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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.

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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. Not surprisingly, physical inactivity is responsible for one in six UK deaths and is estimated to cost the UK £7.4 billion annually. In the UK, 42% of women are estimated to be not active enough to maintain good health.

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. 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%.

Women’s PA levels are low during and after pregnancy. Sixty per cent of women during pregnancy report engaging in no leisure time PA. Fewer than 13% of women meet recommended PA levels during pregnancy, and this decreases with each trimester. 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
| 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) 10 | 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 | 12 weeks | HR monitor | 180 min | Usual care | Dietary intervention | Waist circumference (cm) |
| | Kinnunen et al. (2007) 9 | 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) 2 | Community | Japan | 34 | C, E | Active video games for 30 min/day (WiiFit and balance board) | | | | | Usual care | Weight loss kg |
| | O'Toole et al. (2003) 1 | 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 1000 kcal | Diet counselling session 1500 kcal/day energy deficit | Weight loss kg |
| | Bertz et al. (2012) 3 | Community | Sweden | 68 | C, D, E or DE | E 45 min brisk walk 60%–70% MHR*4/week monitored by HR monitor and diary | | 12 weeks | HR monitor | 180 min | Usual care | Dietary intervention | Weight loss kg |
| | Osman et al. (2010) 4 | 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) 8 | Community | Canada | 68 | 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 |
| | Hieh et al. (2008) 7 | 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) 5 | 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. (2009) 6 | 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) 6 | Community | England | 38 | C, E | 2* exercise counselling sessions, 2* phone calls | | 12 weeks | Pedometer | 105 min | Usual care | EPDS |
| | Armstrong et al. (2009) 6 | 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) 6 | 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 | Zouridakis et al. (2012) 6 | Home | Greece | 37 | C, E | 3* exercise classes/week, 50–60 min aerobic and strengthening exercise | | 12 weeks | Supervised | 150-180 min | Usual care | VO₂max (mL/kg/min) |
| | Lovejoy et al. (1990) 6 | Community | USA | 33 | C, E | 5* exercise sessions/week, 45 min aerobic exercise sessions | | 12 weeks | Supervised | 225 min | Usual care | VO₂max (mL/kg/min) |
| 4 | Fatigue | Drita et al. (2008) 6 | Community | Canada | 88 | C, E | 4* counselling sessions to produce exercise prescription | | 12 weeks | HR monitor | 120 min | Usual care | Multidimensional Fatigue Inventory (MFRI-20): general fatigue |
| | Ashrafina et al. (2019) 2 | 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 | (MFRI-20): general fatigue | |
### Table 1  Continued

| Outcome category | Author               | Setting  | Country | N  | Design | Intervention group 1                                                                 | Intervention group 2 | Duration of intervention | Supervised/monitored/unsupervised PA target per week | Comparison group 1 | Comparison group 2 | Primary outcome measure                  |
|------------------|----------------------|----------|---------|----|--------|---------------------------------------------------------------------------------------|----------------------|--------------------------|------------------------------------------------------|-------------------|-------------------|-----------------------------------------|
| 5 Lactation      | Dewey et al (1994)  | Community| USA     | 33 | C, E   | 5* exercise sessions/week, individually tailored, graduated increase to 45 min.         |                      | 12 weeks                 | Supervised/monitored/unsupervised 225 min             | Usual care         |                  | Infant milk intake g/kg/day               |
|                  | McGorry et al (1999) | 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                     |
| 6 Glycaemia      | Youngwarinchitsetha et al (2019) | 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) | Community| Australia | 28 | C, E   | 1* face-to-face exercise consultation, 8 telephone calls                                  |                      | 12 weeks                 | Unsupervised 150 min                                    | Usual care         |                  | Change in PA (median)                    |
| 8 Sleep quality  | Ashrafni et al (2019) | Home     | Iran    | 80 | C, E   | 4* antenatal pilates training sessions, 5* home pilates sessions/week, 30 min, 45 min leaflet and CD |                      | 8 weeks                  | Unsupervised 150 min                                    | Usual care         |                  | Pittsburgh Sleep Index (global score)     |
| 10 Infant growth | Lovelady et al (2009) | 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) | Community| 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/cm²) |

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; FUI, follow up; HR, heart rate; MHR, maximum heart rate; MVP A, moderate or vigorous physical activity; PA, physical activity.
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 report14 which included the same participants as those reported in Osman et al15.

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 had the same dietary intervention only 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) criteria13 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 board17), exercise prescriptions,18–22 CDs and DVDs23–25 telephone26–27 and face-to-face counselling sessions,27–31 group classes24 25 32 33 and supervised exercise sessions.14 15 19 34 Interventions varied in duration during 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 included studies, 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 interventions23 28 (One study used an actigraph for 7 days prior to follow-up 6 month post intervention though not during the intervention.25)

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, 5/7 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 VO2max 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 Glycaemia22 and sleep quality24 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(s) | 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) | Waist circumference (cm) | 1/34 (3%) | 62/68 (91%) | −4.3 | −8.8 | −1.3 | −8.7 | No |
| | Kinnunen et al (2007) | % return to normal weight at 10 months postnatal | 5/53 (9%) | Not reported | 50 | 30 | No |
| | Tripette et al (2014) | Weight loss kg | Not reported | Not reported | −2.2 | −0.5 | Yes (p<0.001) |
| | O’Toole et al (2003) | Weight loss kg | 4/21 (19%) | 17/21 (81%) | −5.6 | −0.7 | Yes (p<0.05) |
| | Bertz et al (2012) | Weight loss kg | 2/34 (6%) | Not reported | −2.4 | −6.9 | −0.8 | −8.3 | No |
| | Osman et al (2016) | Weight loss kg | Not reported | Not reported | −1.56 | +0.09 | No |
| 2 Postnatal depression | Da Costa et al (2009) | Ediburgh Postnatal Depression Scale (EPDS) | 6/46 (13%) | 35/46 (76%) | −4.6 | −5 | No |
| | Heh et al (2008) | EPDS | 2/35 (5.7%) | Not reported | −6.4 | −3.5 | Yes (p=0.01) |
| | Lewis et al (2014) | % depression by SCID-1 | 5/66 (8%) | Not reported | 8.2 | 7.94 | No |
| | Daley et al (2015) | EPDS | 4/47 (8.5%) | 41/47 (87%) | −4.79 | −2.83 | Yes (p=0.03) |
| | Daley et al (2008) | EPDS | 4/20 (20%) | Not reported | −4.9 | −4.6 | No |
| | Armstrong et al (2003) | EPDS | Not reported | 64 % attendance | −12.8 | −3.7 | Yes (p<0.01) |
| | Norman et al (2010) | Positive affect balance scale | 2/62 (3%) | 130/130 (100%) | +1.19 | −0.18 | No |
| 3 Physical fitness | Zourlidani et al (2012) | VO2max (mL/kg/min) | Not reported | Not reported | Not reported | Not reported | Yes (p<0.001) |
| | Lovelady et al (1995) | VO2max (mL/kg/min) | Not reported | Not reported | +6.8 | +1.3 | Yes (p=0.0001) |
| 4 Fatigue | Driba et al (2008) | MFI-20-general fatigue | 6/46 (13%) | Not reported | −3.87 | −1.83 | Yes (p=0.016) |
| | Ashrafinia et al (2015) | MFI-20-general fatigue | Not reported | Not reported | −3.35 | +1.2 | Yes (p=0.001) |
| 5 Lactation | Dewey et al (1994) | Infant milk intake g/ kg/day | Not reported | 149/165 sessions completed (90%) | 117 | 118 | No |
| | McCrory et al (1999) | Milk volume g/day | 2/44 (5%) | 21/22 (95%) | −16 | +17 | −1 | No |
| | Osman et al (2020) | Breast milk cortisol mcg/mL | Not reported | Not reported | −93.84 | −91.68 | No |
| 6 Glycaemia | Youngwanichsath et al (2013) | 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) | Change in PA min/week (median) | 1/15 (7%) | 6/14 (40%) | +60 | +0 | No |
| 8 Sleep quality | Ashrafinia et al (2015) | Pittsburg Sleep Index (global score) | Not reported | Not reported | 5.45 | 8.35 | Yes (p<0.001) |
| 10 Infant growth | Lovelady et al (2000) | Gain in infant weight (g) | 6/27 (22%) | Not reported | 1925 | 1861 | No |

Continued
by PA interventions. Bone density,\textsuperscript{21} breast milk cortisol\textsuperscript{24} and (surprisingly) PA\textsuperscript{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\textsuperscript{17 22 24 25 27 32} and 5/16 supervised intervention studies\textsuperscript{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,\textsuperscript{37 38} and reducing fatigue.\textsuperscript{19 25} Single studies were identified which reported that PA improved glycaemia\textsuperscript{22} and sleep quality.\textsuperscript{25} These findings are consistent with
| 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 |
|---------------------------|-------------------------------|----------------------------|------------------------|---------------------------------|-----------------|-----------------------------------|--------------------|------------|----------------------|-------|
| Weight, body composition  | Brekke et al (2014)           | Unclear                    | Low                    | High                            | High            | Low                               | Unclear            | Low        | High                  | ⊕     |
|                           | Kinnunen et al (2007)         | High                       | High                   | High                            | High            | Low                               | Unclear            | Low        | High                  |       |
|                           | Tripette et al (2014)         | Unclear                    | High                   | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               |       |
|                           | O'Toole et al (2003)          | Low                        | Low                    | High                            | Low             | Unclear                           | Unclear            | Low        | Unclear               |       |
|                           | Bertz et al (2012)            | Low                        | Low                    | Unclear                         | Low             | Unclear                           | Unclear            | Low        | Unclear               |       |
|                           | Osman et al (2016)            | Low                        | Low                    | High                            | Unclear         | High                              | Unclear            | Low        | High                  | ⊕     |
| Postnatal depression      | Da Costa et al (2009)         | Unclear                    | Low                    | High                            | Unclear         | Unclear                           | Unclear            | Low        | Unclear               | ⊕     |
|                           | Heh et al (2008)              | High                       | High                   | Low                             | High            | Unclear                           | Unclear            | Low        | High                  |       |
|                           | Lewis et al (2014)            | Low                        | Low                    | High                            | Low             | Unclear                           | Unclear            | Low        | Low                   | ⊕     |
|                           | Daley et al (2015)            | Low                        | Low                    | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               |       |
|                           | Daley et al (2008)            | Low                        | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               |       |
|                           | Armstrong et al (2003)        | Low                        | Low                    | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊕     |
|                           | Norman et al (2010)           | Low                        | Low                    | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊕     |
| Physical fitness          | Zouridakis et al (2012)       | Low                        | High                   | High                            | Unclear         | Unclear                           | Unclear            | High       | High                  | ⊙⊕     |
|                           | Lovelady et al (1995)         | Unclear                    | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊕     |
| Fatigue                   | Dritsas et al (2008)          | Low                        | Low                    | High                            | Unclear         | Unclear                           | Unclear            | Low        | Unclear               | ⊕     |
|                           | Ashrafinia et al (2015)       | High                       | High                   | High                            | High            | High                              | Low                | Unclear    | High                  | ⊙⊕     |
| Lactation                 | Dewey et al (1994)            | Unclear                    | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊙⊕⊕     |
|                           | McCrory et al (1999)          | Low                        | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊙⊕     |
| Glycaemia                 | Youngwanichsetha et al (2013) | Unclear                    | Low                    | Unclear                         | Unclear         | Unclear                           | Unclear            | Unclear    | Unclear               | ⊙⊕⊕     |
| Physical activity         | McIntyre et al (2012)         | Unclear                    | Unclear                | High                            | Unclear         | Unclear                           | Unclear            | Unclear    | Unclear               | ⊙⊕⊕     |
| Sleep quality             | Ashrafinia et al (2015)       | Low                        | High                   | High                            | High            | Uncear                            | Unclear            | High       | ⊕                    | ⊕     |
| Infant growth             | Lovelady et al (2000)         | Low                        | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊕     |
| Bone density              | Lovelady et al (2009)         | Unclear                    | Unclear                | High                            | Unclear         | Low                               | Unclear            | Low        | Unclear               | ⊙⊕⊕     |

GRADE score and interpretation:
⊕⊕⊕⊕ 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.
⊕⊕⊕ 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.
⊕⊕ Low. Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
⊕ High. We are very confident that the true effect lies close to that of the estimate of the effect.
changes in physiology which would be expected with increased PA and as seen in other populations.\textsuperscript{40, 41}

Three studies showed no effect of physical activity interventions on breast milk production, intake and cortisol levels,\textsuperscript{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,\textsuperscript{17} pilates,\textsuperscript{24, 25} tai chi\textsuperscript{22} and telephone-based interventions\textsuperscript{26} in addition to more conventional exercise counselling and supervised exercise classes.

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)\textsuperscript{17} | Unsupervised | Not reported | Not reported | Yes (p<0.001) |
| O’Toole et al (2003)\textsuperscript{32} | Unsupervised | 4/21 (19%) | 17/21 (81%) | Yes (p<0.05) |
| Lewis et al (2014)\textsuperscript{26} | Unsupervised | 5/66 (8%) | Not reported | No |
| Daley et al (2015)\textsuperscript{27} | Unsupervised | 4/47 (8.5%) | 41/47 (87%) | Yes (p=0.03) |
| Youngwanichsetha et al (2013)\textsuperscript{22} | Unsupervised | 2/32 (6%) | Not reported | Yes (p=0.02) |
| Ashrafinia et al (2014)\textsuperscript{24} | Unsupervised | Not reported | Not reported | Yes (p<0.001) |
| McIntyre et al (2012)\textsuperscript{31} | Unsupervised | 1/15 (7%) | 6/14 (40%) | No |
| Ashrafinia et al (2015)\textsuperscript{25} | Unsupervised | Not reported | Not given | Yes (p<0.001) |
| Lovelady et al (2009)\textsuperscript{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)\textsuperscript{18} | HR monitor | 1/34 (3%) | 62/68 (91%) | No |
| Bertz et al (2012)\textsuperscript{35} | HR monitor | 2/34 (6%) | Not reported | No |
| Da Costa et al (2009)\textsuperscript{29} | HR monitor | 6/46 (13%) | 35/46 (76%) | No |
| Dritsa et al (2008)\textsuperscript{19} | HR monitor | 6/46 (13%) | Not reported | Yes (p=0.016) |
| McCrory et al (1999)\textsuperscript{36} | HR monitor | 2/44 (5%) | 21/42 (95%) | No |
| Daley et al (2008)\textsuperscript{30} | Pedometer | 4/20 (20%) | Not reported | No |
| Kinnunen et al (2007)\textsuperscript{28} | Unsupervised, optional supervised | 5/53 (9%) | Not reported | No |
| Heh et al (2008)\textsuperscript{23} | Supervised and unsupervised | 2/35 (5.7%) | Not reported | Yes (p=0.01) |
| Osman et al (2016)\textsuperscript{15} | Supervised | Not reported | Not reported | No |
| Osman et al (2020)\textsuperscript{14} | Supervised | Not reported | Not reported | No |
| Armstrong et al (2003)\textsuperscript{20} | Supervised, Pedometer | Not reported | 64% attendance | Yes (p<0.01) |
| Norman et al (2010)\textsuperscript{33} | Supervised | 2/62 (3%) | 130/130 (100%) | No |
| Zourladani et al (2012)\textsuperscript{37} | Supervised | Not reported | Not reported | Yes (p=0.001) |
| Lovelady et al (1995)\textsuperscript{38} | Supervised | Not reported | Not reported | Yes (p<0.0001) |
| Dewey et al (1994)\textsuperscript{29} | Supervised | Not reported | 149/165 sessions completed (90%) | No |
| Lovelady et al (2000)\textsuperscript{41} | 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.
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 and maintenance of PA. Public health approaches which and their healthcare professionals.

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REFERENCES

1. Lee I-M, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 2012;380:219–29.
2. Public Health England. Physical activity: applying All Our Health [Internet]. Available: https://www.gov.uk/government/publications/physical-activity-applying-all-our-health/physical-activity-applying-all-our-health [Accessed 08 Aug 2019].
3. Scholes S. Health survey for England 2016 physical activity in adults. NHS Digital, 2017:. https://files.digital.nhs.uk/publication/rm3/hse16-adult-phy-act.pdf
4. Currie C, Zanotti C, Morgan A. Social determinants of health and well-being among young people, health behaviour in school-aged children (HBSC) study: international report from the 2009/2010 survey. World Heal Organ Health Policy Child Adolesc. 2012;6:1-272. https://www.euro.who.int/en/health-topics/life-styles/child-and-adolescent-health/publications/2012/social-determinants-of-health-and-well-being-among-young-people.-health-behaviour-in-school-aged-children-hbsc-study/
5. Hessketh KR, Evenson KR. Prevalence of U.S. pregnant women meeting 2015 ACOG physical activity guidelines. Am J Prev Med 2016;51:e87–9.
6. Borodulin KM, Evenson KR, Wen F, et al. Physical activity patterns during pregnancy. Med Sci Sports Exerc 2008;40:1901–8.
7. Borodulin K, Evenson KR, Herring AH. Physical activity patterns during pregnancy through postpartum. BMC Womens Health 2009;9:1–7.
8. National Childbirth Trust. NCT & Netmums research finds the six-week postnatal check is unsatisfactory [Internet]. Available: https://www.nct.org.uk/about-us/news-and-views/news/nct-netmums-research-finds-six-week-postnatal-check-unsatisfactory
9. Davies SC. Annual Report of the Chief Medical Officer [Internet]. Annual Report of the Chief Medical Officer. The Health of the 51st%: Women, 2014. Available: https://www.gov.uk/government/organisations/department-of-health.
10. Department of Health and Social Care. Physical activity for pregnant women [Internet]. Promotional material Start active, stay active: infographics on physical activity, 2017. Available: https://assets. publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/622335/CMO_physical_activity_pregnant_women_infographic.pdf
11. Physical activity for women after childbirth 2019;12.
12. Committee on Obstetric Practice. Committee opinion no. 650: physical activity and exercise during pregnancy and the postpartum period. Obstet Gynecol 2015;126:135–42.

Mullins E, et al. BMJ Open 2021;11:e044567. doi:10.1136/bmjopen-2020-044567

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Page MJ, McKenzie JE, Bouzyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

Osman DA, Yousef AM, El-Badry S. Impact of moderate exercise on breast milk cortisol in healthy lactating women: a randomized controlled trial. Eurasian J Biosci 2020;14:1113–7.

Osman D, Yousef A, El-Badry S. Effect of moderate exercise on breast milk leukocytes in exclusively breast-feeding mothers. Int J PharmTech Res 2016;9:01–8.

Geeen S, Higgins J. Cochrane Handbook for Systematic Reviews of Interventions v5.1.0 [Internet]. 2011. p. Section 8.5. Available: https://handbook-5.1.cochrane.org/chapter_8/table_8_5_a_the_cochrane_collaborations_tool_for_assessing.htm

Tripett J, Murakami H, Gando Y, et al. Home-Based active video games to promote weight loss during the postpartum period. Med Sci Sports Exerc 2014;46:472–8.

Brekke HK, Bertz F, Rasmussen KM, et al. Diet and exercise interventions among overweight and obese lactating women: randomized trial of effects on cardiovascular risk factors. PLoS One 2014;9:e88250.

Drita M, Da Costa D, Dupuis G, et al. Effects of a home-based exercise intervention on fatigue in postpartum depressed women: results of a randomized controlled trial. Ann Behav Med 2008;35:179–87.

Armstrong K, Edwards H. The effects of exercise and social support on mothers reporting depressive symptoms: a pilot randomized controlled trial. Int J Ment Health Nurs 2003;12:130–8.

Loveland CA, Bopp MJ, Colleran HL, et al. Effect of exercise training on loss of bone mineral density during lactation. Med Sci Sports Exerc 2009;41:1902–7.

Youngvanichsetha S, Phumdoug S, Ingkathawornpong T. The effects of tai chi qigong exercise on plasma glucose levels and health status of postpartum Thai women with type 2 diabetes. Focus on Alternative and Complementary Therapies 2013;18:182–7.

Heh S-S, Huang L-H, Ho S-M, et al. Effectiveness of an exercise support program in reducing the severity of postnatal depression in Taiwanese women. Birth 2008;35:60–5.

Ashrafinia F, Mirmohammadali M, Rajabi H, et al. The effects of Pilates exercise on sleep quality in postpartum women. J Bodyw Mov Ther 2014;18:190–9.

Ashrafinia F, Mirmohammadali M, Rajabi H, et al. Effect of Pilates exercises on postpartum maternal fatigue. Singapore Med J 2015;56:189–73.

Lewis BA, Gjerdingen DK, Avery MD, et al. A randomized trial examining a physical activity intervention for the prevention of postpartum depression: the healthy mom trial. Ment Health Phys Act 2014;7:42–9.

Daley AJ, Blamey RV, Jolly K, et al. A pragmatic randomized controlled trial to evaluate the effectiveness of a facilitiated exercise intervention as a treatment for postnatal depression: the PAM-PerS trial. Psychoi Med 2015;45:2413–25.

Kinnunen TI, Pasanen M, Aittasalo M, et al. Reducing postpartum weight retention – a pilot trial in primary health care. Nutr J 2012;11:61–9.

Da Costa D, Lowensteyn I, Abrahamowicz M, et al. A randomized clinical trial of exercise to alleviate postpartum depressed mood. J Psychosom Obstet Gynaecol 2009;30:191–200.

Daley A, Winter H, Grimmett C, et al. Feasibility of an exercise intervention for overweight women with postnatal depression: a pilot randomised controlled trial. Br J Gen Pract 2008;58:178–83.

McIntyre HD, Peacock A, Miller YD, et al. Pilot study of an individualised early postpartum intervention to increase physical activity in women with previous gestational diabetes. Int J Endocrinol 2012;2012:1–5.

O’toole ML, Savicki MA, Aartli R. Structured Diet and Physical Activity Prevent Postpartum Weight Retention [Internet]. Vol. 12, JOURNAL OF WOMEN’S HEALTH, 2003. Available: www.ilebertpub.com [Accessed cited 2018 Aug 21].

Norman E, Sherrburn M, Osborne RH, et al. An exercise and education program improves well-being of new mothers: a randomized controlled trial. Phys Ther 2010;90:348–55.

Loveland CA, Garner KE, Moreno KL, et al. The effect of weight loss in overweight, lactating women on the growth of their infants. N Engl J Med 2000;342:449–53.

Bertz F, Brekke HK, Ellegård L, et al. Diet and exercise weight-loss trial in lactating overweight and obese women. Am J Clin Nutr 2012;96:698–705.

McCrory MA, Nosnksen-Rivers LA, Molé PA, et al. Randomized trial of the short-term effects of dieting compared with dieting plus aerobic exercise on lactation performance. Am J Clin Nutr 1999;69:959–67.

Zourladani A, Zafarkas M, Chatzigiannis B, et al. The effect of physical exercise on postpartum fitness, hormone and lipid levels: a randomized controlled trial in primiparous, lactating women. Arch Gynecol Obstet 2015;291:525–30.

Loveland CA, Nosnksen-Rivers LA, McCrory MA, et al. Effects of exercise on plasma lipids and metabolism of lactating women. Med Sci Sports Exerc 1995;27:22–8.

Dewey KG, Loveland CA, Nosnksen-Rivers LA, et al. A randomized study of the effects of aerobic exercise by lactating women on breast-milk volume and composition. N Engl J Med 1994;330:449–53.

Cahin DdS, Tebar WR, Scarabottolo CC, et al. Physical activity across life stages and sleep quality in adulthood - an epidemiological study. Sleep Med 2021;83:34–9.

Cram P, Byron-Daniel J. Exercise for the management of cancer-related fatigue in adults. Cochrane Database Syst Rev 2012;11:CD006145.