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Postnatal exercise interventions: a systematic review of adherence and effect

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ABSTRACT

Objective To evaluate adherence to and effect of postnatal physical activity (PA) interventions.

Design Systematic review of PA intervention randomised controlled trials in postnatal women. The initial search was carried out in September 2018, and updated in January 2021.

Data sources Embase, MEDLINE and Cochrane Central Register of Controlled Trials (CENTRAL) databases, hand-searching references of included studies. The 25 identified studies included 1466 postnatal women in community and secondary care settings.

Eligibility criteria Studies were included if the PA interventions were commenced and assessed in the postnatal year.

Data extraction and synthesis Data were extracted using a prespecified extraction template and assessed independently by two reviewers using Cochrane ROB 1 tool.

Results 1413 records were screened for potential study inclusion, full-text review was performed on 146 articles, 25 studies were included. The primary outcome was adherence to PA intervention. The secondary outcomes were the effect of the PA interventions on the studies' specified primary outcome. We compared effect on primary outcome for supervised and unsupervised exercise interventions. Studies were small, median n=66 (20–130). PA interventions were highly variable, targets for PA per week ranged from 60 to 275 min per week. Loss to follow-up (LTFU) was higher (14.5% vs 10%) and adherence to intervention was lower (73.6% vs 86%) for unsupervised versus supervised studies.

Conclusions Studies of PA interventions inconsistently reported adherence and LTFU. Where multiple studies evaluated PA as an outcome, they had inconsistent effects, with generally low study quality and high risk of bias. Agreement for effect between studies was evident for PA improving physical fitness and reducing fatigue. Three studies showed no adverse effect of PA on breast feeding. High-quality research reporting adherence and LTFU is needed into how and when to deliver postnatal PA interventions to benefit postnatal physical and mental health.

PROSPERO registration number CRD42019114836.

Strengths and limitations of this study

- This review considered only physical activity (PA) intervention studies which were compared with a control group with no PA intervention or with advice to be sedentary, to allow evaluation of effect of the PA intervention on the primary outcomes of each study.
- There may be studies which compare PA interventions in groups other than postnatal women which had high adherence and positive or negative effects and will have been excluded from our analysis.
- We considered only PA interventions in the year after delivery, potentially excluding interventions later after delivery which may be appealing to women and effective in improving physical and mental health.

INTRODUCTION

Physical inactivity is estimated to cause between 6% and 10% of the major non-communicable diseases of breast and colon cancer, type 2 diabetes and coronary heart disease and 9% of premature mortality worldwide.[1] Not surprisingly, physical inactivity is responsible for one in six UK deaths and is estimated to cost the UK £7.4 billion annually.[2] In the UK, 42% of women are estimated to be not active enough to maintain good health.[2]

Adult physical activity (PA) guidelines recommend 150 min of moderate-to-vigorous intensity physical activity (MVPA) per week; only 67% of UK women aged 35–44 achieve this with further reductions with age.[3] Disparity also exists from a young age; the percentage of girls aged 11 achieving the recommended 60 min of daily MVPA declines from 20% to 12% by the age of 15; in boys, this falls from 32% to 25%.[4]

Women's PA levels are low during and after pregnancy. Sixty per cent of women during pregnancy report engaging in no leisure time PA.[5] Fewer than 13% of women meet recommended PA levels during pregnancy, and this decreases with each trimester.[6] PA measured during and after pregnancy is predominately of a low intensity, providing somewhat limited health benefits. It is important to note that postnatal total PA (measured in hours or

Table 1 Study characteristics, interventions, comparison groups and outcomes

	Outcome category	Author	Setting	Country	N	Design	Intervention group 1	Intervention group 2	Duration intervention	Supervised/ monitored/ unsupervised	PA target per week	Comparison group 1	Comparison group 2	Primary outcome measure
1	Weight, body composition	Brekke *et al* (2014)[18]	Community	Sweden	68	C, D, E or DE	45 min brisk walk 60%–70% MHR*4/week monitored by HR monitor and diary	As for group 1 +dietary intervention	6 months	HR monitor	180 min	Usual care	Dietary intervention	Waist circumference (cm)
		Kinnunen *et al* (2007)[28]	Community	Finland	85	C, E	Counselling sessions *5 at 2, 3, 5, 6 and 10 months postnatal. Option of attending weekly supervised exercise class		8 months	Unsupervised, optional supervised	150 min	Usual care		% return to normal weight at 10 months postnatal
		Tripette *et al* (2014)[17]	Community	Japan	34	C, E	Active video games for 30 min day (WiiFit and balance board)		40 days	Unsupervised	Not reported	Usual care		Weight loss kg
		O'Toole *et al* (2003)[32]	Community	USA	40	D, DE	Group educational sessions *17–23 on PA and diet, combined effect 500 kcal daily energy deficit		6–10 months	Unsupervised	Energy deficit of 1050 kcal	Dietary counselling session *1500 kcal/ day energy defecit		Weight loss kg
		Bertz *et al* (2012)[35]	Community	Sweden	68	C, D, E or DE	E 45-min brisk walk 60%–70% MHR*4/week monitored by HR monitor and diary	As for group 1 +dietary intervention	12 weeks	HR monitor	180 min	Usual care	Dietary intervention 500 kcal/day deficit	Weight loss kg
		Osman *et al* (2016)[15]	Community	Egypt	47	D, DE	Supervised aerobic exercise sessions *3/ week for 4 weeks to 60%–70% MHR, dietary and BF advice		4 weeks	Supervised	105 min	Dietary and BF advice		Weight loss kg
2	Postnatal depression	Da Costa *et al* (2009)[29]	Community	Canada	88	C, E	Counselling sessions *4 with exercise physiologist over 12 weeks. 60–120 min/ week at 60%–85% MHR		12 weeks	HR monitor	120 min	Usual care		EPDS
		Heh *et al* (2008)[23]	Community	Taiwan	80	C, E	Exercise programme CD for two home exercise sessions/week, 1 hour weekly exercise session at hospital		3 months	Supervised and unsupervised	180 min	Usual care		EPDS
		Lewis *et al* (2014)[26]	Community	USA	130	C, E	11 telephone sessions to help women increase MVPA		6 months	Unsupervised, actigraph 7 days	Not reported	Usual care		% depression by SCID-1
		Daley *et al* (2015)[27]	Community	England	94	C, E	2* exercise counselling sessions, 2* phone calls, leaflets months 3,4,5 and 6		6 months	Unsupervised	150 min	Usual care		EPDS
		Daley *et al* (2008)[30]	Primary care, community	England	38	C, E	2* exercise counselling sessions, 2* phone calls		12 weeks	Pedometer	105 min	Usual care		EPDS
		Armstrong *et al* (2003)[20]	Community	Australia	20	C, E	Group Pram walking 3*/week, 30–40 min at 60%–75% of MHR, weekly social support session		12 weeks	Supervised, Pedometer	90–120 min	Usual care		EPDS
		Norman *et al* (2010)[33]	Community	Australia	161	C, E	1*exercise class/week. 1* General health advice education session		4 weeks	Supervised	60 min	1* General health education session		Positive affect balance scale
3	Physical fitness	Zourladani *et al* (2012)[37]	Home	Greece	37	C, E	3* exercise classes/week, 50–60 min aerobic and strengthening exercise		12 weeks	Supervised	150–180 min	Usual care		VO_2max (mL/kg/ min)
		Lovelady *et al* (1995)[38]	Community	USA	33	C, E	5* exercise sessions/week, 45 min aerobic exercise sessions		12 weeks	Supervised	225 min	Usual care		VO_2max (mL/kg/ min)
4	Fatigue	Dritsa *et al* (2008)[19]	Community	Canada	88	C, E	4* counselling sessisons to produce exercise prescription		12 weeks	HR monitor	120 min	Usual care		Multidimensional Fatigue Inventory (MFI-20): general fatigue
		Ashrafinia *et al* (2015)[24]	Home	Iran	80	C, E	4 antenatal pilates training sessions, 5*home pilates sessions/week, 30 min, exercise leaflet and CD		8 weeks	Unsupervised	150 min			(MFI-20): general fatigue

Continued

Table 1 Continued

	Outcome category	Author	Setting	Country	N	Design	Intervention group 1	Intervention group 2	Duration intervention	Supervised/ monitored/ unsupervised	PA target per week	Comparison group 1	Comparison group 2	Primary outcome measure
5	Lactation	Dewey *et al* (1994)[39]	Community	USA	33	C, E	5* exercise sessions/week, individually tailored, gradated increase to 45 min,		12 weeks	Supervised	225 min	Usual care		Infant milk intake g/kg/day
		McCrory *et al* (1999)[36]	Community	USA	67	C, D or DE	Exercise 9/11 days at 50%–70% maximum HR	As for group 1 +dietary intervention	11 days	HR monitor	Not reported	Usual care	Dietary intervention	Milk volume
6	Glycaemia	Youngwanichsetha *et al* (2013)[22]	Hospital	Thailand	64	C, E	3*tai chi qigong sessions/week, 50 min		12 weeks	Unsupervised	150 min	Usual care		Fasting plasma glucose (mg/dL)
7	Physical activity	McIntyre *et al* (2012)[31]	Community	Australia	28	C, E	1*face-to-face exercise consultation, 8 telephone calls		12 weeks	Unsupervised	150 min	Usual care		Change in PAmin/ week (median)
8	Sleep quality	Ashrafini *et al* (2015)[24]	Home	Iran	80	C, E	4 antenatal pilates training sessions, 5*home pilates sessions/week, 30 min, exercise leaflet and CD		8 weeks	Unsupervised	150 min	1*postnatal care advice session		Pittsburg Sleep Index (global score)
10	Infant growth	Lovelady *et al* (2000)[34]	Community	USA	48	D, DE	4*exercise sessions/week, 45 min, at 65%–80% MHR		10 weeks	Supervised	180 min	Usual care		Gain in infant weight (g)
11	Bone density	Lovelady *et al* (2009)[21]	Home	USA	20	C, E	6*exercise sessions/week, 45 min, 65%–80% MHR, aerobic and resistance		16 weeks	Unsupervised	270 min	Usual care		Change in whole body bone mineral density (g/cm^2)

BF, breast feeding; C, control; CV, cardiovascular; D, dietary intervention; DE, dietary and exercise intervention; E, exercise intervention; EPDS,EPDS, Edinburgh Postnatal Depression Scale; FU, follow up; FU, follow-up; HR, heart rate; MHR, maxiumum heart rate; MVPA, moderate or vigorous physical activity; PA, physical activity.

weeks) is similar to that seen in mid pregnancy, but comprises a larger proportion of care-giving activities.[7]

The postnatal time is a difficult period for women to restart or maintain PA. Fatigue from poor sleep and the demands of infant feeding can also contribute to lower PA levels. The Institute of Health Visitors advise waiting for the 6-week postnatal visit with women's general practitioners (GPs) before resuming high-impact exercise. GPs have to assess maternal and child health at this visit, though this visit is generally short and advice given can be extremely variable.[8 9] Healthcare professionals need to know which interventions they can best recommend to postpartum women, enabling them to meet recommended levels of PA and optimise their health.

The UK Chief Medical Officers recommend that pregnant and postnatal women undertake 150 min moderate PA per week, and have provided useful infographics which are available as a guide for women and healthcare professionals.[10 11] These are endorsed by the American College of Obstetricians and Gynaecologists' guidelines, who also recommend 20–30 min of PA per day during pregnancy on most or all days of the week,[12] and briefly describe the postpartum period as an opportune time to gradually resume an exercise routine. Clearly, however, the figures above indicate that this is not being achieved.

To review available studies on postnatal PA interventions, we conducted a systematic review to determine adherence to postnatal PA interventions, and the effect of the interventions on the outcomes investigated in the studies identified. The results would also inform healthcare professionals who advise women on the most efficacious PA interventions for desired effect.

We wished to explore whether adherence to PA interventions would be greater for supervised (in person supervision or with monitoring of PA, eg, a pedometer) versus unsupervised interventions; and that the effects of PA interventions on the primary outcomes of studies would be related to adherence.

METHODS

Patient and public involvement

Patient and public involvement (PPI) for a separate study helped to conceive the research question for this study. We did not undertake PPI for this study.

We carried out a systematic review based on a prepublished protocol and reported the findings in accordance with specifications recommended by the per the Preferred Reporting Items for Systematic reviews and Meta-Analyses checklist.[13]

Search strategy and selection criteria

Embase, MEDLINE and Cochrane Central Register of Controlled Trials (CENTRAL) databases were searched in duplicate as per the search strategies (online supplemental files 1-3), without restrictions on publication date. The references of included articles were also handsearched by the reviewers to highlight further studies

for potential inclusion. This review was performed in September 2018, and an updated search was carried out in January 2021. The updated literature research identified one additional report[14] which included the same participants as those reported in Osman et al[15].

An initial screen of titles and abstracts was performed independently by two reviewers (SS and EM) to identify articles for further review. Articles were included after full-text review if they were randomised, controlled trials which compared moderate and/or vigorous PA to no PA. This could be in combination with another intervention, for example, a dietary intervention, if a comparison group with the same dietary intervention alone was tested. If more than one intervention was included, it was essential that there was a comparison between exercise and no exercise groups. If there was any ambiguity regarding a study's inclusion, a third reviewer (AHM) decided on eligibility. Where data were missing or incomplete, contact with the corresponding author was made by email.

Where the PA intervention was restricted to pelvic floor exercises, physiotherapy or single exercise sessions, studies were excluded. Studies were excluded from the review if they did not report on original data or were animal studies. Studies were not excluded based on language, study type or publication status. There was no other restriction on the type of PA intervention.

Data analysis

Two reviewers (SS and EM) extracted the data from the included studies using a prespecified extraction template. Extracted data elements recorded for each study included general information, eligibility criteria, study characteristics (setting, country, year, design, type and duration of PA intervention, sample size), adherence to the intervention and primary outcome measures.

Both reviewers assessed risk of bias for each study independently using the Cochrane Collaboration's tool for assessing risk of bias.[16] The following domains were assessed as having a high, low or unclear risk of bias: random sequence generation, allocation concealment, blinding of participants/personnel, blinding of outcome, incomplete outcome, selective reporting and overall bias. The reviewers then used the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) criteria[13] to assess the quality of the evidence within the review for the specific outcomes identified.

RESULTS

After the initial search (online supplemental files 1-3), 1413 records were screened for potential study inclusion. After title and abstract review, full-text review was performed on 146 articles. Of these, 25 articles reporting the effect of randomised controlled trials of postnatal exercise interventions versus no exercise were included (table 1). Study designs included control versus exercise; control versus dietary intervention versus dietary intervention and exercise and control versus dietary intervention versus exercise intervention versus dietary and exercise intervention (table 1). The 25 studies included 1466 postnatal women.

Studies included were conducted in North America, Europe, Africa, Asia and Australasia. Studies were generally small, ranging from 20 to 130 participants, median n=66. PA interventions used were varied, including provision of active video games (WiiFit and balance board[17]), exercise prescriptions,[18–22] CDs and DVDs,[23–25] telephone[26 27] and face-to-face counselling sessions,[27–31] group classes[24 25 32 33] and supervised exercise sessions.[14 15 33 34] Interventions varied in duration between 11 days and 10 months. Where reported, the targets for PA per week ranged from 60 to 275 min per week. One study prescribed exercise to attain an individualised energy deficit. Four studies did not report a PA target. A meta-analysis was not performed due to the heterogeneity of the studies identified.

Of the studies included, 9 used unsupervised exercise interventions,[17 21 22 24–27 31 32] and 16 used exercise with some form of supervision. Six studies used PA monitoring (a pedometer or an Actigraph),[18 19 29 30 35 36] one used PA monitoring and in-person supervised exercise interventions,[20] six used in-person supervised interventions,[14 15 33 34 37–39] and two used a mixture of in-person supervised and unsupervised interventions[23 28] (One study used an actigraph for 7 days prior to follow-up 6 month post intervention though not during the intervention.[23])

Loss to follow-up (LTFU)in the exercise intervention group was reported in 17/26 studies[18 19 21–23 26–36] and adherence to the PA intervention was reported by 11/26 studies.[18 20 21 27 29 31–33 36 39] When reported, for the groups undergoing PA interventions, mean LTFU was 11.8% and mean adherence was 80.4%. Some studies reported only overall rates of LTFU and adherence. In studies where LTFU and adherence is reported, the proportions were similar for intervention and control/comparison groups.

Effect of PA intervention on weight loss was reported by 2/6 studies,[17 32] with weight loss between 2.1 and 5.6 kg reported (table 2). In studies which compared dietary, PA and combined interventions, PA interventions were not associated with weight loss over and above the effect of the dietary intervention.[18 35] Higher rates of LTFU and lower rates of adherence (where reported) were seen in studies which showed an effect on weight loss.

For measures of postnatal depression, 3/7 reported an effect of a PA intervention.[20 23 27] The effect size varied greatly, from −4.79 to −12.8 points on the Edinburgh Postnatal depression scale. 2 out of 3 of these studies reported LTFU, 8% in both; adherence was reported by 2/3 and was 64% and 87%.

Physical fitness, defined by VO_2max and investigated by two small studies, is improved by PA interventions.[37 38] General fatigue, part of the Multidimensional Fatigue Inventory, appears to be reduced by PA interventions.[19 25] Lactation is not impaired by PA interventions in studies with 90% and 95% adherence,[36 39] nor is infant growth.[34] Glycaemia[22] and sleep quality[24] appear to be improved

Table 2 Study outcomes, lost to follow-up, adherence to interventions, effect of physical activity intervention studies on outcomes and adherence

	Outcome category	Author	Primary outcome measure	LTFU intervention group(s)	Adherence to intervention	Effect in intervention group 1	Effect in intervention group 2	Comparison group 1	Comparison group 2	Exercise effect on primary outcome? (by CI or p<0.05)
1	Weight, body composition	Brekke *et al* (2014)[18]	Waist circumference (cm)	1/34 (3%)	62/68 (91%)	−4.3	−8.8	−1.3	−8.7	No
		Kinnunen *et al* (2007)[28]	% return to normal weight at 10 months postnatal	5/53 (9%)	Not reported	50		30		No
		Tripette *et al* (2014)[17]	Weight loss kg	Not reported	Not reported	−2.2		−0.5		Yes (p<0.001)
		O'Toole *et al* (2003)[32]	Weight loss kg	4/21 (19%)	17/21 (81%)	−5.6		−0.7		Yes (p<0.05)
		Bertz *et al* (2012)[35]	Weight loss kg	2/34 (6%)	Not reported	−2.4	−6.9	−0.8	−8.3	No
		Osman *et al* (2016)[15]	Weight loss kg	Not reported	Not reported	−1.56		+0.09		No
2	Postnatal depression	Da Costa *et al* (2009)[27]	Ediburgh Postnatal Depression Scale (EPDS)	6/46 (13%)	35/46 (76%)	−4.6		-5		No
		Heh *et al* (2008)[21]	EPDS	2/35 (5.7%)	Not reported	−6.4		−3.5		Yes (p=0.01)
		Lewis *et al* (2014)[24]	% depression by SCID-1	5/66 (8%)	Not reported	8.2		7.94		No
		Daley *et al* (2015)[25]	EPDS	4/47 (8.5%)	41/47 (87%)	−4.79		−2.83		Yes (p=0.03)
		Daley *et al* (2008)[28]	EPDS	4/20 (20%)	Not reported	−4.9		−4.6		No
		Armstrong *et al* (2003)[18]	EPDS	Not reported	64% attendance	−12.8		−3.7		Yes (p<0.01)
		Norman *et al* (2010)[31]	Positive affect balance scale	2/62 (3%)	130/130 (100%)	+1.19		−0.18		No
3	Physical fitness	Zourladani *et al* (2012)[37]	VO_2max (mL/kg/min)	Not reported	Not reported	Not reported		Not reported		Yes (p<0.001)
		Lovelady *et al* (1995)[36]	VO_2max (mL/kg/min)	Not reported	Not reported	+6.8		+1.3		Yes (p<0.0001)
4	Fatigue	Dritsa *et al* (2008)[17]	MFI-20-general fatigue	6/46 (13%)	Not reported	−3.87		−1.83		Yes (p<0.016)
		Ashrafinia *et al* (2015)[22]	MFI-20-general fatigue	Not reported	Not reported	−3.35		+1.2		Yes (p<0.001)
5	Lactation	Dewey *et al* (1994)[38]	Infant milk intake g/kg/day	Not reported	149/165 sessions completed (90%)	117		118		No
		McCrory *et al* (1999)[35]	Milk volume g/day	2/44 (5%)	21/22 (95%)	−16		+17	−1	No
		Osman *et al* (2020)[14]	Breast milk cortisol mcg/mL	Not reported	Not reported	−93.84		−91.68		No
6	Glycaemia	Youngwanichsetha *et al* (2013)[20]	Fasting plasma glucose (mg/dL)	2/32 (6%)	Not reported	−10.25		−2.09		Yes (p=0.02)
7	Physical activity	McIntyre *et al* (2012)[29]	Change in PA min/week (median)	1/15 (7%)	6/14 (40%)	+60		+0		No
8	Sleep quality	Ashrafini *et al* (2015)[22]	Pittsburg Sleep Index (global score)	Not reported	Not reported	5.45		8.35		Yes (p<0.001)
10	Infant growth	Lovelady *et al* (2000)[33]	Gain in infant weight (g)	6/27 (22%)	Not reported	1925		1861		No

Continued

Table 2 Continued

	Outcome category	Author	Primary outcome measure	LTFU intervention group(s)	Adherence to intervention	Effect in intervention group 1	Effect in intervention group 2	Comparison group 1	Comparison group 2	Exercise effect on primary outcome? (by CI or $p<0.05$)
11	Bone density	Lovelady *et al* (2009)[19]	Change in whole body bone mineral density (g/cm^2)	3/10 (30%)	83.4% aerobic sessions	−0.8		−0.6		No

EPDS, Edinburgh Postnatal Depression Scale; LTFU, loss to follow-up; MFI-20, Multidimensional Fatigue Inventory; PA, physical activity.

by PA interventions. Bone density,[21] breast milk cortisol[14] and (surprisingly) PA[31] were not significantly affected by PA interventions, although the latter study had n=29 and an adherence of 40% to the intervention.

Risk of bias assessment found that most studies were at high (7/25) or unclear (16/25) risk of bias (online supplemental file 1, table 3). Blinding measures for personnel and participants were absent for all studies, conceding that it would be difficult to do so, especially for supervised exercise interventions. No studies referred to a published protocol and/or was convincing that the published report included all expected outcomes, including those that were prespecified. Many studies did not list a primary outcome, in these cases, we used the title or outcome reported first or with most detail in the results section.

Study quality for the various outcomes tested was generally low or very low by GRADE score (table 3), meaning we had low or very low confidence in the effect estimates for all outcomes.

Unsupervised and supervised studies

Of total, 6/9 unsupervised intervention studies[17 22 24 25 27 32] and 5/16 supervised intervention studies[14 19 20 28 37 38] showed an effect of the PA intervention tested on their specified primary outcome (table 4.) LTFU was higher (14.5% vs 10%) and adherence to the intervention was lower (73.6% vs 86%) for unsupervised versus supervised studies.

DISCUSSION

In this systematic review, we show that PA interventions have inconsistent effects on most outcomes, with generally low study quality and high risk of bias. Adherence was reported by only 9/25 studies and LTFU for 16/25 studies. For any intervention, the LTFU and adherence must be reported to allow judgement on whether the intervention was acceptable to participants and whether there can be confidence in the effect, or lack of it, shown.

Adjustment for known confounders, such as pre-existing exercise habits, physical fitness, weight, BMI were either not present or unclear in the majority of studies. This could have contributed to the heterogeneity of study conclusions.

Supervised exercise interventions did not appear to be more likely to show effect on the various outcomes tested than unsupervised interventions. Studies evaluating unsupervised interventions had lower LTFU and higher adherence, which increases our confidence in the outcomes of the studies. This was unexpected and may reflect that women may feel more empowered when allowed to exercise on their own terms; self-efficacy may lead to greater efficacy of the intervention.

Agreement for effect on primary outcomes in ≥2 studies was evident for PA interventions improving physical fitness[37 38] and reducing fatigue.[19 25] Single studies were identified which reported that PA improved glycaemia[22] and sleep quality.[25] These findings are consistent with

Table 3 Risk of bias and GRADE assessments

	Outcome category	Study	Random sequence generation	Allocation concealment	Blinding participants/ personnel	Blinding outcome	Incomplete outcome ascertainment	Selective reporting	Other bias	Overall risk of bias	GRADE
1	Weight, body composition	Brekke *et al* (2014)[16]	Unclear	Low	High	High	Low	Unclear	Low	High	⊕
		Kinnunen *et al* (2007)[26]	High	High	High	High	Low	Unclear	Low	High	
		Tripette *et al* (2014)[15]	Unclear	Unclear	High	Unclear	Unclear	Unclear	Low	Unclear	
		O'Toole *et al* (2003)[30]	Low	Low	High	Unclear	Low	Unclear	Low	Unclear	
		Bertz *et al* (2012)[34]	Low	Low	High	Unclear	Low	Unclear	Low	Unclear	
		Osman *et al* (2016)[32]	Low	Low	High	Unclear	High	Unclear	Low	High	
2	Postnatal depression	Da Costa *et al* (2009)[27]	Unclear	Low	High	Unclear	Unclear	Unclear	Low	Unclear	⊕
		Heh *et al* (2008)[21]	High	High	High	Low	High	Unclear	Low	High	
		Lewis *et al* (2014)[24]	Low	Low	High	Low	Low	Unclear	Low	Low	
		Daley *et al* (2015)[25]	Low	Low	High	Unclear	Low	Unclear	Low	Unclear	
		Daley *et al* (2008)[28]	Low	Unclear	High	Unclear	Low	Unclear	Low	Unclear	
		Armstrong *et al* (2003)[18]	Low	Low	High	Unclear	Low	Uncear	Unclear	Unclear	
		Norman *et al* (2010)[31]	Low	Low	High	Unclear	Low	Unclear	Low	Unclear	
3	Physical fitness	Zourladani *et al* (2012)[37]	High	High	High	Unclear	Unclear	Unclear	High	High	⊕
		Lovelady *et al* (1995)[36]	Unclear	Unclear	High	Unclear	Low	Unclear	Low	Unclear	
4	Fatigue	Dritsa *et al* (2008)[17]	Unclear	Low	High	Unclear	Unclear	Unclear	Low	Unclear	⊕
		Ashrafinia *et al* (2015)[22]	High	High	High	High	High	Unclear	High	High	
5	Lactation	Dewey *et al* (1994)[38]	Unclear	Unclear	High	Low	Low	Unclear	Low	Unclear	⊕⊕⊕
		McCrory *et al* (1999)[35]	Low	Unclear	High	Unclear	Low	Unclear	Low	Unclear	
6	Glycaemia	Youngwanichsetha *et al* (2013)[20]	Unclear	Low	High	Unclear	Low	Unclear	Low	Unclear	⊕
7	Physical activity	McIntyre *et al* (2012)[29]	Unclear	Unclear	High	Unclear	Unclear	Unclear	Unclear	Unclear	⊕⊕
8	Sleep quality	Ashrafini *et al* (2015)[22]	High	High	High	High	High	Uncear	High	High	⊕
10	Infant growth	Lovelady *et al* (2000)[33]	Low	Unclear	High	Unclear	Low	Unclear	Low	Unclear	⊕
11	Bone density	Lovelady *et al* (2009)[19]	Unclear	Unclear	High	Unclear	Low	Unclear	Low	Unclear	⊕⊕

GRADE score and interpretation.
⊕⊕⊕⊕ High. We are very confident that the true effect lies close to that of the estimate of the effect.
⊕⊕⊕O Moderate. We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
⊕⊕OO Low. Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
⊕OOO Very low. We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Table 4 Comparison of studies using unsupervised and supervised interventions for mean % lost to follow-up (LTFU), mean % adherence and effect of interventions on primary outcome

Study	Supervised/ monitored/ unsupervised	LTFU intervention group(s)	Adherence to intervention	Exercise effect on primary outcome? (by CI or p<0.05)
Unsupervised studies				
Tripette *et al* (2014)[17]	Unsupervised	Not reported	Not reported	Yes (p<0.001)
O'Toole *et al* (2003)[32]	Unsupervised	4/21 (19%)	17/21 (81%)	Yes (p<0.05)
Lewis *et al* (2014)[26]	Unsupervised	5/66 (8%)	Not reported	No
Daley *et al* (2015)[27]	Unsupervised	4/47 (8.5%)	41/47 (87%)	Yes (p=0.03)
Youngwanichsetha *et al* (2013)[22]	Unsupervised	2/32 (6%)	Not reported	Yes (p=0.02)
Ashrafinia *et al* (2014)[24]	Unsupervised	Not reported	Not reported	Yes (p<0.001)
McIntyre *et al* (2012)[31]	Unsupervised	1/15 (7%)	6/14 (40%)	No
Ashrafini *et al* (2015)[25]	Unsupervised	Not reported	Not given	Yes (p<0.001)
Lovelady *et al* (2009)[21]	Unsupervised	3/10 (30%)	83.4% aerobic sessions	No
		14.5% (reported by 6/9)	73.6% (reported by 4/9)	6/9 showed effect
Supervised studies				
Brekke *et al* (2014)[18]	HR monitor	1/34 (3%)	62/68 (91%)	No
Bertz *et al* (2012)[35]	HR monitor	2/34 (6%)	Not reported	No
Da Costa *et al* (2009)[29]	HR monitor	6/46 (13%)	35/46 (76%)	No
Dritsa *et al* (2008)[19]	HR monitor	6/46 (13%)	Not reported	Yes (p=0.016)
McCrory *et al* (1999)[36]	HR monitor	2/44 (5%)	21/22 (95%)	No
Daley *et al* (2008)[30]	Pedometer	4/20 (20%)	Not reported	No
Kinnunen *et al* (2007)[28]	Unsupervised, optional supervised	5/53 (9%)	Not reported	No
Heh *et al* (2008)[23]	Supervised and unsupervised	2/35 (5.7%)	Not reported	Yes (p=0.01)
Osman *et al* (2016)[15]	Supervised	Not reported	Not reported	No
Osman *et al* (2020)[14]	Supervised	Not reported	Not reported	No
Armstrong *et al* (2003)[20]	Supervised, Pedometer	Not reported	64% attendance	Yes (p<0.01)
Norman *et al* (2010)[33]	Supervised	2/62 (3%)	130/130 (100%)	No
Zourladani *et al* (2012)[37]	Supervised	Not reported	Not reported	Yes (p<0.001)
Lovelady *et al* (1995)[38]	Supervised	Not reported	Not reported	Yes (p<0.0001)
Dewey *et al* (1994)[39]	Supervised	Not reported	149/165 sessions completed (90%)	No
Lovelady *et al* (2000)[34]	Supervised	6/27 (22%)	Not given	No
		9.97% (reported by 10/16)	86% (reported by 6/16)	5/16 showed effect

HR, heart rate; LTFU, lost to follow-up.

changes in physiology which would be expected with increased PA and as seen in other populations.[40 41]

Three studies showed no effect of physical activity interventions on breast milk production, intake and cortisol levels,[14 36 39] which is encouraging for women who wish to undertake recommended PA levels in the postnatal period and breastfeed.

Women considering postnatal PA can be counselled that PA is unlikely to have an impact on breastfeeding or infant growth. Additionally, no studies led to any serious adverse events. While the wide range of interventions makes recommendations on the types of exercise difficult to assess, it also demonstrates the inventiveness of researchers in the field who have considered using video games,[17] pilates,[24 25] tai chi[22] and telephone-based interventions[26] in addition to more conventional exercise counselling and supervised exercise classes.

Since the majority of these studies were conducted, there are now many wearable devices available, which could improve objective assessment of PA in intervention studies. These will allow accurate assessment of adherence and measures of fitness to be measured, such as morning resting heart rate. Our group is conducting feasibility studies before, during and after pregnancy using wearables and phone applications to monitor cardiovascular health.

Strengths of this study included a published protocol and a literature search which was updated close to publication. In order to provide information relevant to clinicians and policy-makers looking to improve PA in postnatal women, we focused our study on moderate-vigorous exercise programmes which were evaluated for effect on a range of mental and physical health parameters. A key factor in designing and costing PA interventions is whether they are supervised or unsupervised, our study allows these groups to be compared. The weakness of this study is that the studies included were generally small in size and of largely low quality and high or uncertain risk of bias. This review considered only PA intervention studies which were compared with a control group with no PA intervention or with advice to be sedentary, to allow evaluation of effect of the PA intervention on the primary outcomes of each study. Our inclusion of only women in the postnatal year meant that we did not included studies which compares PA interventions in groups other than postnatal women which had high adherence and positive or negative effects and will have been excluded from our analysis. Inclusion of only PA interventions in the year after delivery may also have potentially excluded studies of interventions later after delivery which may be appealing to women and effective in improving physical and mental health.

Further research is needed on the optimal timing, method of delivery and content of postnatal PA interventions to maximise recruitment, adherence and ensure effects on outcomes are effectively evaluated. Weight gain is encouraged in pregnancy, but complications such as excessive gestational weight gain, preeclampsia or gestational diabetes may help identify women likely to benefit from PA interventions to improve their long-term health. Studies must report using internationally agreed standards and outcome sets to improve their utility to women and their healthcare professionals.

More generally, the postnatal period is a difficult time restart and maintain PA. Public health approaches which encourage and enable women to increase their PA after having a baby could have broader population impacts with benefits seen in short-term and long-term risk of chronic diseases. However, studies to date have not consistently demonstrated these effects. None of the included studies referred to public and patient involvement (PPI) in the design or conduct of their research. PPI is invaluable to ensure recruitment, adherence and rigorous evaluation with outcomes which are relevant to women and their healthcare providers.

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