Received: 13 June 2023 | Revised: 2 August 2023 | Accepted: 17 August 2023

DOI: 10.1002/ijgo.15091

International Journal of GYNECOLOGY OBSTETRICS FIGO WILEY

REVIEW ARTICLE

Obstetrics

# Comparative impact of exercise-based interventions for postpartum depression: A Bayesian network meta-analysis

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## Abstract

**Objective:** The current study aimed to address and rank which exercise-based interventions are preferable to standard care/no therapy or another exercise intervention for postpartum depression (PPD) management and provide estimates for future definitive evidence.

**Methods:** The authors systematically searched PubMed, Embase, the Web of Science, PsycInfo, and ClinicalTrails.gov for randomized controlled trials (RCTs) on exercise-based interventions for PPD from their inception to May 9, 2023. Included were RCTs of exercise-based interventions for PPD with at least 4 weeks' duration. The pooled effects of intervention comparisons were generated by the Bayesian random-effects model, and the quality of evidence was evaluated by the Grading of Recommendations, Assessment, Development, and Evaluations framework.

**Results:** Twelve RCTs (1260 women; mean age, 20–35 years) comparing exercise-based interventions with usual care/no therapy were included. Exercise effectively treats depressive symptoms (standard mean difference [SMD], −0.81 [95% confidence interval (CI), −1.20 to −0.42], $P<0.001$). Pram walking was significantly associated with a reduction of depressive symptoms during the postpartum period (SMD, −1.00 [95% CI, −2.60 to −0.10], $P=0.020$), as well as yoga (SMD, −0.73 [95% CI, −1.84 to −0.43], $P<0.001$) and supervised mixed exercise (SMD, −0.77 [95% CI, −1.67 to −0.01], $P=0.041$) compared with usual care/no therapy. In indirect comparisons, pram walking (surface under the cumulative ranking curve, 58.9%) was better than yoga (SMD, −0.28 [95% CI, −1.86 to 1.22], $P=0.322$) and supervised mixed exercise (SMD, −0.23 [95% CI, −1.59 to 1.12], $P=0.358$). However, the difference was not statistically significant. The confidence in evidence was very low to moderate.

**Conclusion:** In women with PPD, all commonly prescribed physical exercises were effective alternative or complementary treatments. However, pram walking may perform better in improving the symptoms of PPD.

KEYWORDS
complementary therapies, exercise therapy, maternal health, network meta-analysis, perinatal mental health, physical exercise, postpartum depression

## 1 | INTRODUCTION

Depression is a global and multiregional burden on public health, affecting approximately 5% of adults (4% of men and 6% of women).[1] More than 280 million people experience depression, and 60% of the nearly 800000 people who commit suicide annually have major depression worldwide.[2,3] Compared with general women, the prevalence of postpartum depression (PPD) is substantially greater (ranging from 10% to 22%) among women within the first year after delivery.[4,5] PPD refers to a minor and major depressive disorder that occurs during pregnancy or shortly after delivery (until the first 4 weeks after birth), according to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-5*). In clinical practice and research, PPD may occur for up to 1 year after the birth of a child.[6] Because of its similarities to pregnancy and postpartum distress symptoms, PPD is frequently underdiagnosed and undertreated.[7]

PPD is characterized by feelings of sadness or depression, disinterest in the newborn, excessive crying, and dread of hurting or harming the infant. PPD results in maternal distress and decreased functioning and is associated with an increased risk of couple conflict and impaired infant-caregiver closeness.[8] The impact may also be long-term, with adverse effects on emotional, social, and cognitive development in children.[9] For mothers, approximately 40% of cases relapse during subsequent pregnancies or under other circumstances.[10]

Drug therapies and psychological treatments are the standard treatments for PPD, as recommended by most clinical practice guidelines.[11,12] However, with concerns about the long-term impacts of antipsychotic drugs on infants, mothers are hesitant to take the medication while breastfeeding.[13] Although antidepressants are effective treatment options for PPD, treatment-related stigma may account for the low treatment rate.[14] In addition, accessibility and costs for psychotherapy can be challenging issues for low-income households. Thus, alternative and complementary treatments are urgently needed.

In the general population experiencing depression, exercise has been recognized as a practical, inexpensive, readily accessible, and side-effect-free therapy option.[15] Several meta-analyses have verified the efficacy of exercise-based interventions in ameliorating and reducing depressive symptoms in the management of PPD.[16,17] However, these studies were unable to clear recommendations among different exercise modalities because most of them have not been directly compared in trials. Therefore, we performed a network meta-analysis (NMA) to comprehensively compare and rank the types of exercise-based interventions for women with PPD.

## 2 | MATERIALS AND METHODS

Our NMA of exercise interventions in PPD was registered on PROSPERO (No. CRD42023424646) and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and the extension statement of NMA. The study protocol is available in the supplementary material (Table S1).

### 2.1 | Information sources and search strategy

A systematic search strategy was applied for eligible studies using online electronic databases (PubMed, Embase, Web of Science, PsycInfo, and ClinicalTrails.gov). We searched the relevant randomized controlled trials (RCTs) from database inception until May 09, 2023. Reference lists of retrieved reviews were also manually searched for additional eligible records. The following key terms were used for searching: depression, depressive disorder, depressive syndrome, depressive disease, postpartum period, postnatal, postpartum, puerperium, perinatal, exercise, sport, training, fitness, physical activity, physiotherapy, yoga, pram walking, running, swimming, aerobics, and their Medical Subject Headings if existed. The details of search strategies appear in Table S2.

### 2.2 | Eligibility criteria and study selection

Two investigators (J.W. and S.S.) reviewed study titles, abstracts, and full texts independently to confirm eligibility. Any disagreement between the investigators was discussed, and an agreement was reached with a third independent investigator (C.C.).

Included studies satisfied the following criteria: (1) RCTs of exercise-based interventions for PPD; (2) exercise-based interventions started during pregnancy or the postpartum period, and their duration ≥4 weeks; (3) the maternal depression scale was assessed at both baseline and after the exercise interventions; and (4) control groups were another type of exercise intervention, usual care, social support, psychotherapy, and nonexercise therapy.

Studies were excluded when: (1) studies did not have maternal depression assessment in the postpartum period; (2) there were unresolved data integrity concerns; and (3) studies were not written in English or Chinese.

### 2.3 | Data extraction and assessment of risk of bias

The following data were extracted by two investigators (J.W. and S.S) who independently piloted the same data collection table. The following data were extracted by two investigators (J.W. and S.S.) who independently piloted the same data collection table: first author; publication year; country; sample size; interventions; instruments used to measure PPD; patient age; length, frequency, type, and intensity of exercise; and maternal depression scores at baseline and postintervention.

Two investigators (J.W. and S.S.) independently assessed the quality of each study using the Cochrane Collaboration Risk of Bias Tool.[18] Disagreements were resolved after discussion to reach a consensus. The quality of RCT was designated as unclear, low, and high based on random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias.

### 2.4 | Data synthesis

The primary outcome was the change in overall symptoms of depressive symptoms as assessed by rating scales, such as the Edinburgh Postnatal Depression Scale (EPDS), the Self-Rating Depression Scale (SDS), and the Hamilton Depression Rating Scale (HDRS), or any other validated published instruments.

If head-to-head studies were available, pairwise meta-analyses were conducted using the random-effects model with Review Manager (RevMan version 5.3; The Cochrane Collaboration). Effect sizes were summarized with the standardized mean difference (SMD) and its 95% confidence interval (CI). Heterogeneity was detected using $I^2$ statistic and Cochran Q test, classified as low to moderate heterogeneity ($I^2 < 50\%$) and high-level heterogeneity (≥50%). Funnel plot and Egger test were applied to detect potential publication bias. We used the trim-and-fill method to estimate the effect of publication bias on interpreting the outcomes once Egger test detected a potential publication bias with STATA version 17.0 (StataCorp LLC).[19]

For the NMA, a Bayesian framework with a random-effects model was conducted to generate comparisons of different exercise-based interventions for PPD.[20] This method aggregated direct and indirect comparisons for any pair of interventions using a more robust deviance information criterion model.[21] In NMA, trace plots, Brooks-Gelman-Rubin diagnosis plots, and density plots were used to detect the convergence of Markov chain Monte Carlo methods. All models were set on 10 000 burn-in samples yielding 80 000 iterations to obtain the SMD in four chains. Rank probabilities were estimated to obtain the possible rank of each intervention, and a rank plot was generated to visualize the results. The hierarchy of exercise-based interventions was summarized and ranked using the surface under the cumulative ranking curve (SUCRA).[22] The sensitivity analysis was conducted by excluding studies with high heterogeneity to ensure reliability. All processes of NMA were performed using a Bayesian framework with the GeMTC 1.0-1 package in R software version 4.3.0 (R Project for Statistical Computing).[23]

We rated the quality of the evidence following the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) working group's methodology for a pairwise meta-analysis. The quality of evidence could be downgraded into moderate, low, or very low under the evaluation of five sections for the primary outcomes (risk of bias, indirectness, inconsistency, imprecision, and publication bias).[24] In NMA, we integrated evidence from indirect and direct comparisons using a recently published GRADE method.[25]

## 3 | RESULTS

### 3.1 | Study selection

A total of 1076 records were identified according to our search strategy from five databases. After removing 1419 duplicate records, our team screened the titles and abstracts and excluded an additional 619 irrelevant studies. A total of 26 studies were relevant for full-text review and 15 studies were excluded due to the absence of maternal depression assessment at baseline, the wrong study design, insufficient data, and duplicate populations. One study was identified from citations by manual searching. Eventually, 12 studies met the inclusion criteria and were included in the final analyses.[26–37] Figure 1 illustrates the flowchart of the literature selection.

### 3.2 | Study characteristics

Table 1 presents the detailed characteristics of the 12 included RCTs. The study sample sizes ranged from 19 to 579 women, with 532 participants randomly assigned to an exercise-based intervention and 728 to usual care/no therapy. All trials were two-armed studies with three different exercise interventions, including pram walking (4 of 12 [33.3%]), yoga (3 of 12 [25.0%]), and supervised mixed exercise (5 of 12 [41.7%]), while the comparator was usual care/no therapy. For pram walking, participants were required to push a pram/stroller in flat walking paths and walk at a moderate intensity (60%–75% of age-predicted heart rate) with a group. During the yoga intervention, participants practiced common yoga poses (i.e. balancing, twisting, breathing, and relaxation poses) under the guidance of a yoga instructor or obstetrician. Supervised mixed exercises were supervised by exercise instructors/physiologists and included aerobics, strength training, stretching, moderate-intensity exercise, and pregnancy-specific exercises.

Three (25%) trials recruited patients from the Americas, three (25%) from Oceania, three (25%) from Europe, two (16.7%) from Asia, and one (8.3%) from Africa. Three scales were used across studies for PPD, including the EPDS, the SDS, and the HDRS. The intervention duration of PPD ranged from 4 to 24 weeks.

### 3.3 | Risk of bias

All 12 trials were open-label studies with a high risk of performance bias. However, low risks of selection bias were detected due to

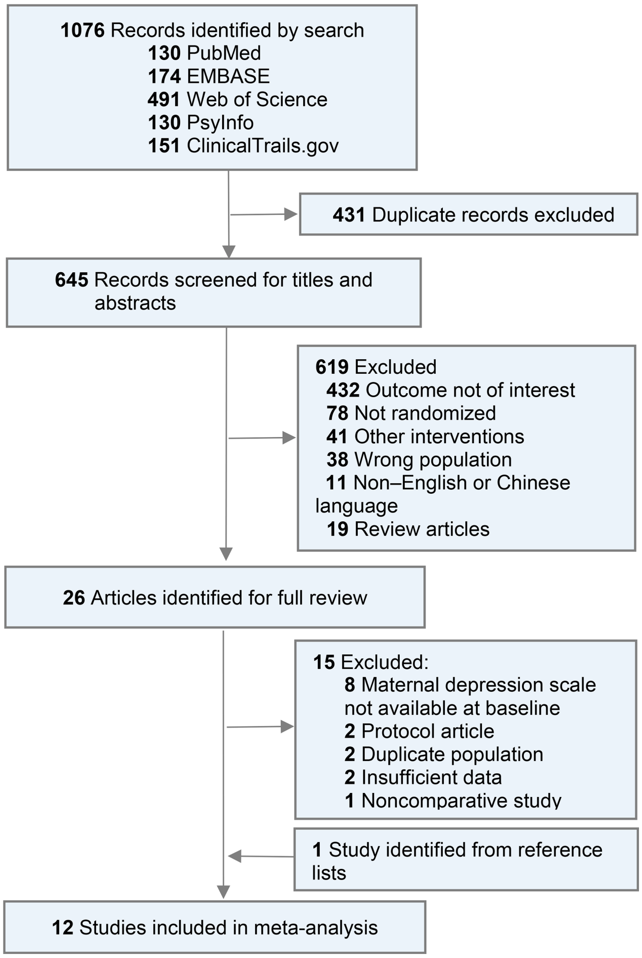


FIGURE 1 Search flow diagram.

explicit descriptions of sequence generation and allocation concealment methods. Unclear risks were observed in detection bias, attrition, and other bias because the details of outcomes assessment and incomplete follow-up data were often not described in texts. Details of quality assessment are presented in Figure 2 and Table S3.

## 3.4 | Pairwise meta-analysis for exercises versus control

We compared the pooled efficacy of exercise-based interventions against usual care or no therapy in women with PPD. In exercise-controlled studies, the pooled efficacy for exercise-based interventions was −0.81 (95% CI, −1.20 to −0.42 [$P<0.001$]; low quality of evidence), suggesting that exercise was significantly associated with reducing depressive symptoms during the postpartum period. Heterogeneity was $I^2=88\%$ ($P<0.001$). In this analysis, the visual asymmetry of the funnel plot (Table S4) was observed and potential publication bias was detected by Egger test ($P<0.001$). The trim-and-fill test revealed that this publication bias had no effect on the estimates (i.e. no trimming was performed and the data remained unaltered).

In pram walking–controlled studies, the pooled effect was −0.91 (95% CI, −1.47 to −0.36, [$P=0.001$]; $I^2=49\%$, moderate quality of evidence) compared with the usual care group. Exercise with yoga and supervised mixed exercise presented similar benefits after interventions (−0.67 for yoga, [95% CI, −0.98 to −0.36], $P<0.001$; $I^2=4\%$, moderate quality of evidence; −0.77 for supervised mixed exercise [95% CI, −1.47 to −0.07], $P=0.030$; $I^2=94\%$, low quality of evidence) (Figure 2; Table S5).

## 3.5 | NMA for efficacy

Figure 3 presents the network of each intervention for efficacy. All exercise-based treatments had at least three exercise-controlled trials, while no exercise therapies were directly compared. Thus, there are no closed loops in the network plot.

The density plot, the trace plot (Table S6), and the Brooks–Gelman–Rubin diagnosis plot (Table S7) demonstrated that no chain fluctuation or skewed distribution of the density map was observed, indicating that the models conducted in NMA fit for all outcomes.

The Figure 4 league table reveals that compared with usual care/no therapy, all commonly utilized exercise-based interventions decreased the symptoms of PPD for the mother. Effect estimates (SMD) ranged from a 0.73 reduction with yoga (−0.73 [95% CI, −1.84 to −0.43]; $P<0.001$, moderate quality of evidence) (Table S8) and a 0.77 reduction with supervised mixed exercise (−0.77 [95% CI, −1.67 to 0.01]; $P=0.041$, moderate quality of evidence) to a 1.00 reduction with pram walking exercise (−1.00 [95% CI, −2.06 to −0.10]; $P=0.020$, moderate quality of evidence) on the left of Figure 4. In the intercomparison of multiple exercise interventions, pram walking exercise was more effective than yoga (SMD, −0.28, [95% CI, −1.86 to 1.22]; $P=0.322$, very low quality of evidence). Compared with supervised mixed exercise, the SMD for pram walking was also associated with an improvement in the symptoms of PPD (−0.23 [95% CI, −1.59 to 1.12]; $P=0.358$, very low quality of evidence). However, no statistically significant difference was seen between the indirect comparisons. In addition, pram walking showed the highest SUCRA value (58.9%) with the best efficacy, followed by supervised mixed exercise (21.9%), yoga (19.2%), and usual care/no therapy (0.0%) (Figure 5; Table S9).

After assessing interstudy heterogeneity, we found low heterogeneity in the yoga-controlled comparisons ($I^2=9.3\%$, $P=0.310$), moderate heterogeneity in the pram walking–controlled comparisons ($I^2=46.1\%$, $P=0.130$), and high heterogeneity in the supervised mixed exercise-controlled comparisons ($I^2=87.0\%$, $P<0.001$; Table S10). A sensitivity analysis was conducted by excluding studies with high heterogeneity to ensure reliability. Two trials (Daley et al and Özkan et al) with high heterogeneity (extreme intervention durations [24 and 4 weeks]) were omitted. Figure 4 and Table S11 demonstrate similar results for the efficacy of the sensitivity analysis. Model fit was examined for its adequacy for the initial and sensitivity analyses according to deviance information criterion (Table S12).

**TABLE 1** Characteristics of included studies.

| Source | Country | Patients (*n*) | Duration of intervention, wk | Frequency (per week) | Depression scale | Age, mean (SD) | Baseline depression score, mean (SD) |
|---|---|---|---|---|---|---|---|
| Pram walking versus control | | | | | | | |
| Armstrong et al.[26] | Australia | 10 (exercise) | 12 | 3 | EPDS | 21–30[a] | 17.9 (4.6) |
| | | 10 (control) | – | – | – | – | – |
| Armstrong et al.[27] | Australia | 9 (exercise) | 12 | 2 | EPDS | 30.0 (NR) | 17.2 (4.1) |
| | | 10 (control) | – | – | – | – | – |
| Daley et al.[28] | United Kingdom | 47 (exercise) | 24 | 3–5 | EPDS | 30.5 (5.6) | 17.4 (3.4) |
| | | 47 (control) | – | – | – | – | – |
| Forsyth et al.[29] | United Kingdom | 11 (exercise) | 24 | 3 | EPDS | 26.0 (5.3) | 16.8 (3.5) |
| | | 11 (control) | – | – | – | – | – |
| Yoga versus control | | | | | | | |
| Buttner et al.[30] | United States | 28 (exercise) | 8 | 2 | HDRS | 31.2 (5.1) | 16.3 (4.3) |
| | | 29 (control) | – | – | – | – | – |
| Shu et al.[31] | China | 40 (exercise) | 6 | 1 | EPDS | 32.0 (5.0) | 9.9 (2.5) |
| | | 38 (control) | – | – | – | – | – |
| El Refaye[32] | Egypt | 20 (exercise) | 12 | 7 | SDS | 24.0 (2.3) | 58.7 (4.5) |
| | | 20 (control) | – | – | – | – | – |
| Supervised mixed exercise versus control | | | | | | | |
| Da Costa et al.[33] | Canada | 46 (exercise) | 12 | 3 | EPDS | 33.5 (4.2) | 13.6 (3.7) |
| | | 42 (control) | – | – | – | – | – |
| Coll et al.[34] | Brazil | 192 (exercise) | 16 | 3 | EPDS | 27.3 (5.5) | 6.2 (4.2) |
| | | 387 (control) | – | – | – | – | – |
| Özkan et al.[35] | Turkey | 34 (exercise) | 4 | 5 | EPDS | 28.9 (4.8) | 16.1 (2.0) |
| | | 31 (control) | – | – | – | – | – |
| Heh et al.[36] | China | 33 (exercise) | 12 | 3 | EPDS | 20-35[b] | 16.4 (2.9) |
| | | 30 (control) | – | – | – | – | – |
| Norman et al.[37] | Australia | 62 (exercise) | 8 | 1 | EPDS | 29.7 (4.7) | 7.3 (5.8) |
| | | 73 (control) | – | – | – | – | – |

Abbreviations: EPDS, Edinburgh Postnatal Depression Score; HDRS, Hamilton Depression Rating Scale; SD, standard deviation; SDS, Self-Rating Depression Scale.

[a]Recorded in age range.

## 4 | DISCUSSION

This analysis represents the first NMA in the field of exercise-based interventions for PPD, based on 12 RCTs enrolling 1260 women randomly assigned to three different physical therapies or usual care. Through NMA of published RCTs of exercise therapy for PPD, we demonstrated that compared with usual care/no therapy, all of the common exercise-based interventions reduce PPD symptoms, with a big effect size (overall pooled SMD, −0.81; low quality of evidence). In terms of effectiveness, pram walking is an advanced exercise intervention to improve the symptoms of PPD according to cumulative probability plots and SUCRA (rank 1, 58.9%). However, overlapping confidence intervals between different physical interventions suggest that differences between exercise modalities were not significant. Thus, evidence regarding exercise types (pram walking, yoga, supervised mixed exercise) was of very low certainty.

Unsurprisingly, exercise-based therapy outperforms, by an enormous margin, usual care/no treatment in improving PPD symptoms. Indeed, the World Health Organization and the National Institute for Health and Care Excellence now advise psychiatrists to offer physical activity interventions to patients with depression.[38,39] However, some meta-analyses found weak or no effects of exercise interventions compared with controls.[40,41] These disparate results stem from conceptual and methodological differences regarding outcome evaluation and inclusion criteria. For instance, some studies investigated the effect of exercise on cognitive symptoms in patients with depression,[41] but the impact of physical activities on depressive symptoms was not thoroughly evaluated. Others concentrated on patients with major depressive disorder,[40] while the benefits of

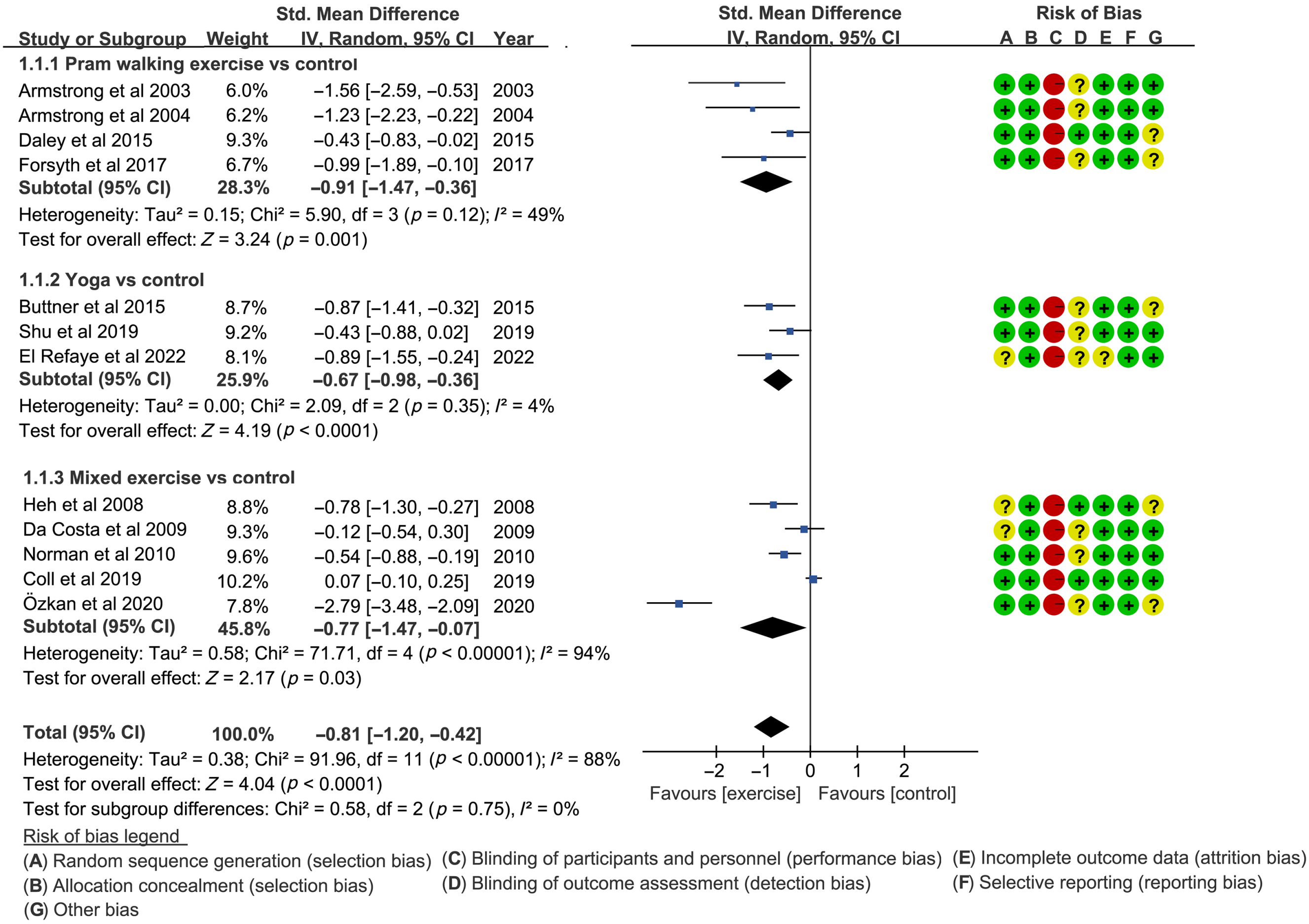


FIGURE 2 Pairwise meta-analysis for exercises versus control, subgroup analysis, and quality assessment of included studies. CI, confidence interval.

exercise interventions may be diminished or underestimated in this population. Current divergences and controversies prevent psychiatrists from implementing exercise as an optional treatment for depression, especially in special populations (i.e. women with PPD).

We have limited comprehension of the mechanisms underlying which exercise alleviates symptoms of depression, despite its antidepressant effects. However, some hypotheses speculate the involvement of psychosocial and cognitive regulation, inflammation, and neuronal regeneration.[42,43] Individuals with depression generally have reduced levels of self-worth and self-esteem.[44] Previous research indicates that exercise can boost self-perception and self-esteem and enhance social support to mitigate depressive symptoms.[45] In addition, exercise-based therapy provides extra opportunities for socialization, thereby reducing the feeling of isolation.[46]

It is well established that neuroinflammation is altered by activation in depressed patients. In pathological conditions, activated microglia release massive inflammatory factors, including interleukin (IL) 6, IL-1B, and tumor necrosis factor α, which produce neurotoxic effects, cause a reduction in neurogenesis, and finally lead to depression.[47] A 16-week study of home training with moderate-intensity exercise found that the production of anti-inflammatory

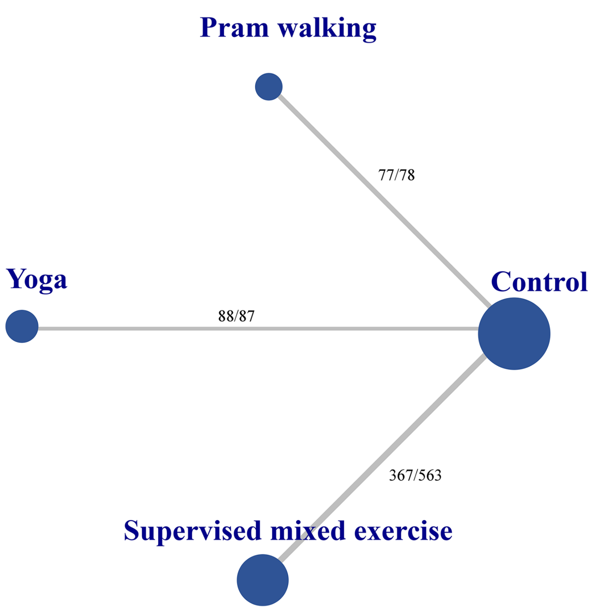


FIGURE 3 Network plot for comparisons. The "number 1/number 2" listed in the upper left of each comparison means that number 1 is the number of participants in the exercise group and number 2 is the number of participants in the control group.

| | | | |
|---|---|---|---|
| **Control** | −1.24 (−2.00, −0.52) | −0.70 (−1.28, −0.16) | −0.29 (−0.77, −0.13) |
| −1.00 (−2.06, −0.10) | **Pram walking** | 0.54 (−0.38, 1.45) | 0.95 (0.07, 1.78) |
| −0.73 (−1.84, −0.43) | 0.28 (−1.22, 1.86) | **Yoga** | 0.41 (−0.31, 1.12) |
| −0.77 (−1.67, −0.01) | 0.23 (−1.12, 1.59) | −0.04 (−1.52, 1.36) | **Supervised mixed exercise** |

| Pram walking | Supervised mixed exercise | Yoga | Control |
|---|---|---|---|
| Best | Initial analysis | | Worst |

| Pramwalking | Yoga | Supervised mixed exercise | Control |
|---|---|---|---|
| Best | Sensitivity analysis | | Worst |

**FIGURE 4** League tables of network meta-analysis (lower left) and sensitivity analysis (upper right), followed by the ranking distribution according to surface under the cumulative ranking curve values.

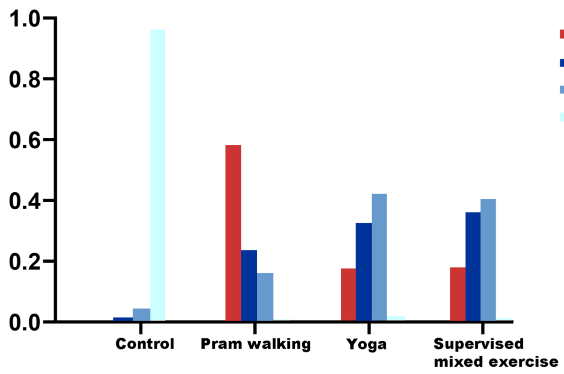


**FIGURE 5** Histogram of rank probability. Rank 1 is the best and Rank 4 is the worst.

factors (such as cytokine IL-10) increased and the levels of proinflammatory cytokines and markers (i.e. C-reactive protein and IL-6) decreased in patients diagnosed with major depression after the program, inversely.[48] Meanwhile, in brain-derived neurotrophic factor (a marker of neuronal plasticity and growth), its reduction is related to the pathogenesis of depression. Long-term exercise can increase serum brain-derived neurotrophic factor concentrations and hippocampus volume.[49]

The advantages of postpartum physical activity are evident in weight control, cardiorespiratory function, self-confidence, physical performance, socialization, and reduction of anxiety and depression.[50] Moreover, body image and form changes may help women regain confidence and self-worth during the postpartum period.[51] In contrast, guidelines for perinatal depression recommend antidepressants and psychotherapy (or a combination of both) as the first-line treatment. It was reported that psychotherapy only resulted in a remission rate of 50% and was typically expensive.[52] Concerns about antidepressant side effects for infants, relapse, and withdrawal symptoms may be the primary reasons for the low antidepressant treatment rate.[53] This demonstrates the need for readily available and expeditious alternative treatments.

### 4.1 | Strengths and limitations

Previous meta-analyses report a similar impact of exercise interventions for PPD. Daley et al included five RCTs involving 221 participants revealing a large pooled effect size of exercise (SMD, −0.81) on PPD symptoms but only focused on aerobics without the certainty of evidence evaluation.[54] Small to moderate effect sizes were found in the studies from Carter et al. and Poyatos-León et al.[16,55] However, these studies were limited by the methodology and objective, failing to expose the effects of different exercise types on PPD and the comparison between them. The strengths of our studies include systematic literature selection of RCTs for exercise interventions on PPD, evaluation of the certainty using the GRADE method, and a Bayesian analytic approach for analyzing. Notably, an NMA with the Bayesian random-effects model was applied to conduct direct comparisons of exercise interventions versus usual care and indirect evidence for comparisons of exercise types that have not been directly compared in trials (e.g. pram walking versus yoga and yoga versus supervised mixed exercise).

Our study had limitations. The high heterogeneity among included trials may stem from the different duration of intervention, cultural backgrounds, severity of PPD, and variable assessment instruments. We performed comparisons of exercise types versus usual care and sensitivity analysis, which reduced heterogeneity (Tables S9 and S10). All included studies had defects in blinding participants and were at high risk of performance bias. In addition, most of the results comprised a very low to moderate quality of evidence, e.g. evidence levels for efficiency comparisons between pram walking, yoga, and supervised mixed exercise were very low due to insignificant 95% confidence intervals along with *P* values. There was large uncertainty regarding indirect estimates among the comparison of exercise types due to a lack of direct evidence and closed loops in the analysis. Studies involving novel exercise interventions (e.g. aerobic water exercise), which maternal depression assessments were missing at baseline, were unable to be included in the analysis.

### 4.2 | Clinical implications

The next step is to consider exercise as an alternative or even a first-line treatment for PPD alongside medication and psychotherapy. Future large-scale, multiarm studies should investigate the direct comparison of the effects of exercise types on PPD. Exercise-induced adverse events should be reported and recorded in documents (even though they rarely occur). Further, in order to reduce the burden of public health care and enhance treatment rates, it is also necessary to document the costs associated with various forms of exercise.

## 5 | CONCLUSION

In summary, compared with usual care, all common forms of exercise improved the symptoms of PPD with low to moderate quality of evidence. Pram walking performed better than other types of exercise and ranked first, followed by supervised mixed exercise, yoga, and usual care. The quality of evidence for these indirect comparisons was very low, with considerable uncertainty. Given concerns about the limitations, further high-quality trials/studies should focus on the direct comparisons of the efficacy among exercise types.

## AUTHOR CONTRIBUTIONS

**Zhichao Chen and Jing Wang:** Designed the study. **Jing Wang, Stefania Sedda, and Ciriaco Carru:** Conducted the literature search. **Zhichao Chen, Jing Wang, Ciriaco Carru, Pier Luigi Fiori, and Zhi Li:** Had full access to all data in the study and took responsibility for the accuracy of the data analysis and integrity. **Zhichao Chen and Jing Wang:** Performed the analyses and wrote the first draft of the manuscript. All authors contributed critical comments to the drafts.

## ACKNOWLEDGMENTS

We are grateful to the Second Affiliated Hospital of Shantou University Medical College (Shantou, China) and the University of Sassari (Sassari, Italy) for the doctoral grant.

## FUNDING INFORMATION

None.

## CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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## SUPPORTING INFORMATION

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

**How to cite this article:** Wang J, Carru C, Sedda S, Fiori PL, Li Z, Chen Z. Comparative impact of exercise-based interventions for postpartum depression: A Bayesian network meta-analysis. *Int J Gynecol Obstet*. 2023;00:1-9. doi:10.1002/ijgo.15091