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Does aerobic exercise reduce postpartum depressive symptoms? A systematic review and meta-analysis

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Does aerobic exercise reduce postpartum depressive symptoms?

A systematic review and meta-analysis

Running Title: Systematic review of exercise for postpartum depressive symptoms

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ABSTRACT

Background

There is currently no specific guidance on the role of exercise in managing postpartum depression in the UK and USA and international guidance is inconsistent.

Aim

To assess the effectiveness of aerobic exercise on postpartum depressive symptoms.

Design and setting

Systematic review and meta-analysis including randomised controlled trials (RCTs) of interventions to increase exercise in the postpartum period. There was no restriction to study site or setting.

Method

The databases MEDLINE, EMBASE, Cochrane Library, PsychINFO, SportDiscus, <http://clinicaltrials.gov> and the World Health Organisation International Clinical Trials Registry Platform were searched. Titles and abstracts, then full text articles were screened against inclusion criteria: RCTs measuring depressive symptoms in mothers ≤ 1 year postpartum; interventions designed to increase aerobic exercise compared with usual care or other comparators. Included studies were assessed using the Cochrane Collaboration's risk of bias tool. Meta-analysis was conducted. Pre-planned subgroup analyses explored heterogeneity.

Results

Thirteen RCTs were included, with 1734 eligible participants. Exercise significantly reduced depressive symptoms when all trials were combined (standardized mean difference (95% confidence interval) -0.44, (-0.75 to -0.12)). Exploration of heterogeneity did not find significant differences in effect size between women with possible depression and in general postpartum populations; exercise-only and exercise with co-interventions; and group exercise and exercise counselling.

Conclusion

This systematic review provides support for the effectiveness of exercise in reducing postpartum depressive symptoms. Group exercise, participant-chosen exercise and exercise with co-interventions may all be effective interventions. These results should be interpreted with caution due to substantial heterogeneity and risk of bias.

Key Words:

Depression, Postpartum, Postnatal, Exercise, Systematic review

Word count 2525

How this fits in

UK clinical guidance recommends psychological therapy and antidepressants for postnatal depression, but women can be reluctant to take antidepressants postnatally and the availability of psychological therapies is often limited. Exercise is effective in treating depression in the general adult population, however, there are particular challenges in the postnatal period which may impact on the feasibility and effectiveness of exercise in reducing postnatal depressive symptoms. This systematic review found that exercise is an effective intervention for reducing postnatal depressive symptoms. Encouraging women to take aerobic exercise in the postnatal period may have psychological and other health benefits.

Introduction

Postpartum depression is a global mental health issue, annually affecting 13 million women worldwide (1-3). Postpartum depression can lead to thoughts of self-harm and/or harm of the child (4) and negatively affect children's development (5, 6). There can be reluctance by women to take antidepressants postnatally, particularly if they are breastfeeding (7, 8). Cognitive behavioral therapy can be effective but waiting lists are often long in the United Kingdom (UK) (9).

Exercise can have a moderate effect in reducing general adult depression (standardized mean difference -0.62, 95% confidence interval -0.81 to -0.42) (10). Practitioner led group exercise is recommended by the UK National Institute for Health and Care Excellence (NICE) for persistent subthreshold depressive symptoms and mild to moderate depression (11). However, postpartum women have particular physical, practical and psychological challenges to exercising (12, 13). A 2009 review provided some support for exercise as an adjunctive treatment for postpartum depressive symptoms (14).

Despite its challenges, exercise provides another intervention option when many mothers are reluctant to seek treatment and/or take antidepressants (8). Exercise also offers improved fitness and weight loss and opportunities for social interaction at a time when women experience decreased exercise and weight retention (15-17).

Aim and objectives

To undertake a meta-analysis of randomized controlled trials (RCTs) investigating the effect of aerobic exercise interventions, compared to usual care, on depressive symptoms in women up to one year postpartum.

To explore the effect of exercise on depressive symptoms in three subgroup analyses: (i) women with possible depression and general postpartum populations; (ii) interventions based only on exercise and those with co-interventions; and (iii) interventions providing structured group exercise and those supporting participant choice of exercise.

Methods

The review was registered on PROSPERO: CRD42016047656.

Data sources and searches

We followed the Cochrane Collaboration's guidance on reviews of interventions (18) and PRISMA guidelines (19). We searched the following bibliographic databases electronically for eligible trials: MEDLINE, EMBASE, the Cochrane Library, PsychINFO, SportDiscus and Clinical Trials.gov. The World Health Organisation (WHO) International Clinical Trials Registry Platform was searched for trials in progress. We conducted searches for grey literature in Open Grey (20) and OAlster Worldcat (21).

Searches were conducted on a range of psychological outcomes, only the results for depression are presented. We searched for the following terms as text words and MeSH terms where applicable: exercise, physical activity, postpartum, postnatal, mother, birth, perinatal, depression, anxiety, self-efficacy, quality of life, mother and infant bonding and child development (for Medline search strategy see Appendix 1). Searches were unrestricted by date or language and undertaken up to September 2016. We searched bibliographies of eligible studies and reviews for additional trials and contacted authors if required. Two researchers independently reviewed titles, abstracts and full text articles. Eligibility discrepancies were discussed with a third reviewer.

Study Selection

Inclusion criteria were: (i) populations of mothers less than one year postpartum; (ii) interventions designed to increase aerobic exercise (activity causing increased heart rate, respiratory rate and sweating), including those with co-interventions such as social support or nutrition elements; (iii) comparator groups receiving no care or any form of usual care; (iv) depressive symptoms measured by questionnaire or diagnostic interview; (v) RCTs.

Exclusion criteria: Trials comparing two types of exercise.

Data extraction and quality assessment

Data describing the population, intervention and findings were extracted independently by two researchers using standardized, piloted, extraction spreadsheets. Reviewers were not blinded to authors, institution, or journal. Authors were contacted if clarification was required.

Two researchers independently applied the Cochrane Collaboration's risk of bias tool (18) in relation to sequence generation; allocation concealment; blinding of outcome assessors; incomplete outcome data; selective outcome reporting and other sources of bias (18).

Blinding of personnel and participants to group allocation was not assessed due to the impracticalities of this in exercise trials. Each study was allocated an overall risk of bias, with a low risk of bias being assigned if the risk of bias was deemed to be low in all sub domains; an unclear risk of bias if the risk was considered unclear in one or more subdomains and a high risk of bias if the risk was considered high in one or more subdomains (18). Publication bias was assessed by visually inspecting a funnel plot of the standardized mean differences (SMD) for depressive symptoms.

Data synthesis and analysis

Populations indicating possible depression on screening questionnaires or in the clinical judgement of a health professional are referred to as 'depressed' postpartum populations.

We conducted meta-analyses and meta-regressions using Review Manager 5.3 (22). We calculated an SMD (18) for continuous outcomes of depressive symptoms. If more than one measure for depression was reported, we used the primary continuous outcome measure.

The final point of follow up was used as we wished to report long term outcomes. We calculated a weighted mean difference (WMD) for all trials using the Edinburgh Postnatal Depression Scale (EPDS) to assess depressive symptoms (23). Where the standard deviation of the difference in score was not reported, we calculated this. A correlation of 0.6 was used in the assumptions to estimate standard deviations of differences, based on a previous sample of postpartum women (24). We used a random effects model throughout

because of known clinical heterogeneity between populations and methodological heterogeneity between interventions.

We calculated an initial pooled standardized mean difference with 95% CI, with all trials included. Statistical significance was defined as having a 95% CI that did not include zero. We explored clinical heterogeneity (by qualitatively comparing characteristics between trials) and statistical heterogeneity using chi-squared tests of heterogeneity and the I^2 statistic.

We performed three a priori subgroup analyses, investigating whether the effectiveness of exercise in reducing postpartum depressive symptoms varied in relation to (i) the population of women (women with possible depression or general postpartum populations); (ii) the presence of co-interventions (exercise-only or exercise with co-interventions such as diet or social support) and (iii) the context of exercise (exercise groups or participant choice, participant choice often consisted of exercise counselling interventions in which participants typically elected to exercise alone, often by walking). For each hypothesis we categorised the trials into subgroups and used a random effects meta-regression model to determine the effects of exercise in each subgroup and the significance of differences between subgroups.

Results

Trial selection

Of the 9165 records identified after the removal of duplicates, 9043 were excluded after reading titles and abstracts. A further 109 full text records were excluded based on the eligibility criteria. Thirteen trials were included in the meta-analysis (Figure 1).

Trial characteristics

All 13 RCTs had been peer reviewed and published as journal articles (25-36) or abstracts (37). Four trials were conducted in the USA (28, 30, 32, 34); three in England (31, 36, 37); two in Australia (25, 29); one in Canada (26); one in India (33); one in Japan (35) and one in Taiwan (27).

The total population of the combined studies was 1734 eligible participants, with follow up data provided by 1307 participants who were included in the primary meta-analysis. Seven trials recruited participants with possible depression (25-28, 31, 36, 37), of which three required participants to score above a threshold on the EPDS questionnaire (from ≥ 10 to >12) (29,30,35) and two required a diagnosis of depression (ICD-10 (36) or DSM-IV criteria (37)). Despite not reporting baseline depression threshold criteria, two trials reported mean baseline depression scores indicating depressed populations (EPDS scores of 18.9 - 19.8 (28), BDI 15.8 - 16.9 (27)). These trials were therefore considered to have 'depressed' postpartum populations. Six trials recruited general postpartum populations (29, 30, 32-35) (Table 1).

Intervention characteristics

All trials included interventions designed to increase exercise levels. In addition, two trial interventions also aimed to improve diet and encourage a healthy lifestyle (27, 30); two also provided social support (25, 34) and one also provided education on postpartum issues (29). Six trials had group exercise interventions (25, 29, 33-35, 37); seven trials had interventions in which exercise counselling was provided and the participant was free to choose their own form of exercise (26-28, 30-32, 36) (Table 1). The interventions ranged from 4 weeks duration (33,35) to 6 months (27,32,36). Most aimed to achieve 30 minutes of moderate activity 3-5 times weekly (25,26,28,30-32,35-37), although some consisted of once weekly group exercise (29,33). Eight of the studies reported adherence to the intended intervention (25,26,28,31,32,35-37).

Risk of bias in included studies and publication bias

Six trials were considered at unclear risk (25, 26, 31-33, 37) and seven at high risk of bias (27-30, 34-36). Principal factors introducing a risk of bias were a lack of intention-to-treat analyses (some studies excluded non-adherent participants), a lack of clarity on selective outcome reporting, a lack of robust sequence generation and concealment of randomisation

procedures and unclear blinding of those conducting outcome assessments and analyses (Appendix 2).

We visually inspected the funnel plot for the main analysis including all trials. There appeared to be a lack of smaller studies with results indicating an increase in depression in exercise intervention groups compared to comparator groups. This may be an indication of publication bias (Appendix 3).

Provision of additional data

Authors of four trials provided additional data for this review: DaCosta et al (26), Surkan et al (30) Lewis et al (32) and Boath et al (37).

Data analysis

Overall effect of exercise on depression scores

Exercise interventions significantly reduced depressive symptoms (SMD -0.44, 95% CI -0.75 to -0.12, n=1307, I^2 : 85%, 13 trials) (Figure 2) (25-37). The WMD was -1.54 EPDS units, 95% CI -2.97 to -0.12, n=652, I^2 : 87% (25, 26, 28, 29, 31, 33-37).

Population

Exercise interventions had a significant effect in reducing depressive symptoms in 'depressed' postpartum populations (SMD -0.32, 95% CI -0.63 to -0.00), I^2 : 55%, (25-28, 31, 36, 37) (Table 2, Appendix 4) and in general postpartum populations (-0.57, 95% CI -1.12 to -0.02, I^2 : 92%) (29, 30, 32-35) (Table 2, Appendix Figure 3). The effect of exercise interventions in the 'depressed' and general postpartum populations was not significantly different (test for subgroup differences $X^2= 0.62$, $P= 0.43$, I^2 : 0%) (Appendix 4).

Intervention type

Exercise-only interventions had a non-significant effect in reducing depressive symptoms (SMD -0.56, 95% CI -1.13 to 0.01, I^2 : 89%) (26, 28, 31-33, 35-37). Exercise with co-interventions had a significant effect on reducing depressive symptoms (-0.35, 95% CI -0.66 to -0.04, I^2 : 72%) (25, 27, 29, 30, 34). The effect of exercise-only interventions and exercise

co-interventions on depressive symptoms was not significantly different (test for subgroup differences: $X^2= 0.41$, $P= 0.52$, $I^2: 0\%$) (Table 2, Appendix 5).

Exercise context

Group exercise interventions had a significant effect in reducing depressive symptoms (standardized mean difference -1.10, 95% CI -1.99 to -0.21, $P: 93\%$) (25, 29, 33-35, 37).

Participant choice interventions such as exercise counselling with personal choice of exercise (often exercise alone) had a significant effect in reducing depressive symptoms (-0.20, 95% CI -0.33 to -0.06, $P: 0\%$) (26-28, 30-32, 36). The effects of group exercise and participant choice exercise on depressive symptoms were not significantly different (test for subgroup differences: $X^2= 3.89$, $P= 0.05$, $I^2: 74\%$) (Table 2, Figure 6).

Discussion

Summary

There is no specific guidance on the role of exercise in the management of perinatal mental health in the UK or USA (7, 38), this systematic review provides support for exercise as an effective treatment for reducing postpartum depressive symptoms, whether or not women meet robust criteria for PND. Additionally, we have been able to explore the characteristics of exercise interventions which are most likely to be effective for the postpartum population.

Strengths and limitations

Caution should be taken when interpreting our results, as a substantial level of heterogeneity was present. Heterogeneity was present in the design of the trials, including exercise-only interventions and those also promoting a healthy diet or social support amongst peers.

Exercise contexts also varied between structured, group-based exercise and tailored exercise counselling with participant choice of exercise. A random effects model was used in analyses to account for this variation and potential causes of heterogeneity were explored in subgroup analyses, however, there were insufficient numbers of trials to explore this

heterogeneity in depth. We used the last follow-up point as we were interested in long term outcomes; the median duration of follow-up was 6 months from recruitment (IQR 3,9).

The methodological quality of several of the included trials was low. Exclusion of non-adherent participants, insufficiently robust sequence generation and unclear blinding of outcome assessors resulted in an increased risk of bias. Only two included trials in 'depressed' populations recruited women with a diagnosis of depression (ICD-10 or DSM-IV) (36, 37); the remainder used screening questionnaires such as the EPDS (23) to indicate women with possible depression. The EPDS has the advantage of being relatively short and simple to complete, but has been reported to have considerable heterogeneity in sensitivity and specificity for detecting PND across different settings and populations (39).

There was a lack of assessment of exercise duration and intensity in included studies; of those that did provide this information, only two included an objective measure of exercise (34, 36). Exercise intensity can be difficult to determine accurately by self-report. For future research, objective accelerometry would allow for greater accuracy and more meaningful comparison between intervention types.

This review has several strengths. Recommended methods were followed; searching was systematic and not limited by language of publication. We restricted the review to RCTs to reduce the potential for confounding. We explored the effectiveness of exercise in different populations; intervention types and exercise contexts, which has not been previously attempted.

Comparison with existing literature

The evidence in this field has increased substantially since the review by Daley et al. in 2009 (14). Although the primary effect size in this review is smaller than that reported by Daley et

al. (SMD -0.44, 95%CI -0.75 to -0.12 rather than -0.81, 95%CI -1.53 to -0.10 (14)), the CI surrounding the effect is narrower here, indicating more precision.

In this review, the effect of exercise in depressed postpartum populations was smaller than that reported in a recent review of exercise in general adult depressed populations (SMD -0.62, 95%CI -0.81 to -0.42) (10), indicating that there may be differences in the way general adult populations and postpartum populations respond to exercise or differing abilities to adhere to an exercise regime. Women in the postnatal period have the time constraints of new parenthood and barriers to exercise such as fatigue. These factors could be explored by qualitative research with postnatal women.

The effect of exercise on postpartum depressive symptoms reported in this review compared favourably with that reported in a review of low intensity psychological interventions (such as online CBT and self-help literature) versus usual care for depression in the general population (SMD -0.42, 95%CI -0.55 to -0.29) (40). Despite some temporary changes in the composition of breastmilk following maximal exercise, the literature does not suggest any detrimental effects of moderate levels of aerobic exercise (41), as evaluated by the trials in this review. Such interventions are often amongst the first treatments offered to individuals presenting with depression (11). The effect of exercise on postpartum depressive symptoms we report is also comparable to those reported for antidepressants in depressed adult populations; (SMD -0.49, 95%CI -0.67 to -0.32 for tricyclic antidepressants and -0.24, 95%CI -0.35 to -0.12 for selective serotonin reuptake inhibitors compared to placebo) (42).

Exercise interventions also offer the additional health benefits of improved physical fitness and weight loss, outcomes particularly relevant to postpartum women, who often experience decreased exercise levels and excess weight (15-17). The finding that both group exercise and participant choice of exercise (often solitary exercise) may be effective in reducing postpartum depressive symptoms is also noteworthy. Current guidance from NICE on the treatment of postpartum mental illness refers clinicians to exercise advice for the general

adult population recommending only group exercise (11), which may not be the most feasible or acceptable option for women after having a baby (43).

Implications for research and practice

National and international guidance on the use of exercise to reduce depressive symptoms in the postpartum period is lacking. Whilst acknowledging considerable uncertainty about our findings due to substantial heterogeneity, given the high prevalence of postpartum depression and the potential for exercise to be a low cost, freely available intervention, aerobic exercise should be considered as a management option for postpartum women with depressive symptoms and as a potentially prevention measure more generally in postpartum women.

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Ethical approval

Not applicable

Competing interests

All authors declare no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work. Dr Pritchett (née Blamey) reports I am an author of one of the trials in this review, Dr Daley

reports I am an author of two of the trials included in this review, Dr Jolly reports I am an author of one of the trials included in this review.

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Authors RP, KJ and AD conceived the study. RP designed the search strategy. All authors selected the papers for inclusion and abstracted the data. RP undertook the meta-analysis under the guidance of AD. RP wrote the first draft of the paper. All authors had critical input into the writing and approved the final version. No other persons contributed significantly to this work.

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Figure 1: PRISMA flow chart

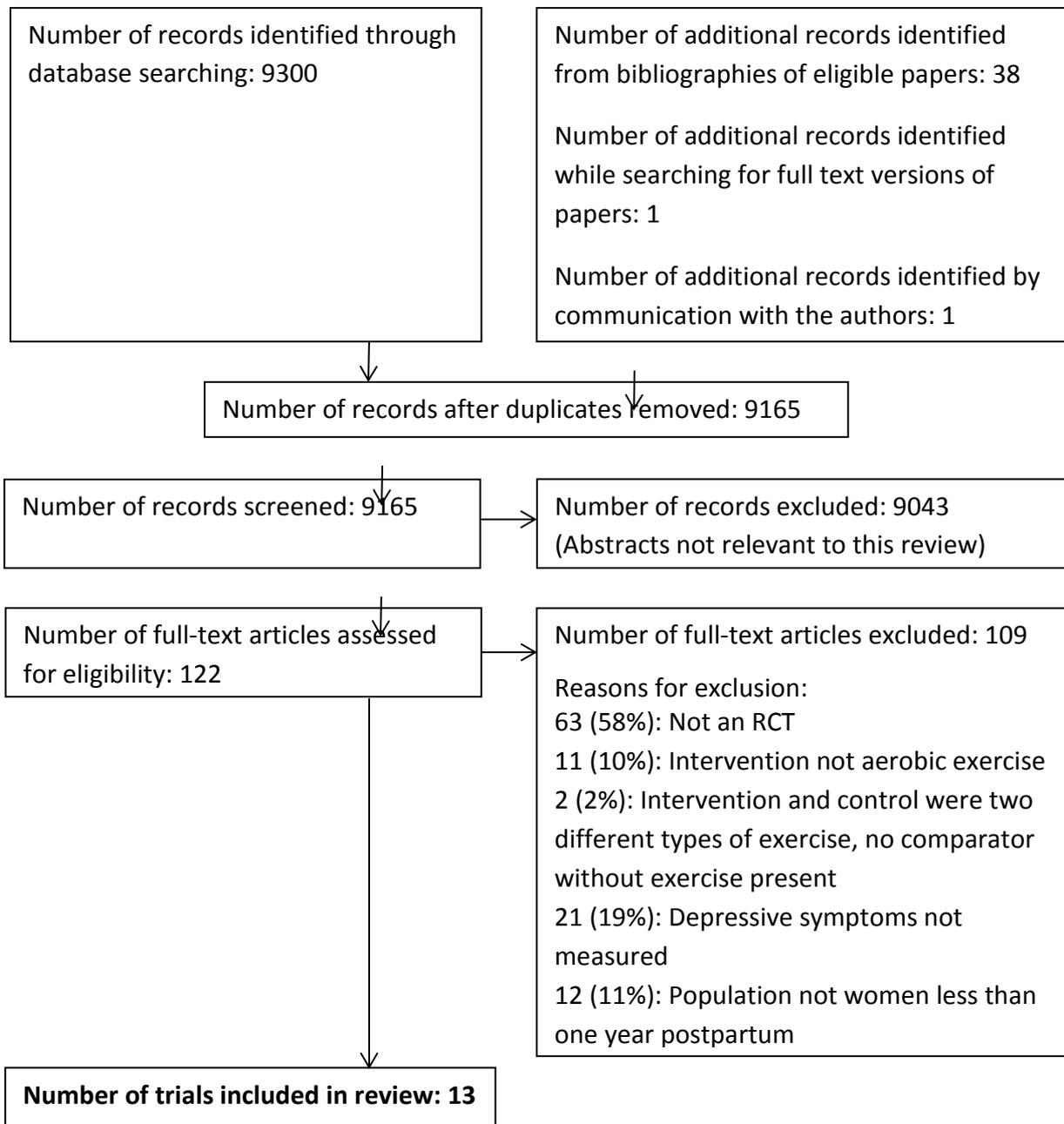


Figure 2: Meta-analysis of the effect of exercise on depressive symptoms

(Standardized mean difference)

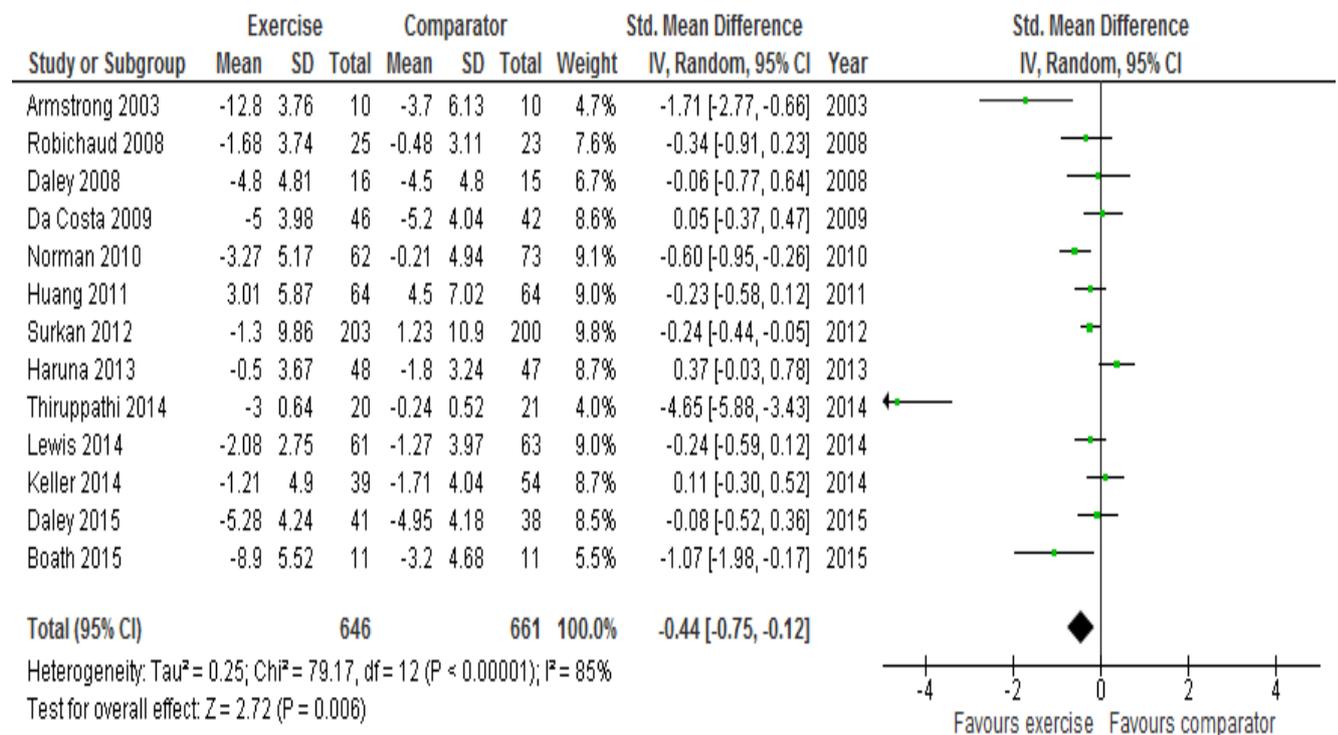


Table 1: Trial characteristics

Study	Country	Population	N	Intervention	Comparator	Outcomes	Result
Armstrong 2003 (25)	Queensland Australia	Depressed population	20	Group exercise programme (pram walks) with social co-intervention 12 weeks	Phone support at 6 weeks post randomization	EPDS and DASS 6 & 12 weeks	Intervention group depression improved significantly compared to control
Daley 2008 (31)	Birmingham UK	Sedentary population Depressed population	38	Exercise counselling 12 weeks	Usual care Exercise consult at end of trial	EPDS 24 weeks	No significant difference in EPDS between groups
Robichaud 2008 (28)	Tennessee USA	Depressed population	48	Exercise Programme (home-based walking) 6 weeks	Usual activity Intervention after trial	EPDS 8 weeks	No significant difference in EPDS between groups
Da Costa 2009 (26)	Montreal Canada	Sedentary population Depressed population	88	Exercise counselling 12 weeks	Usual care	EPDS and 17 item HAM-D 3 & 6 months	No significant change in EPDS from baseline to follow up.
Norman 2010 (29)	Melbourne Australia	General postpartum population	161	Group exercise programme with co-intervention (weekly educational session on postpartum issues) 8 weeks	Education on topics unrelated to diet or physical activity Booklet of exercises List of gyms and community facilities	EPDS 8 & 12 weeks	Significant decrease in EPDS in intervention compared to comparator
Huang 2011 (27)	Northern Taiwan	Depressed population	160	Exercise counselling with dietary co-intervention Postpartum group: 6 months	'Standard care' Discussions with nurses and leaflets on unrelated topics	BDI 6 months	Significant increase in BDI in intervention and comparator groups
Surkan 2012 (30)	Northeast USA	General postpartum population	679	Exercise counselling with dietary co-intervention	Usual WIC care: nutrition	CES-D Mean follow	Modest decrease in CES-D in intervention

				12 months	assessment, education, food vouchers	up 13.3 months (SD 3.7)	compared to control. Difference was significant in fully adjusted analysis
Haruna 2013 (35)	Tokyo Japan	General postpartum population	110	Group exercise programme 4 weeks	No details provided intervention at end of trial	EPDS 2 & 4 months	No significant difference in EPDS between groups
Thiruppathi 2014 (33)	Nellore India	General postpartum population	45	Group exercise programme 4 weeks	Health care education program Written materials on nutrition, baby care, posture	EPDS 12 weeks	Significant decrease in intervention group from baseline to follow up. No significant change in comparator group
Keller 2014 (34)	A south western city, USA	General postpartum population	139	Exercise counselling with group exercise (walking) and a co-intervention of 'promotoras' (peer support) 12 weeks	Attention control Month newsletters and weekly phone calls on unrelated topics	EPDS 6 and 12 months	No significant difference between groups
Lewis 2014 (32)	Minnesota USA	General postpartum population	130	Exercise counselling 6 months	Counsellor delivered telephone sessions on stress management, sleep, nutrition.	SCID-1 at 6 months only, PHQ-9 EPDS at 6 months only	Significant decrease in PHQ-9 and EPDS in intervention compared to control
Boath 2015 (37)	Stoke-on-Trent, UK	Depressed population	22	Group exercise programme (pram walk or facility-based) 12 weeks	One discussion about their goals for managing postpartum depression	EPDS 3 and 6 months	No significant difference in EPDS between groups
Daley 2015	Birmingham	Depressed population	94	Exercise counselling	Usual care	EPDS	Decrease in EPDS in

(36)	UK			6 months	Leaflet on healthy postpartum lifestyle	6 and 12 months	intervention vs comparator, only significant at 6 months not at 12 months
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BDI: The Beck Depression Inventory; CES-D: The Centre for Epidemiologic Studies Depression Scale; Comp: Comparator; DASS: The Depression Anxiety Stress Scale; EPDS: The Edinburgh Postnatal Depression Scale; HAM-D: The Hamilton Rating Scale for Depression; Int: Intervention; PHQ-9: The Patient Health Questionnaire-9; SCID-1: Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I); WIC: Special Supplemental Nutrition Program for Women, Infants and Children

Table 2: Subgroup analyses: population, intervention type and exercise context

Category	Standardized Mean Difference	95% Confidence Interval	P value	I²	Number of trials	Number of participants
Depressed postpartum populations	-0.32	-0.63 to -0.00	0.05	55%	7	416
General postpartum populations	-0.57	-1.12 to -0.02	0.04	92%	6	891
Exercise-only interventions	-0.56	-1.13 to 0.01	0.05	89%	8	528
Exercise co-interventions	-0.35	-0.66 to -0.04	0.03	72%	5	779
Group exercise interventions	-1.10	-1.99 to -0.21	0.02	93%	6	406
Participant choice exercise interventions	-0.20	-0.33 to -0.06	0.003	0%	7	901

APPENDIX 1: Medline search strategy

1. Exercise
 2. Exercise.tw
 3. Physical activity
 4. Physical activity.tw
 5. Activity
 6. Activity.tw
 7. 1 OR 2 OR 3 OR 4 OR 5 OR 6
 8. Postpartum
 9. Postpartum.tw
 10. Postnatal
 11. Postnatal.tw
 12. Mother
 13. Mother.tw
 14. Birth
 15. Birth.tw
 16. Perinatal
 17. Perinatal.tw
 18. 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17
 19. 7 AND 18
 20. Depression
 21. Depression.tw
 22. Postnatal depression
 23. Postnatal depression.tw
 24. Postpartum depression
 25. Postpartum depression.tw
 26. Anxiety
 27. Anxiety.tw
 28. Mother and infant bonding
 29. Mother and infant bonding. tw
 30. Self efficacy
 31. Self efficacy.tw
 32. Quality of life
 33. Quality of life.tw
 34. Child development
 35. Child development.tw
 36. 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35
 37. 19 AND 36
 38. Limit 37 to female
 39. Limit 38 to human
- Remove duplicates from 39

APPENXIX 2: Risk of bias of included studies

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Armstrong 2003 (25) (Depressed postnatal population)	Unclear:	Unclear: sealed envelope. Unclear if opaque or sequentially numbered	Unclear: Blinding of outcome assessor unclear. Unclear if researchers conducting analysis blinded	Low: All participants included in analysis (n=20).	Unclear: All listed outcomes reported on. Trial not registered on trial registries (proposed outcomes unavailable)	Unclear
Daley 2008 (31) (Depressed postnatal population)	Low: computer-generated random list from independent statistician	Unclear: No details	Unclear: Outcomes assessed by postal questionnaire. Unclear if researchers conducting analysis blinded	High: Follow up: 31/38 (81.6%) Missing data balanced across arms. No data on characteristics of drop outs. Intention-to-treat analysis was performed but drop outs were excluded.	Low: Listed primary outcomes reported on. All primary outcomes listed on the ISRCTN reported in results (ISRCTN75708176)	High
Robichaud 2008 (28) (Depressed postnatal population)	Low: Computerised Adaptive Randomisation Programme with controlled baseline characteristics	Unclear: No details	Unclear: Unclear if outcome assessor blinded. Unclear if researchers conducting analysis blinded	High: 48/51 (94.1%) participants included in analysis. However, not intention-to-treat analysis. Three excluded: 1 non-adherent intervention participant, 1 participant in each group who commenced antidepressants.	High: Anxiety as measured by PPQ not reported. Trial not registered on trial registries (proposed outcomes unavailable)	High

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Da Costa 2009 (26) (Depressed postnatal population)	Unclear: stratification in blocks of 4-6 based on baseline depression severity. Unclear how sequence generated	Low: Trial personnel blinded at point of allocation	Unclear: One measure of the primary outcome administered by phone by blinded interviewer. One outcome assessed by postal questionnaire. Unclear if researchers conducting analysis blinded	Low: Follow up: 62/88 (70.45%) Missing data balanced across arms. Non completers had similar baseline demographic and clinical characteristics to completers. Analysis intention-to-treat, missing data imputed (n=88).	Unclear: Listed primary outcome measures reported on. Trial registered after its completion NCT00384943	Unclear
Norman 2010 (29) (General postnatal population)	Low: computer generated random list in blocks of 16, stratified by parity	Low: consecutively numbered, sealed, opaque envelopes	Low: Researcher scoring outcome questionnaires blinded. Unclear if researchers conducting analysis blinded but if data anonymised before imputing it is likely	High: Follow up: 135/161 (83.9%). A large amount of missing data in intervention versus control. Analysis not intention-to-treat. Non-starters excluded from analysis. No data on characteristics of non-starters. Data imputed by last observation carried forward for drop outs. Reasons for non-starters and drop outs given.	Low: All listed outcomes reported. Trial registered on ANZCTR	High

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Huang 2011 (27) (Depressed postnatal population)	Low: a randomised table used by the researcher	High: Randomised list visible to researcher	Unclear: Outcome assessment blinded but unclear if researchers conducting analysis blinded	High: Follow up (postnatal and control) 128/160 (80%). Missing data identical in both arms. Analysis not intention-to-treat. Drop outs not included in analysis. Completers and drop outs were not statistically different in demographics.	Unclear: All listed outcomes reported (weight reported but not BMI). Trial not registered on trial registries (proposed outcomes unavailable)	High
Surkan 2012 (30) (General postnatal population)	Unclear: Stratified randomisation by BMI (<29, >=29) and trial region. No further details of how sequence was generated	Unclear: No details	Unclear: Unclear if outcome assessor blinded. Unclear if researcher conducting analysis blinded	High: Follow up: 403/679 (59.35%). Analysis was not Intention-to-treat. Only 322/679 included in analysis. Drop outs and those not receiving 'minimal intervention' excluded. Proportion breastfeeding significantly lower among drop outs. Reasons for non-completion given.	Unclear: Main outcome reported. No results on other primary outcomes listed in methods paper. Trial not registered on trial registries (proposed outcomes unavailable)	High

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Haruna 2013 (42) (General postnatal population)	Low: Permutated block randomisation by researchers not involved in allocation. Block size 4.	Unclear: No details	High: Outcome assessors not blinded. Data analyser not blinded. Data enterer blinded.	High: Follow up: 95/110 (86.4%). Not an intention-to-treat analysis - drop outs excluded. Missing data balanced across arms. No data on characteristics of drop outs.	Unclear: Listed primary outcomes reported. Trial not registered on trial registries (proposed outcomes unavailable)	High
Thiruppathi 2014 (33) (General postnatal population)	Unclear: No details	Unclear: No details	Unclear: No details	High: Follow up 41/45 (91.1%) participants included in analysis. Not intention to treat analysis. Two mothers who did not receive the intervention/ control excluded from analysis. Number of drop outs and reasons for dropping out balanced across arms. No detail provided on differences between those included/ lost to follow up.	Unclear: Listed primary outcome measures reported on. Trial not registered on trial registries (proposed outcomes unavailable)	High

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Keller 2014 (34) (General postnatal population)	Unclear: No details	Unclear: No details	Unclear: No details	High: Follow up 93/139 (66.9%) Loss to follow up not balanced between arms: Intervention follow up 54/68: 79.4% Comparator follow up 39/71: 54.9% Reasons for loss to follow up were provided. No imputation Not intention to treat analysis – drop outs excluded	Low: All listed outcomes reported. Trial registered on clinical trials.gov	High
Lewis 2014 (32) (General postnatal population)	Low: Random number table used, with permuted blocks of varying sizes	Unclear: No details	Low: Follow up blinded to group allocation. Comparator was a wellness/support intervention, participants received the same level of contact as those in the exercise intervention.	Low: 124/130 (95.4%) participants included in the analysis. Not intention-to-treat analysis as drop outs excluded. Number of drop outs not balanced between arms (5 lost in intervention, 1 in comparator). No reasons given for drop outs. Differences between drop outs and those followed up not presented.	Unclear: Trial registered on clinical trials.gov NCT00961402. All outcome measures recorded have been reported in the results paper. Baseline EPDS not provided. PHQ-9 medians provided but not IQRs	Unclear

Trial	Sequence generation	Allocation concealment	Blinding of outcome assessor/analysis	Incomplete outcome data	Selective outcome reporting	Overall risk of bias
Boath 2015 (37) (Depressed population)	Low: Computer generated random number table	Unclear: No details	Unclear: Randomisation was obscured from those conducting follow up, unclear if obscured from those doing analysis	Unclear: All those randomised included in follow up. Unclear if intention to treat analysis	Unclear: Listed primary outcome measures reported on. Trial not registered on trial registries (proposed outcomes unavailable)	Unclear
Daley 2015 (36) (Depressed population)	Low: Computerised randomisation service	Low: Internet based randomisation: allocation concealed until randomisation took place	High: Outcome assessors and those conducting analysis not blinded	Low: Follow up overall 85/94 (90.4%) Balanced between arms: Intervention follow up 43/47 (91.5%) Comparator follow up 42/47 (89.4%) Reasons for loss to follow up reported. No Imputation Not intention to treat analysis – drop outs excluded	Low: All outcomes in protocol reported. Registered on ISRCTN	High

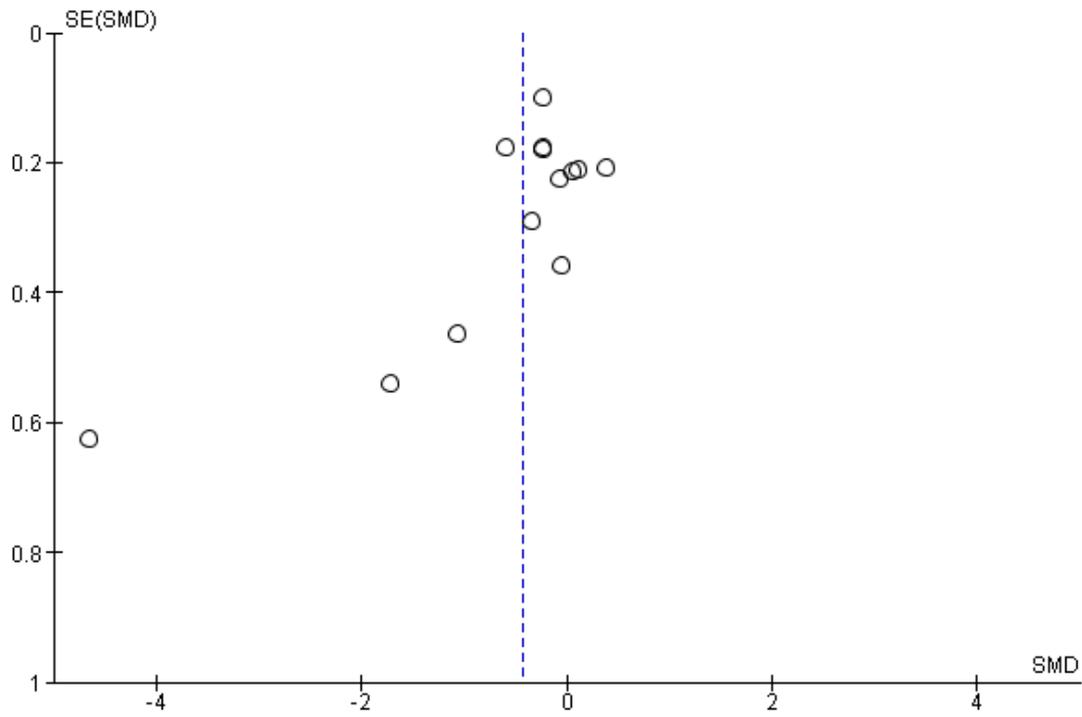
Low: Low risk of bias, High: High risk of bias, Unclear: Unclear risk of bias

BMI: Body Mass Index;

ISRCTN: International Standard Randomised Controlled Trial Number (Registry), ANZCTR: Australian New Zealand Clinical Trials Registry

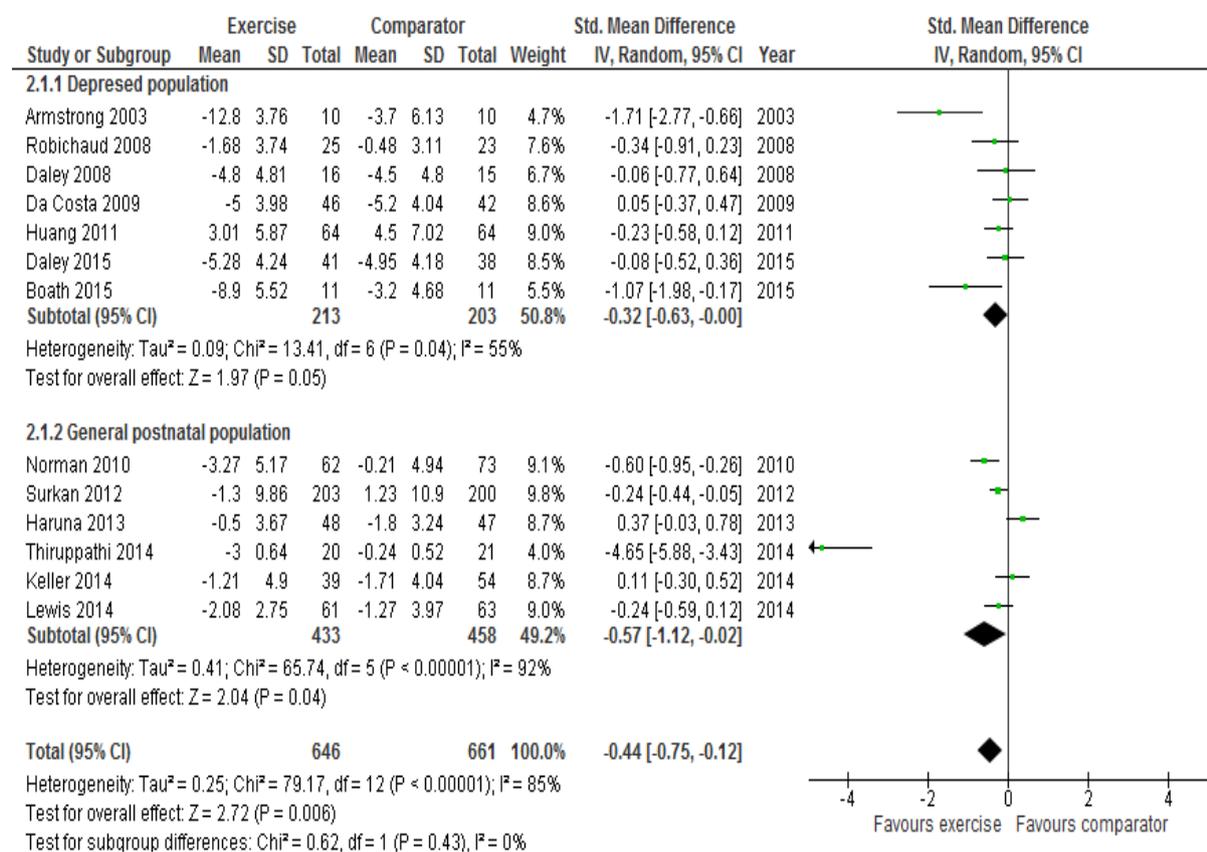
EPDS: Edinburgh Postnatal Depression Questionnaire, PHQ-9: The Patient Health Questionnaire-9, PPQ: The Lederman Postpartum Self-Evaluation Questionnaire

APPENDIX 3: Funnel plot of the distribution of publications



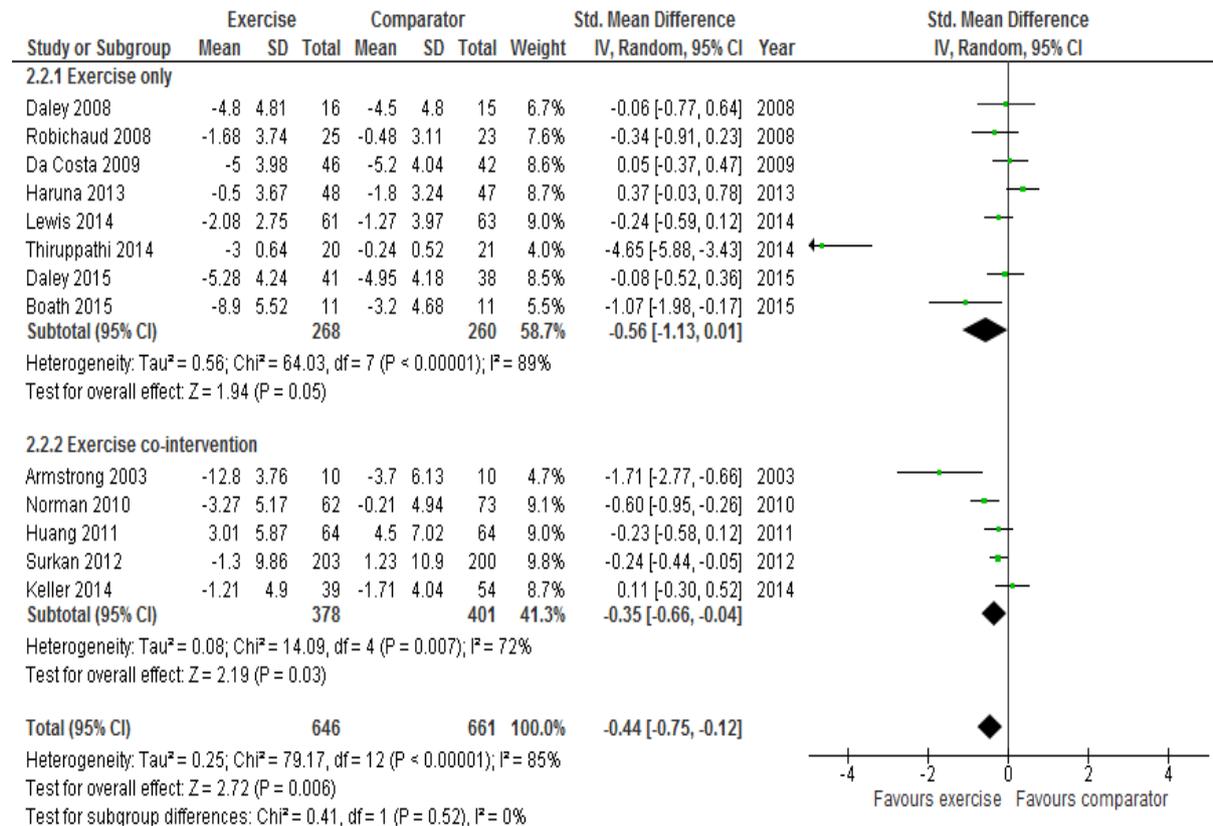
APPENDIX 4: Meta-analysis of the effect of exercise on depressive symptoms in depressed and general postnatal populations

(Standardised mean difference)



APPENDIX 5: Meta-analysis of the effects of different intervention types on depressive symptoms

(Standardised mean difference)



APPENDIX 6: Meta-analysis of the effects of different exercise contexts on depressive symptoms

(Standardised mean difference)

