except underweight)	Pregnancy	From the first trimester to delivery	Exercise interventions that varied by intensity, duration, and mode of activity

Note: Underweight: BMI <18.5; Normal weight: BMI 18.5–24.9; Overweight: 25–29.9; Obesity: >30.

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); GWG, gestational weight gain; IOM, Institute of Medicine; NRCT, nonrandomized clinical trial; PA, physical activity; RCT, randomized clinical trial; SR, systematic review.

activity related to women's occupation or housework, and leisure activity.[35] The remaining reviews[36,38,39,42–44,46–48,51,52] included unsupervised exercise programs such as video-game interventions, walking, stationary cycling, swimming, or pelvic floor muscle training (Table 2).

All but one[48] of the reviews included studies that initiated the interventions in the first trimester of pregnancy (although not all of them specified inclusion criteria regarding the gestational age of the mother to initiate the intervention) and persisted to the third trimester (Table 1).

3.3 | Main outcomes in pregnancy

Twelve out of 19 SRs in pregnancy presented promising results regarding the weight loss or the control of GWG in pregnant women who exercise compared with those who received standard care or did not participate in PA[37,39–41,43,45–49,51,52] (Table 2).

The SRs of Wang et al.[52] and Streuling et al.[51] concluded that PA during pregnancy leads to an average reduction of approximately 1.0 kg in GWG, along with a 20% decrease in the likelihood of excessive GWG.

The Ruchat et al.[48] SR stated that to achieve a 25% reduction in the likelihood of experiencing excessive GWG, pregnant women should engage in moderate-intensity exercises, such as walking, swimming, the use of cardiovascular exercise machines—stationary bike or elliptical, water-based exercises, strength or resistance exercises, or yoga and Pilates, at least twice a week, with each session lasting at least 35 min. Muktabhant et al.[46] and Nascimento et al.[47] reported that supervised physical exercise provides the greatest benefits in this context. McDonald et al.[44] reported positive results in intervention groups where greater adherence to the exercise program was observed.

Seven SRs[35,36,38,42,44,50,53] found no significant differences in terms of GWG reduction and/or control between pregnant women who exercise and those who received standard care or did not exercise. Chan et al.[38] noted no significant differences ($P = 0.310$) when using an intention-to-treat statistical approach. However, when data analysis was performed per protocol, including only participants with 100% adherence to the intervention, significant results were observed ($P = 0.001$).

3.4 | Characteristics of the included studies in pregnancy and postpartum

Two reviews published in 2022 and 2013, in the UK and the USA, respectively, focused on PA interventions in the pregnancy and postpartum stages.[54,55] In the first one the intervention stated onset during the first and second trimester,[55] whereas the other did not indicate the intervention period.[54] In both cases, the intervention was conducted until the end of the postpartum period. Women included in these studies belonged to different BMI ranges: normal-weight, overweight and obese (Table 1).

3.5 | Description of the interventions in pregnancy and postpartum

The interventions implemented were different in the two SRs. In both, control group was routine care (Table 2). In the SR by Hanley et al.,[55] the intervention was supervised, and was undertaken both in groups and individually. Duration was set at 50–90 min, with a frequency of three to five times per week and of moderate intensity. The workouts were predominantly aerobic, mixed with some resistance exercises (such as bench presses, biceps curls). In Choi et al.'s SR[54] the intervention consisted of structured PA programs, in which women participated in supervised sessions three times per week. The duration, intensity, and type of exercises performed in the sessions were not specified.

3.6 | Main outcomes in pregnancy and postpartum

In terms of GWG, the interventions showed different effects (Table 2). In the Hanley et al.[55] SR, no significant differences were found with the control group; whereas in Choi et al.'s SR,[54] a significant weight reduction was observed compared with the control group, with a mean weight loss of 0.91 kg. In the postpartum period, weight reductions were observed in both cases compared with the usual care group, whether the exercise was supervised[55] or not[54] (Table 2). In the unsupervised PA group, a mean weight loss of 0.94 kg was recorded compared with the control group. However, the result was not statistically significant.

3.7 | Characteristics of the included studies in postpartum

Four out of 25 SRs focused on the postpartum, relating PA interventions to postpartum weight loss or weight retention.[56–59] The SRs were published between 2014 and 2021, and were carried out in Australia,[57,58] the UK,[59] and the USA.[56] They also recruited women with different BMI ranges, including normal weight, overweight, and obese women, with one of them focusing specifically on women who were overweight or obese[57] (Table 1).

3.8 | Description of the interventions in postpartum

All studies aimed to evaluate the efficacy of exercise programs to promote postpartum weight loss versus usual postnatal care or non-PA interventions. However, the majority did not specify the duration of these interventions, except for one,[56] which established a minimum duration of 4 weeks. Different PA programs were identified: supervised, plus mobile phone app,[58] unsupervised,[57] behavioral interventions[56] or a mixture of both, as well as the use of pedometers[59] (Table 2).

TABLE 2 Interventions, comparison group, and results from the systematic reviews.

Author	Year	Type of intervention	Comparison group	Results
Bernardo et al.	2023	Structured supervised physical exercise	No intervention or usual prenatal care	Exercise groups displayed a statistically significant reduction in GWG (MD, −1.19 kg; 95% CI −1.79 to −0.60). No differences in excessive GWG (RR, 0.96; 95% CI 0.69 to −1.33)
de Castro et al.	2022	In-person prenatal supervised group exercise interventions (aerobic, resistance, pelvic floor training, stretching, and relaxation sessions) conducted over a 12-week period	Three comparison groups were established: (1) No exercise CG; (2) A group that did not exercise but received other types of interventions; and (3) CG engaged in a different exercise program	- The CG reported higher GWG - PA during pregnancy increases weight loss after delivery
Hanley et al.	2022	Supervised sessions in groups and one-on-one settings, and individual focused (video-game intervention and progressive resistance program) Duration 50–90 min, frequency three to five times per week, and moderate intensity. Predominantly aerobic, with additional resistance exercises (e.g., bicep curls, bench presses, etc.)	Routine care or another intervention	In the postpartum period, results showed that 50% of the included studies reported significant reductions in weight when compared with CG. Exercise during pregnancy had mixed effects on GWG, as non-significant differences were observed between the intervention and CG in 6 of the 11 included studies
Hamann et al.	2022	PA measurement was collected via self-administered questionnaires	Sedentary women	Nine results suggest an association between PA and a reduced risk of excessive GWG, while 11 results do not
Díaz-Burrueco et al.	2021	Supervised exercise (aerobic, strengthening and stretching guided exercises), yoga, walking and bicycle	Healthy pregnant women receiving standard prenatal care (lifestyle advice on nutrition, activities, and precautions)	Compared to control, PA intervention had a protective effect on GWG (SMD −0.32; 95% CI −0.46 to −0.17, $I^2=77$) Supervised exercise (SMD = −0.15; 95% CI −0.28 to −0.02, $I^2=51\%$) and cycling sessions (SMD = −0.32, 95% CI −0.59 to −0.05, $I^2=49\%$) had a protective effect on GWG
Santos et al.	2021	Supervised physical exercise (1) Aerobic exercise or dance; (2) strength exercises and water activities, including standing supine and ventral exercises for 15–18 min; (3) swimming lengths of the pool using all styles except butterfly for 8–10 min	Pregnant women who did not participate in the water activity	A higher percentage of women with excessive GWG was observed in the CG compared with the intervention group
Almalki et al.	2021	Occupational activity related to women's occupation or housework, and leisure activity	Pregnant women with standard prenatal care	Among the 14 studies, only 5 demonstrated a significant reduction in maternal or GWG among the participants after the intervention

(Continues)

TABLE 2 (Continued)

Author	Year	Type of intervention	Comparison group	Results
Mullins et al.	2021	(1) Unsupervised exercise interventions; (2) exercises with some form of supervision; (3) PA monitoring (a pedometer or an Actigraph); (4) PA monitoring and in-person supervised exercise interventions; (5) in-person supervised interventions; and (6) a mixture of in person supervised and unsupervised interventions	No PA intervention	Effect of PA intervention on weight loss was reported by 2/6 studies, with weight loss between 2.1 and 5.6 kg reported
Muhammad et al.	2021	Supervised light to moderate intensity exercises such as bicycle, aerobic, treadmill walk/jog, strength and stretching	Standard prenatal care	GWG was significantly different between supervised exercise and CG (MD −0.88 kg; 95% CI −1.73 to −0.03, $P=0.04$), with no evidence of heterogeneity between studies ($I^2=30\%$, $P=0.18$)
Wang et al.	2019	PA interventions (aerobic exercises, strength training, walking, cycling, or weight training) ranged from once or twice a week to four to five times per week	Standard prenatal care	GWG was significantly decreased in pregnant women with physical exercise (WMD −1.02, 95% CI −1.35 to −0.70) with moderate heterogeneity among trials ($I^2=48.4\%$) Subgroup analyses showed that GWG decreased significantly for women having PA from the first to the third gestational trimester (WMD −1.42, 95% CI −1.85 to −0.98; $I^2=0\%$) and the second to the third gestational trimester
Chan et al.	2019	Interventions involving land-based exercises. Exercise for 30–60 min at a frequency of two to three times per week involving moderate intensity PA such as aerobic exercises	Standard prenatal care	Out of the 14 included studies that reported the effect of PA interventions on GWG, eight of them did not observe a significant effect from the interventions. However, in five of these studies, a significantly lower GWG was observed among the participants following the intervention
Shieh et al.	2019	Structured and supervised PA that was monitored by a trained exercise physiologist or coach, from one or two to four or five times per week	Standard prenatal care	*Structured and supervised PA*: Only one of four studies showed a significant effect in controlling GWG *Structured but unsupervised PA*: The two studies did not find a significant effect in controlling GWG
Beetham et al.	2019	Vigorous intensity exercise	Lower intensity exercise or standard care	No significant difference in GWG was apparent for women who engaged in vigorous intensity exercise (MD −0.46 kg, 95% CI −2.05 to 1.12). The RCTs targeting overweight and obese pregnant women did show a significant reduction in GWG compared with a CG

TABLE 2 (Continued)

Author	Year	Type of intervention	Comparison group	Results
Ruchat et al.	2018	Moderate-intensity exercise ranged from one to seven times per week, with a duration of each exercise session from 10 to 90 min *Type of exercise*: Walking, swimming, stationary cycling, water gymnastics, resistance training, stretching, yoga, or pelvic floor muscle training	No exercise or different frequency, intensity, duration, volume, or type of exercise	There was a "low" quality evidence from 33 RCTs regarding the association between prenatal exercise and excessive GWG. To achieve at least a 25% reduction in the odds of excessive GWG, pregnant women needed to exercise at least two times per week, 35 min/session or accumulate at least 456 MET-min/week of moderate intensity exercise (e.g. 105 min of brisk walking, water aerobics, stationary cycling, or resistance training per week)
Dodd et al.	2018	Diet alone, PA alone, mixed diet and PA	Standard postnatal care to promote weight loss	Women who received a postpartum PA intervention experienced greater weight loss upon completing the intervention compared with women who did not receive any intervention (MD −1.45 kg; 95% CI −2.41 to −0.50 kg)
da Silva et al.	2017	*RCT studies*: Moderate-intensity PA was implemented three times per week. The duration of the sessions ranged from 20 to 70 min and included exercise strategies that encompassed both aerobic and muscle resistance or strength training *Cohort studies*: Most of the instruments used to assess PA were self-reported questionnaires	*RCT studies*: Standard care *Cohort studies*: Inactive women	*RCT studies*: Women exposed to exercise interventions gained less weight during pregnancy than those not taking part in an exercise intervention *Cohort studies*: Active women during pregnancy had an 18% lower risk of excessive GWG (exceeded the IOM recommendations) as compared with inactive women
Watson et al.	2017	Most of the interventions consist of supervised aerobic activities (aquatic or land-based)	Not specified	Out of the seven studies, only two suggested that a PA intervention during pregnancy may significantly reduce GWG. The remaining five studies were assessed as being of poor quality
McDonald et al.	2016	Study of the relationship between exercise dose and GWG in exercise interventions These were classified into two groups: "successful" and "unsuccessful", based on their effect on GWG	Control condition of the participants could be: (1) Current prenatal care routine; (2) stretching routine; or (3) lower level of exercise intensity	Out of the 21 studies, 8 interventions were "successful" and 13 were "unsuccessful" at reducing GWG. Among the "successful" interventions, the difference in GWG between the exercise and control conditions ranged from −1.3 to −6.0 kg. There were no discernible patterns of exercise dose and the calculated reductions in GWG within the "successful" exercise interventions

(Continues)

TABLE 2 (Continued)

Author	Year	Type of intervention	Comparison group	Results
Muktabhant et al.	2015	All the interventions involved modifications or restrictions in diet, increased exercise, or a combination of both. Interventions varied in terms of intensity	CG mostly comprised routine or standard care (which also varied considerably in different settings and was not always well-described)	There was an average risk reduction of excessive GWG of 20% in favor of the intervention group (RR 0.80; 95% CI 0.73–0.87). The greatest reduction occurred with the "supervised exercise and diet" interventions
Lim et al.	2015	Most studies combined diet and exercise or focused solely on exercise, with one study being diet-only. All interventions required in-person participation except for two telephone-delivered studies	Usual care, no intervention, or explicit instructions to maintain their usual diet or activity patterns	Exercise as a stand-alone intervention has not consistently been shown to result in clinically significant weight loss in the general population. Significant weight loss is observed at very high levels of PA, which is difficult to achieve and maintain for most individuals
Berger et al.	2014	Behavioral interventions that included diet, exercise, or a combination of diet and exercise components occurred during the postpartum period and had a duration of at least 4 weeks	Standard usual care	Greater weight loss was observed in the intervention group compared with the usual care group. Additionally, women in the intervention group had a lower BMI ($P<0.001$) and waist-to-hip ratio ($P=0.02$) compared with those in the usual care group
Lamina y Agbanusi	2013	The primary intervention was aerobic exercise of moderate intensity (40–60 VO_2max or 60%–79% HRmax), at least three times per week	Sedentary group	The regular practice of aerobic exercise training by active, low-risk and previously sedentary expectant mothers do have a favorable and beneficial effect on GWG
Choi et al.	2013	(1) Structured PA programs alone, in which women participated in supervised PA sessions three times per week (2) Supervised PA sessions once a week along with counseling on diet and the recommended GWG (3) Group or individual counseling or advice on PA (unsupervised), diet, and the recommended GWG Studies targeting postpartum women initiated their programs with a relatively wide-open period, ranged between 4 weeks and 12 months	Standard usual care	Significant reduction of GWG on average in the PA intervention groups, with a WMD of −0.91 kg (95% CI −1.76 to −0.06) when compared with women in the CG In postpartum period, women in unsupervised PA programs lost more weight than women in the CG, but it was not statistically significant (WMD = −0.94 kg; 95% CI −2.00 to 0.12; $P=0.082$)
Nascimento et al.	2012	The majority were a 12-week aerobic and strengthening intervention, between one and three times per week, with a duration of 40–60 min per session	Standard prenatal care	Supervised exercise programs are more effective than home exercise counseling. Women who exercise frequently, have a lower mean weight gain and lower postpartum retention. Women with higher BMI before pregnancy are resistant to achieving the target weight gain according to the IOM

TABLE 2 (Continued)

Author	Year	Type of intervention	Comparison group	Results
Streuling et al.	2011	Women exercised three times a week, at least 20 min up to 1 h performing aerobics, running, cycling, water aerobics, or muscle strengthening	Women in the individual CG did not receive regular exercise interventions during pregnancy, except for one trial where a stretching program was provided to the CG	Significant reduction of GWG on average in the exercise groups ($P = 0.03$), with an MD of −0.61 (95% CI −1.17 to −0.06)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); CG, control group; CI, confidence interval; GWG, gestational weight gain; HRmax, maximum heart rate; IOM, Institute of Medicine; MD, mean deviation; PA, physical activity; RR, relative risk; SMD, standardized mean difference; VO_2max, maximum oxygen consumption; WMD, weighted mean difference.

3.9 | Risk of bias of included studies

The quality characteristics and scores of the SRs are provided in Table 3 and Figure 2. The highest achievable category was "high quality" and the lowest was "critically low". Three SRs[41,45,48] were classified as "high quality", and only one[46] was classified as "moderate quality". Fifteen SRs[35–40,42,49,51–56,59] were rated as "low quality", and the remaining reviews ($n = 6$) were rated as "critically low quality".[43,44,47,50,57,58] Therefore, most of the included reviews were rated as "low quality" according to the criteria used (AMSTAR-2). Quality assessment was evaluated independently by two authors (A.G.G. and A.S.d.P.). Most of the studies ($n = 21$) assessed publication bias. Heterogeneity was measured in all reviews although causes of heterogeneity were not analyzed in some ($n = 3$).[43,49,51] However, only 8 out of 25 SRs reported protocol publication.[36,37,41,45,46,48,56,59]

3.10 | Synthesis of results

This review reaffirms the beneficial role of PA regarding weight management during pregnancy and postpartum in women with normal-weight, overweight, or obesity. Most of the SRs showed a reduction in the likelihood of experiencing excessive GWG when pregnant women participated in moderate-intensity exercise at least twice a week, and each session lasted for at least 35 min. Effectiveness in weight reduction was observed in women who engaged in structured PA programs, involving supervised sessions three times per week during both pregnancy and postpartum periods. SRs focused on the postpartum period concluded that weight loss was greater in the intervention group, from 1.45 to 5.6 kg, than the control group.

4 | DISCUSSION

Some research suggests that PA could be a critical factor in the distribution of nutrients during pregnancy, regulating maternal placental metabolism, or regulating the maternal hormone leptin and the level of free fatty acids.[60] However, PA and exercise interventions have yet to have standardized methodologies for developing, delivering, and evaluating such programs due to their complexity, in relation to the different types of interprofessional components and contexts of intervention.

It is difficult to reach a firm conclusion on the specific type of intervention that is most effective in reducing and/or controlling excessive GWG. Likewise, the lack of specificity in the duration of the interventions limits the understanding of the long-term efficacy of the interventions and makes it difficult to compare the results of different studies.

Interventions that incorporate mandatory exercise classes as an integral component appear to be more effective in increasing the level of PA among women during pregnancy and postpartum, resulting in a protective effect on GWG or postpartum weight retention.[37,39–41,45,47,49–55,59]

Nevertheless, interventions that include healthy eating strategies are more effective[46,54,56–58] than PA by itself. As previously mentioned, evidence for exercise interventions only is limited, and some women will likely prefer to focus on both diet and PA to encourage weight management.

Although our umbrella review also aimed to include motivational strategies and behavioral changes that influence the practice of physical exercise in pregnant women, few studies present such motivational strategies.[46,56] As described above, women's adherence to the program is a determining factor. Accordingly, these exercise programs should be adapted to each pregnant woman to generate motivational responses so that they have a low dropout rate among participants.

The results of postpartum weight loss were diverse. Some SRs showed positive results,[56,57,59] but another SR was less conclusive.[58] It should be noted that the limited number of SRs (only six) and the lack of detailed information on interventions make it difficult to understand the impact of PA interventions on the observed outcomes in the postpartum.

Preconception stage is the optimal time to achieve adherence to new exercise habits and appropriate to control or reduce GWG, to promote postpartum weight loss, and prevent weight retention.[23] However, no SR has been found about PA interventions in this stage. This may be because unplanned pregnancy often occurs,[31] which makes it highly improbable that women initiate healthy behavioral changes in the months before conception. In most cases, as we have observed in the SRs, this type of intervention is usually implemented once pregnancy has been initiated.

TABLE 3 AMSTAR-2 tool on quality assessment of systematic reviews.

Author, year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Quality
Bernardo et al., 2023	Yes	Yes	No	PY	Yes	No	PY	PY	PY	No	Yes	No	Yes	Yes	No	Yes	Low
de Castro et al., 2022	Yes	No	Yes	PY	Yes	Yes	PY	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Low
Hanley et al., 2022	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Low
Hamann et al., 2022	Yes	No	Yes	PY	Yes	Yes	PY	Yes	Yes	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
Díaz-Burrueco et al., 2021	Yes	Yes	Yes	PY	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	High
Santos et al., 2021	Yes	No	Yes	PY	Yes	Yes	Yes	Yes	No	No	NMC	NMC	No	No	NMC	Yes	Low
Almalki et al., 2021	Yes	No	Yes	PY	Yes	PY	PY	PY	PY	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
Mullins et al., 2021	Yes	Yes	Yes	PY	Yes	Yes	No	Yes	Yes	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
Muhammad et al., 2021	Yes	Yes	Yes	PY	Yes	Yes	Yes	PY	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	High
Chan et al., 2019	Yes	No	No	PY	Yes	Yes	Yes	Yes	Yes	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
Wang et al., 2019	No	No	Yes	PY	Yes	Yes	Yes	PY	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Low
Shieh et al., 2019	No	No	Yes	PY	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	C. Low
Beetham et al., 2019	Yes	Yes	Yes	PY	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Low
Ruchat et al., 2018	Yes	Yes	Yes	PY	Yes	Yes	Yes	PY	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	High
Dodd et al., 2018	Yes	No	Yes	PY	No	No	PY	PY	Yes	No	Yes	Yes	Yes	Yes	No	Yes	C. Low
da Silva et al., 2017	No	No	Yes	Yes	Yes	Yes	Yes	Yes	PY	No	Yes	Yes	Yes	Yes	Yes	Yes	Low
Watson et al., 2017	No	No	Yes	Yes	Yes	Yes	PY	Yes	PY	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
McDonald et al., 2016	No	No	Yes	Yes	No	No	Yes	Yes	No	No	NMC	NMC	No	Yes	NMC	Yes	C. Low
Muktabhant et al., 2015	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Lim et al., 2015	No	No	Yes	PY	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	C. Low
Berger et al., 2014	No	Yes	Yes	Yes	Yes	Yes	Yes	PY	No	No	NMC	NMC	Yes	Yes	NMC	Yes	Low
Lamina y Agbanusi, 2013	No	No	Yes	No	No	Yes	No	PY	PY	No	No	No	No	No	No	Yes	C. Low
Choi et al., 2013	No	No	Yes	Yes	Yes	Yes	Yes	Yes	PY	No	Yes	Yes	Yes	Yes	Yes	Yes	Low
Nascimento et al., 2012	No	No	Yes	PY	Yes	Yes	No	PY	No	No	NMC	NMC	No	No	NMC	Yes	C. Low
Streuling et al., 2011	No	No	Yes	PY	Yes	Yes	Yes	Yes	PY	No	Yes	Yes	Yes	Yes	Yes	Yes	Low

Note: 1. Did the research questions and inclusion criteria for the review include the components of PICO? 2. Did the report of the review contain an explicit statement that the review methods were established before the conduct of the review and did the report justify any significant deviations from the protocol? 3. Did the review authors explain their selection of the study designs for inclusion in the review? 4. Did the review authors use a comprehensive literature search strategy? 5. Did the review authors perform study selection in duplicate? 6. Did the review authors perform data extraction in duplicate? 7. Did the review authors provide a list of excluded studies and justify the exclusions? 8. Did the review authors describe the included studies in adequate detail? 9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review? 10. Did the review authors report on the sources of funding for the studies included in the review? 11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results? 12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis? 13. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review? 14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review? 15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review? 16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

Abbreviations: C. low, critically low; NMC, no meta-analysis conducted; PY, partial yes; RoB, risk of bias.

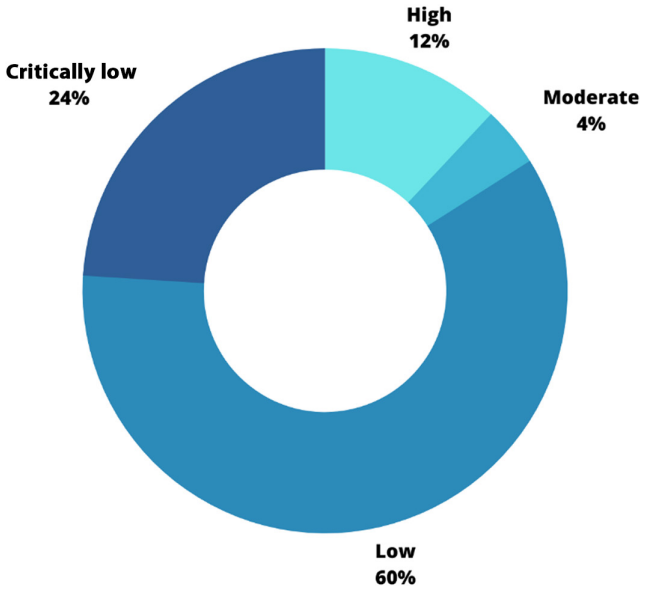

FIGURE 2 Quality assessment of systematic reviews according to AMSTAR-2 classification.

The strengths of the present review include the synthesis of evidence from 15 countries and five continents, and the application of the AMSTAR-2 tool to assess the methodologic quality of the reviews. The overall quality of the included studies was low. Therefore, the results should be interpreted with caution and the reliability of conclusions based on these studies should be considered. However, the design of the selected studies belongs to the highest level of evidence.

Finally, most of the studies included any type of BMI, so covering pregnant women from all weight categories. This variety of approaches in SRs and meta-analyses allows us to understand the effects of pregnancy and postpartum weight in different BMI categories.

This study has some limitations. First, mainly SRs of RCTs have been included, which could have limited its completeness. On the other hand, the significance of the results could have been influenced by the fact that different types of interventions have been considered. Another limitation is that some of the SRs were not limited to physical exercise interventions and included diet or lifestyle,[46,54,56–58] which could have also induced biases. In addition, SRs on PA interventions are focused on body weight difference as a measure, rather than body fat. This is especially important in exercise interventions that include muscle training or resistance exercises, because women may have increased their overall muscle mass regardless of the change in body weight.

Excessive GWG can have many negative health outcomes for women and infants. As a result, there is significant public health interest in preventing weight gain before, during and after pregnancy.

Health programs targeting women during preconception, pregnancy, and postpartum should consider incorporating PA interventions as an integral component. Such interventions should include elements such as exercise classes, PA counseling, and dissemination of information on appropriate and tailored exercise for individual women. In addition, exercise classes should include activities with a duration and intensity consistent with recommended guidelines for pregnant women. Based on this umbrella review, it is likely that women of all BMI groups could benefit from specific advice on PA.

Despite the existence of studies focusing on PA in pregnancy and the postpartum period, no specific preconception-based interventions have been found. These findings suggest a necessity for further research in the preconception period, and how effective interventions can be implemented to promote healthy habits in women of reproductive age.

Women who comply with recommendations on PA program during pregnancy are more likely to achieve adequate GWG. Moderate-intensity aerobic exercise, such as walking, swimming, cardiovascular exercise machines, water exercise, strength or resistance exercises, or yoga and Pilates, seems beneficial in terms of controlling excessive GWG. Supervised physical exercise at least twice a week, with each session lasting at least 35 min, seems to provide the greatest benefits. Structured PA programs, in which women participated in supervised sessions three times per week during pregnancy and postpartum, were effective in weight reduction.

AUTHOR CONTRIBUTIONS

CA-P, CAV, JSJ, and LG-V made significant contributions to the design, elaboration of objectives, and methodology. The manuscript was drafted by AGG, ASP, and BML, while CA-P, CAV, JSJ, and LG-V provided critical revision of the paper in terms of important intellectual content. All authors meet the criteria for authorship and have approved the final submitted version.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest.

DATA AVAILABILITY STATEMENT

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

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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