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SYSTEMATIC REVIEW

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Effects of exercise-based interventions on postpartum depression: A meta-analysis of randomized controlled trials

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Abstract

Background: There is inconsistent evidence about the effect of physical activity on the prevention and treatment of depression during the postnatal period. The aim of this meta-analysis was to determine the effect of physical activity interventions during pregnancy and the postpartum period for controlling postpartum depressive symptoms.

Methods: We systematically searched Cochrane Library Plus, Science Direct, EMBASE, CINAHL, PubMed, Web of Science, and Scopus, from January 1990 to May 2016, for randomized or nonrandomized controlled trials addressing the effect of physical activity on postpartum depression. The inverse variance-weighted method was used to compute pooled estimates of effect size and respective 95% confidence intervals (95% CI) for physical activity intervention on postpartum depression. Subgroup analyses were performed comparing women with and without postpartum depressive symptoms according to specific scales measuring this construct. Meta-regression and sensitivity analysis were computed to evaluate heterogeneity.

Results: Twelve studies were included in the meta-analysis. Effect size for the relationship between physical activity interventions during pregnancy and the postpartum period on postpartum depressive symptoms was 0.41 (95% CI 0.28-0.54). Heterogeneity was $I^2 = 33.1\%$ ($P = .117$). When subgroup analyses were done, pooled effect sizes were 0.67 (95% CI 0.44-0.90) for mothers who met postpartum depressive symptoms criteria at baseline based on specific scales, and 0.29 (95% CI 0.14-0.45) for mothers who did not meet those depressive symptoms criteria at baseline.

Conclusion: Physical exercise during pregnancy and the postpartum period is a safe strategy to achieve better psychological well-being and to reduce postpartum depressive symptoms.

KEYWORDS

intervention programs, motor activity, peripartum depression, physical exercise, postnatal depression, postpartum depression

1 | INTRODUCTION

Depression constitutes a major public health problem among women worldwide to such an extent that 10%-25% of women have at least one episode of depression during their lifetime.[1] Postpartum depression, the most common complication of childbearing, is defined by the Diagnostic and Statistical Manual of Mental Disorders as any depressive disorder that occurs from the beginning of pregnancy or within 4 weeks of delivery. Although estimates vary, between 3% and 15% of women experience the onset of a major depressive episode during pregnancy or in the weeks or months after delivery,[2,3] and about 50% of these episodes begin before delivery and occur in women who have suffered a miscarriage; this is why, taken together, these episodes are referred to as peripartum episodes.

Although many women experience mild symptoms, postpartum depression should be suspected when symptoms are severe and have lasted over 2 weeks. These could include: reduced quality of life, anxiety attacks, tearfulness, loss of interest in life, insecurity, inappropriate obsessional thoughts, irritability, fatigue, guilt, fear of harming the baby, and a reluctance to breastfeed.[4]

After postpartum depression, the risk of future episodes of depression over a 5-year period is doubled.[5] Moreover, postpartum depression also has a negative influence on the maternal-infant relationship including sleep deprivation, anxiety about parenthood and caring for an infant, identity crisis, a feeling of loss of control over life, and anxiety because of lack of support from a romantic or sexual partner.[6] The compromised mother–infant interaction (ie, mothers are less likely to be affectionate toward their baby) could explain the poorer emotional and cognitive development of infants with depressed mothers.[7] Maternal and infant mortality have been described as rare consequences of postpartum depression.[8,9]

Exercise has been recognized as a useful treatment option for depression among the general population, showing potential facilitators in contrast to traditional treatments: it is free, accessible, and without stigma or side effects.[10] The pathways for positive influence of exercise on depression include biochemical and physiological mechanisms that affect sleep quality, depressive symptoms, and memory. These mechanisms include the increase in circulatory plasma endorphins, norepinephrine and serotonin, and also the increase in core temperature and cerebral blood flow, reduced muscular tension, and neurotransmitter efficiency. Moreover, physical activity may be a suitable alternative of prevention and treatment for some psychosocial mechanisms, such as stressful life events and interpersonal relationships.[3,11]

In 2002, and reaffirmed in 2009, the American College of Obstetrics and Gynaecology[12] recommended that all adults (including pregnant and postpartum women without complications) should participate in at least 30 min of moderate-intensity physical activity on most days of the week. Additionally, it has been suggested that exercise is as successful as antidepressants in the treatment of major clinical depression.[13] A previous systematic review and meta-analysis showed the effectiveness of physical activity in preventing and treating antenatal depression.[14] However, there is a lack of knowledge on the positive effect that physical activity interventions could produce on the prevention and treatment of postpartum depression.

The aim of this systematic review and meta-analysis was to assess the effectiveness of physical activity interventions during pregnancy and the postpartum period on preventing and controlling postpartum depressive symptoms. Also, by conducting subgroup analyses, we aimed to assess the effect of physical activity in women who met the depressive symptoms criteria and in women who did not meet these criteria at baseline. Therefore, we aim to evaluate which characteristics of physical activity intervention could be adapted to different levels of aptitude of puerperas to improve adherence to a physical activity program.

2 | METHODS

This meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement[15] and the Cochrane Collaboration Handbook.[16] The protocol was registered on PROSPERO (CRD42016047970).

2.1 | Data sources and searches

The systematic search was conducted by two independent researchers (RP and GS) in seven databases: Cochrane Library Plus, Science Direct, EMBASE, CINAHL, PubMed, Web of Science, and Scopus. Disagreements were solved by consensus and discrepancies were resolved with a third reviewer (CA). The search strategy included the following key terms: "aerobic," "exercise," "physical exercise," "physical activity," "motor activity," "postpartum," "postnatal," and "depression." The references of the retrieved articles were screened to identify additional studies. The search was aimed to identify studies published from January 1990 to May 2016.

The studies were selected if: (1) they were randomized controlled trials or nonrandomized controlled trials; (2) they included pregnant women with a single fetus and an uncomplicated pregnancy or women who had a child aged between 6 weeks and 18 months; (3) maternal well-being was determined, using a depression scale such as the following: the Edinburgh Postnatal Depression Score (EPDS)[17] or the Beck Depression Inventory (BDI);[18] (4) they assessed physical activity programs that started during pregnancy and extended to the puerperium period or were only developed during the puerperium period. The exclusion criteria were as follows:

(1) insufficient data to calculate effect size, (2) studies with physical activity interventions only during pregnancy, and (3) studies not written in English or Spanish.

2.2 | Data extraction and quality assessment

The following relevant characteristics of the included studies were summarized in an ad hoc form: country; sample; scale used to measure postpartum depression; length, frequency, type and intensity of exercise; and Jadad score.

The quality of the studies was evaluated by two independent researchers (RP and GS) using the Jadad scale[19] and disagreements were solved by consensus. This scale includes three items with respect to randomization, blinding, and drop-outs that could be scored as "1" or "0" depending on whether the studies satisfied the criteria or not. The items on randomization and blinding could receive an additional point if they were appropriately described. Studies could score from 0 to 5 points; quality was considered acceptable if they scored ≥3.

2.3 | Data synthesis

Effect sizes and their 95% confidence intervals (CIs) were calculated for each study using mean t-scores, number of subjects, and standard deviation.[20] If cohorts were measured more than once in the same study, the 6-month measurement was considered for the meta-analysis; when there was no measurement for the 6th month, the closest measurement was used.

The inverse variance-weighted method[21] was used to compute pooled effect size estimates and respective 95% CIs comparing physical exercise interventions with a control group without any intervention during pregnancy and postpartum period. The heterogeneity of the results across studies was evaluated using the I^2 statistical parameter. I^2 values of <25%, 25-50%, and >50% usually correspond to small, medium, and large heterogeneity, respectively;[22] the corresponding P values were also considered. Subgroup analyses were performed comparing women with and without postpartum depressive symptoms to observe which had the highest effect size and to control for heterogeneity in each weight status category. The separate influence of each study in the pooled effect size was estimated by recalculating the pooled estimate after the exclusion of individual studies. Random-effects meta-regression was used to separately evaluate whether results were different by frequency and intensity of physical activity sessions, as these could be considered major sources of heterogeneity. Finally, publication bias was evaluated using Egger's regression asymmetry test for the assessment of "small studies effects."[23] Statistical analyses were performed using StataSE software, version 14 (StataCorp, College Station, TX, USA).

3 | RESULTS

3.1 | Study selection

A total of 370 articles were retrieved from the literature search. After removing duplicates, 355 studies were screened by title and abstract. The inclusion and exclusion criteria were applied to all of them. Finally, 12 articles were included in the meta-analysis[24-35] (Figure 1).

3.2 | Study characteristics

Table 1 summarizes the study characteristics. The total sample included 932 women: 471 in the intervention group and 461 in the control group. The studies were performed in several countries: Canada,[25] Iran,[30] China,[35] United States,[31,32] United Kingdom,[24,26] Taiwan,[27,33] and Australia.[28,29,34] All studies included healthy pregnant women without contraindications for doing exercise, and who were pregnant or had a child aged between 6 weeks and 18 months at the beginning of the study. Depressive symptoms were assessed, using the EPDS[24-32,34] and the Chinese version of the BDI.[33,35] Studies included women who met the depressive symptoms criteria[24-29] and women who did not meet these criteria[30-35] at baseline.

Women belonging to the control group were given usual prenatal care. Physical activity programs for the intervention group were conducted during the postpartum period in all studies, except for two studies in which the programs started during pregnancy.[30,33]

There was a wide variety in the physical activity programs that included the following: stretching and breathing exercises,[27,30] a walking program,[24,26,28,29,31] cardiovascular exercises,[25] mixed cardiovascular and strength exercises,[34] Pilates and Yoga exercises,[35] and home-based programs.[25,30,32] The two studies[30,33] that started the intervention during pregnancy did not change the type of physical activity after delivery.

Session frequency varied from 1 to 5 days per week and intensity levels included low,[30,35] moderate,[24,26,28,29,31,34] or moderate to high.[25,32] Physical activity interventions were individualized in three studies.[25,32,33]

With respect to quality (risk of bias) assessment, after the Jadad scale was applied, 10 of the included studies met the three criteria for quality assessment (randomization, double blinding, and description of adherence and dropouts),[24-26,30-34] one study met two criteria (randomization, random method),[27] and another study only met the description of adherence and dropouts criterion[35] (Table 1).

3.3 | Adherence, dropouts, and adverse effects

The adherence rate was higher than 85% in six studies,[24,26,27,32,34,35] around 75% in three studies,[25,28,29] and

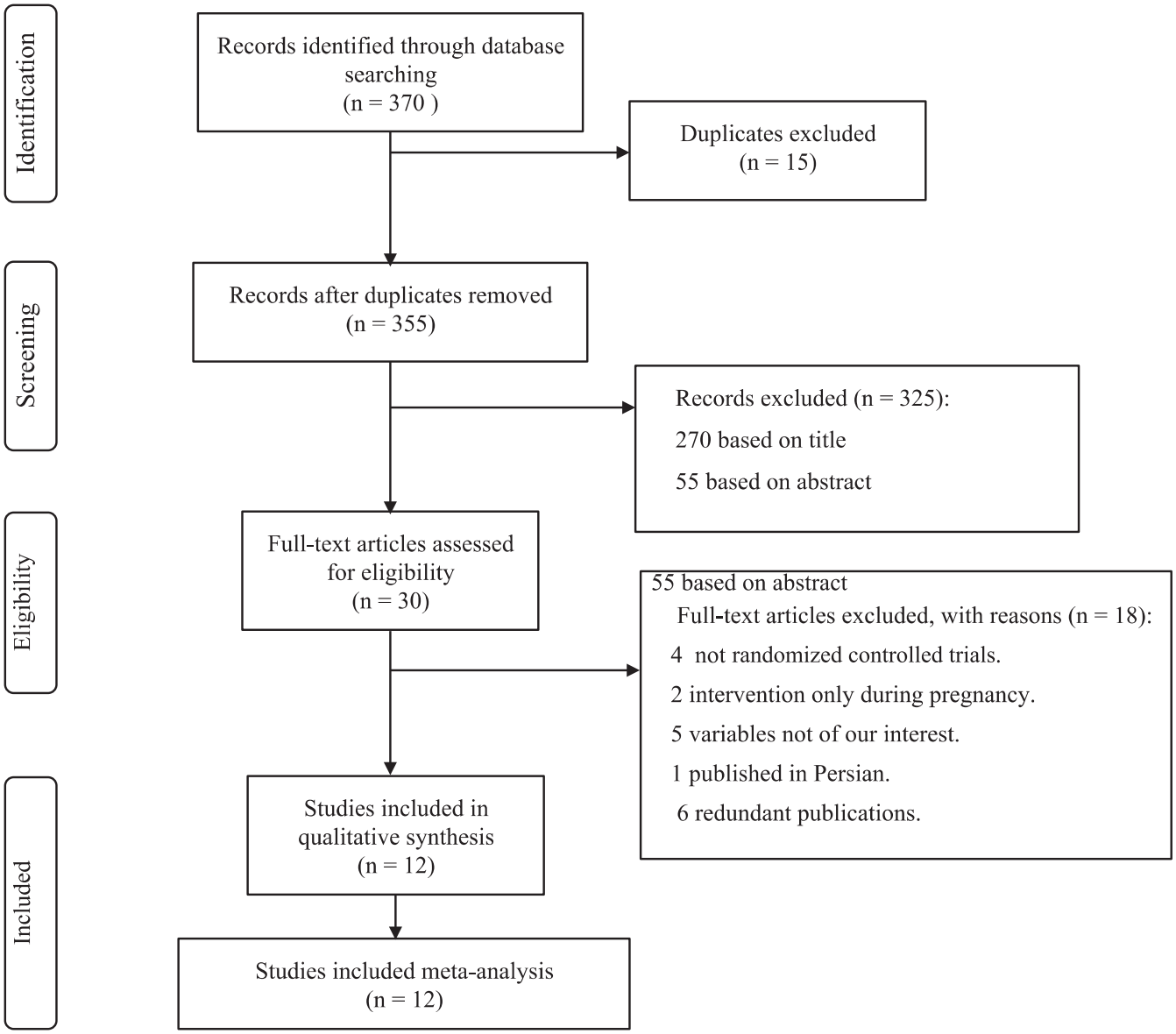

FIGURE 1 Literature search preferred reporting items for systematic reviews and meta-analysis (PRISMA) consort diagram

33% in two studies.[30,31] Only one study did not provide information about adherence rate.[33]

Dropout rates were less than 10% in five studies,[24,26,27,30,32,34] between 20% and 30% in four studies,[25,28,29,33] and one study reported an attrition rate of 33%.[31] The main reasons for dropouts were: not having enough time,[24,30] a new pregnancy, moving to another state,[24,31] and mother or baby health problems.[28,34] Most studies did not report data regarding adverse effects attributable to interventions.

3.4 | Meta-analysis

For physical activity interventions during pregnancy and the postpartum period vs the control group, there was a decrease in postpartum depressive symptom scores, measured by EPDS or BDI, in favor of the physical activity group (effect size: 0.41; 95% CI 0.28-0.54). Heterogeneity was $I^2 = 33.1\%$ ($P = .117$) (Figure 2).

When subgroup analyses by postpartum depression status were conducted, the effect size was 0.67 (95% CI 0.44-0.90) for mothers with postpartum depression diagnosis and 0.29 (95% CI 0.14-0.45) for mothers who did not score above the cutoff on the depressive symptom scales. Likewise, heterogeneity decreased to $I^2 = 20.8\%$ ($P = .277$) and $I^2 = 0.0\%$ ($P = 0.566$), respectively (Figure 3).

Summary estimates were consistent when analyses were repeated using a fixed-effects model. Moreover, when each study was removed from the model, the results remained significant (Table 2). The meta-regression model showed that the frequency ($P = .853$) and intensity ($P = .647$) of physical activity sessions was not associated with heterogeneity across the studies. There was no

TABLE 1 Meta-analysis of the effect of pregnancy/postpartum exercise programs on postpartum depressive symptoms

				Intervention characteristics				
Reference	**Subjects (*n*)**	**Country**	**Scale**	**Length (months)**	**Frequency (sessions per week)**	**Type of exercise intervention**	**Intensity**	**Jadad scale**
Mohammadi et al.[30]	84	Iran	EPDS	3-4	3	Stretching and breathing practices	Light	3
Keller et al.[31]	93	US	EPDS	3	3	4 types of support (emotional, instrumental, appraisal, and informational) with group walking	Moderate	3
Lewis et al.[32]	122	US	EPDS	3	5	11 telephone sessions	Moderate to high	2
Huang et al.[33]	125	Taiwan	BDI	a: 12 b: 6	NA	Individualized dietary and PA education plans	NA	3
Norman et al.[34]	130	Australia	EPDS	2	1	"Mother and Baby" (M&B) program, including specialized exercise	Moderate	3
Ko et al.[35]	61	China	BDI	1	3	Pilates and Yoga	Light	1
Daley et al.[24]	79	UK	EPDS	6	5	2 face-to-face consultations and 2 telephone sessions with a PA facilitator	Moderate	3
Da Costa et al.[25]	88	Canada	EPDS	3	3	Individualized exercise prescription and followed ACSM guideline	Moderate to high	3
Daley et al.[26]	31	UK	EPDS	3	5	Pram walking exercise	Moderate	3
Heh et al.[27]	80	Taiwan	EPDS	3	3	1 h/w at the hospital and 2 sessions at home	NA	2
Armstrong et al.[28]	19	Australia	EPDS	3	3	Pram walking exercise	Moderate	3
Armstrong et al.[29]	20	Australia	EPDS	3	3	Pram walking exercise	Moderate	3

EPDS, Edinburgh Postnatal Depression Score; BDI, Beck Depression Inventory; a and b: cohort samples from Huang et al. study; PA, physical activity; ACSM, American College of Sports Medicine; h/w, hours per week; NA, not available.

Jadad scale is a procedure to independently assess the methodological quality of a clinical trial.

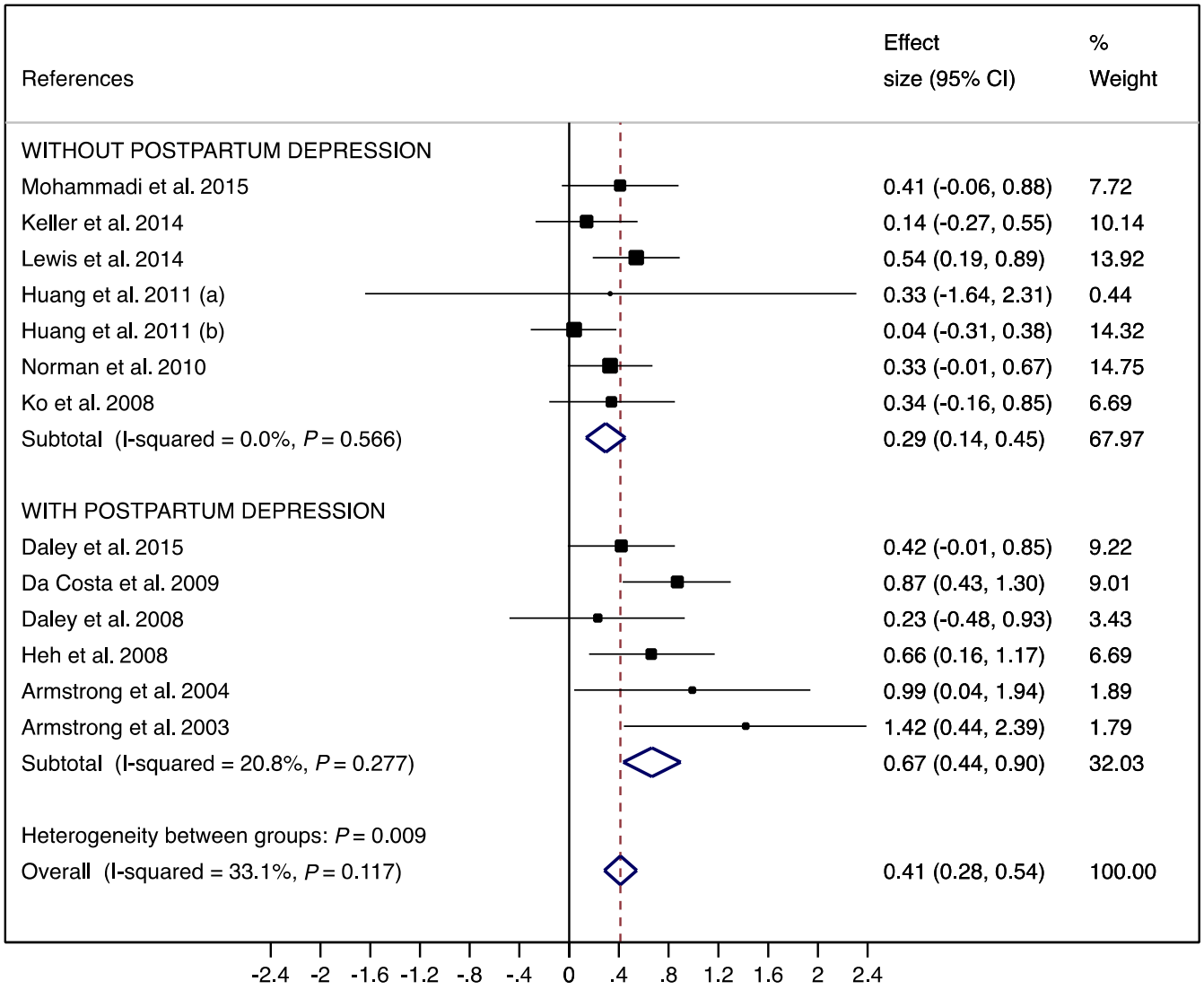

FIGURE 2 Pooled estimated effect sizes for physical activity intervention

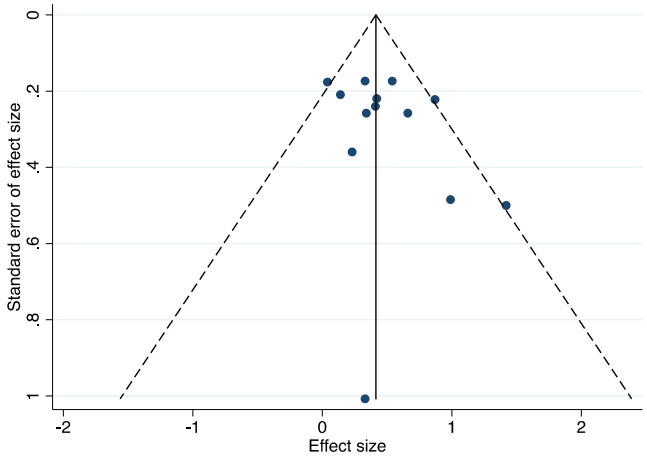

FIGURE 3 Egger test for assessment of potential publication bias

significant publication bias, as evidenced by visual inspection of the funnel plot and Egger's regression asymmetry test ($P = .176$) (Figure 3).

4 | DISCUSSION

Our results synthesize the evidence about the benefits of physical activity interventions developed during pregnancy and the postpartum period on postpartum depressive symptoms. Moreover, our meta-analysis shows that physical activity programs are effective in controlling depressive symptoms. In addition, physical activity characteristics in terms of frequency and intensity seem to not modify the effect of these interventions on postpartum depressive symptoms.

Postpartum physical activity can improve mood, body image, cardiorespiratory fitness, weight control, and physical performance, and could also reduce depression and anxiety.[36] Our findings reinforce the hypothesis that physical activity during pregnancy and the postpartum period could reduce postpartum depressive symptoms, probably because physical activity has an emotional influence on social and environmental aspects that could improve self-confidence and distract from negative thoughts.[37] Furthermore, changes in body

TABLE 2 Sensitivity analysis of potential bias due to excluding each study from the meta-analysis

References	Effect size	95% CI	I^2	*P*
Without postpartum depression				
Mohammadi et al.[30]	0.41	0.28-0.56	38.7	0.083
Keller et al.[31]	0.44	0.31-0.58	31.5	0.139
Lewis et al.[32]	0.39	0.25-0.53	36.6	0.098
Huang et al.[33] (a)	0.41	0.28-0.54	38.7	0.083
Huang et al.[33] (b)	0.48	0.33-0.62	13.5	0.313
Norman et al.[34]	0.43	0.29-0.57	38.8	0.089
Ko et al.[35]	0.42	0.28-0.55	38.4	0.085
With postpartum depression				
Daley et al.[24]	0.41	0.28-0.55	38.7	0.083
Da Costa et al.[25]	0.37	0.23-0.50	17.2	0.275
Daley et al.[26]	0.42	0.29-0.55	37.8	0.089
Heh et al.[27]	0.40	0.26-0.53	35.2	0.109
Armstrong et al.[28]	0.40	0.27-0.53	33.3	0.123
Armstrong et al.[29]	0.39	0.26-0.53	21.1	0.246

a and b, cohort samples from Huang et al. study; CI, confidence interval.

shape and image could have a positive influence on feelings of self-worth.[38] The effect size of physical activity on women with postpartum depressive symptoms is markedly higher than other traditional therapeutic approaches. The pooled effect sizes for physical activity interventions in women with postpartum depressive symptoms, who took part in a physical activity intervention, was always greater than 0.4; while the pooled effect size for traditional approaches was lower than 0.3 for any depression-related outcomes.[39]

Some reviews and one meta-analysis addressing issues related to postpartum depression have been published so far. Most of them are narrative,[3,40,41] and their conclusions seem to indicate that physical activity during the postpartum period has some positive influence on mood and cardiorespiratory fitness. The single meta-analysis that addressed the influence of physical activity on postpartum depression[42] only included five published trials with only 221 participants, which results in a lack of precision in their estimates. Therefore, their conclusions should be cautiously considered. Moreover, this meta-analysis was limited to studies specifically assessing depressive symptoms in women with postpartum depression criteria. In addition, the positive influence of supervised aerobic exercise during pregnancy on depressive symptoms during pregnancy and the postpartum period has been reported.[40]

The recommendations for general health outlined by the American College of Obstetrics and Gynaecology[12] establish that pregnant and postpartum women without complications should participate in at least 30 min of moderate intensity physical activity on most days of the week. Only two studies included in our meta-analysis did not follow these recommendations, and they reported a nonsignificant effect.[30,35] Moreover, the meta-regression analysis did not find an association between postpartum depressive symptoms, and the length and intensity parameters of the intervention.

Individualized interventions tailored to the mother's previous fitness level of moderate or moderate to vigorous intensity reported higher levels of adherence. This should be considered when designing a feasible physical activity intervention;[43] it should be enjoyable and convenient to encourage compliance. Intensity needs to be adapted to the reduced fitness levels of postnatal women, because these women are dealing with exceptional demands of caring for their babies and their family. In addition, exercise could provide a reason for engaging with others and, as part of this, intervention participants might be encouraged to find social support, and to ask friends and/or family for support.

The limitations of this study were as follows: (1) The quality of the studies was low to medium, thus the risk of bias is increased. It should be noted that the main reason behind the low scoring of the included studies was the impracticality of blinding interventions, and this limitation is unavoidable. (2) Pregnant women who participated in these studies were volunteers, so their levels of compliance could be higher than in the general population of women. (3) The diagnostic criteria used in the included studies for postpartum depression were different, and this could produce a difference in the classification of depression status. The scales were the most commonly used to determine postnatal well-being of mothers and both are widely validated scales for depression in the general population. Two subgroups were established according to the depression cutoffs of these scales: EPDS ≥12, and BDI ≥10. (4) An analysis about the effectiveness of physical activity on postpartum depression depending on the severity of symptoms could not be done, because of lack of information in the included studies. Thus, further research is needed to clarify this concern. (5) Finally, there was a wide variety in the exercise programs and in the frequency of sessions.

5 | CONCLUSION

Our analyses allow us to conclude that physical activity during pregnancy and the postpartum period is associated with a lower incidence of postpartum depressive symptoms. Our findings have important clinical implications as they provide evidence about the effectiveness of physical activity on the mitigation of postpartum depressive symptoms. Consequently, our study provides support for the recommendation to advise pregnant women and new mothers to engage in exercise programs as an effective and safe strategy to achieve better psychological well-being and to avoid postpartum depressive symptoms.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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