Maternal Exercise and Growth in Breastfed Infants: A Meta-analysis of Randomized Controlled Trials

abstract

BACKGROUND AND OBJECTIVES: Studies have revealed that women who breastfeed their infants may be reluctant to exercise due to concerns that to do so would adversely affect their breast milk and consequently the growth of their infants. In this review, we seek to systematically review and statistically synthesize evidence from randomized controlled trials (RCTs) that have assessed the effects of maternal exercise on breastfed infant growth (weight gain and gain in length).

METHODS: Searches of the following electronic bibliographic databases were performed to identify RCTs: Cochrane Library (CENTRAL), Medline/PubMed, Embase, Cumulative Index to Nursing and Allied Health Literature, and SPORT Discus. RCTs that compared any type of exercise intervention with other treatments or no treatment in women exclusively or predominately breastfeeding were eligible for inclusion, as were trials involving exercise as a cointervention. Two authors extracted data from studies independently.

RESULTS: Four RCTs (5 comparisons) were included in the meta-analysis of infant weight gain that incorporated 170 participants. In breastfed infants, maternal exercise did not significantly affect infant weight gain (difference in mean weight gain = 18.6 g [95% confidence interval: −113.52 to 150.80, \( P = .73 \))). Only 1 trial assessed infant gain in length; no difference between the exercise and control groups was reported. Trials were classified as moderate or good methodological quality (moderate risk of bias).

CONCLUSIONS: It appears that mothers can exercise and breastfeed without detriment to the growth of their infants, but this is based on limited evidence, and more research is required before this finding is confirmed. Pediatrics 2012;130:108–114
Studies have previously revealed1–2 that women who breastfeed their infants may be reluctant to exercise due to concerns that doing so would adversely affect the composition of their breast milk, breastfeeding performance, and ultimately the growth of their infant. These concerns may have originated from early experimental studies (immediately before and after exercise) that revealed that lactic acid concentrations were significantly higher and infant milk acceptance scores were lower before exercise than after exercise.3–5 However, the authors of other studies do not support these findings.6

Based on research involving dairy cows, it has been suggested that short bouts of aerobic exercise may have negative effects by draining the body of fluid and energy, and this could cause a substantial energy deficit in lactating mothers, resulting in reduced milk volume after exercise.7 It might be that single bouts of maternal exercise adversely alter the composition and taste of breast milk to infants due to lactic acid concentrations postexercise. However, evidence has suggested that the effects of lactic acid on taste primarily occur with maximal exercise, when lactic acid concentrations are much higher, than would be the case from a typical exercise session for most women. Although over the longer term exercise may have benefits by facilitating maternal weight loss, a reduction in adipose tissue could negatively impact mothers’ ability to produce breast milk when required, as well as its composition. There is, however, a counter argument to these assertions that suggests acute bouts of aerobic exercise could have several benefits for breastfeeding outcomes. Exercise can serve to protect lactation when an energy deficiency occurs because plasma prolactin (an important hormone implicated in the maintenance of lactation) increases in response to short bouts of aerobic exercise.8,9 In addition, if aerobic exercise were performed on a regular basis over time, these responses might contribute to the facilitation of increased blood glucose homeostasis and the mobilization of fat stores during lactation.10

Given the strong and convincing evidence of the independent benefits of both regular exercise11 and breastfeeding,12 it would be optimal and reasonable to expect that mothers might want to do both.13 However, mothers are unlikely to engage in any practices that would compromise the growth of their infants or lead to failure to thrive. Doctors and other health professionals might also be reluctant to encourage regular exercise in breastfeeding mothers unless there is evidence that it does not cause harm to the infant. After giving birth, women are often keen to lose weight and regain muscle tone; exercise and breastfeeding are methods by which this could be achieved and reasons health professionals can use to promote these behaviors.

Evidence has suggested there might be negative consequences and benefits associated with maternal exercise while breastfeeding. In this review, we seek to systematically review the evidence from randomized controlled trials (RCTs) to assess the effects of maternal exercise on breastfed infant growth (weight gain and gain in length). We aim to produce evidence regarding whether mothers can exercise and breastfeed without detriment to the growth of their infants, so as to inform clinical guidance on this issue. A secondary aim of this review is to evaluate the effects of exercise on infant length (in centimeters) and maternal weight loss (in kilograms) in eligible trials.

**METHODS**

**Search Strategy for Identification of Studies**

Searches of the following electronic bibliographic databases were performed to identify RCTs and quasi-RCTs: Cochrane Library (CENTRAL), Medline/PubMed, Embase, Cumulative Index to Nursing and Allied Health Literature, and SPORT Discus. Searches were based on text words, which encompassed breastfeeding, weight gain lactation, infant growth, exercise, and physical activity. Information about ongoing and completed research trials were obtained by searching the National Research Register, Current Controlled Trials, and ClinicalTrials.gov. Searches were carried out between June 5, 2011, and June 10, 2011, and were not restricted by date or language. We searched the bibliographies of studies identified by electronic searches to identify additional studies. Relevant review articles were searched for information on additional trials.

**Study Selection**

This review included published and unpublished RCTs that compared any type of exercise intervention with other treatments or no treatment. Trials involving exercise with additional interventions (cointerventions) were eligible. We excluded uncontrolled trials that compared different type of exercise interventions as well as before and after trials. Trials needed to include exercise interventions of at least 7 days duration and include data on infant weight gain or gain in length. To be eligible for inclusion, trials needed to recruit women who were exclusively or predominately breastfeeding their infant.

Infant weight gain (grams) is the primary outcome of interest, rather than breast milk composition/volume, for several reasons. Infant weight gain would be an objective and tangible outcome that was likely to have been more accurately reported in studies than breast milk composition/volume. We knew a priori there was likely to be a lack of relevant trials that included breast milk composition/volume.
volume was an intermediary outcome and ultimately it is infant growth, specifically weight gain, that is critical where breastfeeding and exercise is concerned.

**Data Extraction**

One reviewer (Dr Daley) searched for studies by using the keywords search strategy, and screened the title and abstracts identified. Full articles of any possibly relevant reports were retrieved for more detailed evaluation, and 2 authors (Drs Daley and Thomas) independently performed a final selection of trials to be included in the review by using a standardized eligibility form. If the study fulfilled the inclusion criteria, data concerning participant characteristics, study design, number of cases, recruitment procedures, nature and length of the intervention, type of comparator group, outcome assessments, and intervention adherence were extracted by 2 reviewers (Drs Daley and Thomas) by using a standard extraction form. Reviewers were not blinded to names of authors, institutions, or journal of publication. Study authors were contacted if additional information was required to adequately complete the data extraction form.

**Assessment of Study Quality**

Two reviewers (Dr Daley and Ms Fitzpatrick) independently assessed the methodological quality of studies independently. The scoring system was modified from the Delphi List Criteria, a set of 9 criteria for quality assessment of RCTs (Table 2) and tailored to the needs of exercise-based research. In the current review, 7 of the 9 Delphi List quality criteria were evaluated. The criteria relating to the use of blinding procedures were not rated (ie, blinding of the care providers and blinding of the patients) because it is unlikely, if not impossible, to conduct exercise intervention trials where patients and care providers are blinded. Blinding of the outcome assessor was included as 1 of the quality criteria. Interreviewer discrepancies concerning the quality of a particular report were resolved by consensus with a third reviewer.

**Data Synthesis**

The primary outcome in the meta-analysis was the difference in mean weight gain between the intervention and control groups (exercise minus comparator). Means and SDs of weight gains were extracted from study reports, or by conversion of SEs and other measures of variability. Where necessary, infant weight gain was converted from kilograms or pounds to grams.

One 3-arm trial assessed 2 experimental conditions (exercise plus energy restriction or diet only) relative to a single control group; this was entered into the analysis as 2 separate comparisons (ie, exercise plus energy restriction versus control and exercise plus energy restriction versus diet only). To avoid double counting, the sample size in the exercise plus dietary restriction group was halved.

Where studies revealed multiple follow-up times, we used data from the final assessment of outcomes. To use as much of the data as possible for the main analyses, we pooled all the studies, regardless of the type of intervention. We did not use funnel plots to investigate the presence of publication bias because the number of trials included was too small.

Data are presented as weighted mean difference scores. Heterogeneity was assessed by using the *I*² statistic (describes the proportion of total variation in study estimates that is due to heterogeneity). A fixed effect meta-analysis was undertaken in the absence of heterogeneity, otherwise a random effects model was used.

When preparing the data for meta-analysis, we noted that the study by McCrory had large SDs for the outcome infant weight gain, probably due to the short nature of the intervention. This would result in the comparisons for this study having disproportionate low weight in the meta-analysis relative to other studies. Consequently, in the meta-analysis for this outcome, we weighted each study according to sample size and not inverse variance. Standard inverse variance meta-analyses were undertaken for other outcomes.

**RESULTS**

**Trial Flow**

Figure 1 shows details of the exclusion and inclusion of studies. We initially identified 1164 studies from our search strategy. Of these, 4 trials (5 comparisons) were eventually included in the review. Table 1 reveals the characteristics of the 4 included studies.

**Characteristics of Included Studies**

Four trials (5 comparisons) that incorporated 170 randomized participants with follow-up data reported 160 participants (n = 71 intervention; n = 89 comparators) were included in the meta-analysis of infant weight gain. Trials were published between 1994 and 2009. All trials were RCTs, conducted in the United States, and had some investigators in common. Women were recruited between 3- and 16-week postpartum and were exclusively breastfeeding. One trial included women with a BMI score of 25 to 30 and 1 trial included women with a BMI score of 20 to 30. Interventions lasted 11 days and 18 weeks. Two trials included exercise as a cointervention with restriction of energy intake. Comparators were either control groups or diet/energy restriction only.

All trials assessed infant weight gain but not necessarily as the primary outcome. One trial provided data on infant gain in length (in centimeters). Maternal weight (in kilograms) was...
recorded in a form useable for meta-analysis in 3 of the eligible trials (4 comparisons)\textsuperscript{16–18} (n = 53 exercise; n = 73 comparators).

Methodological Quality of Included Studies
Trials obtained a quality rating score between 4 and 5 points out of a possible score of 7 (Table 2). Some authors were not clear in reporting the trial methods, particularly regarding whether the outcome assessor was blinded or whether allocation concealment was adequate. One trial used intention to treat analysis.\textsuperscript{16}

Infant Weight Gain
In breastfed infants, maternal exercise did not significantly effect infant weight gain (difference in mean weight gain = 18.6 g [95% confidence interval: −113.52 to 150.80, \(P = .73\)]) relative to comparators, when using a fixed effects model (Fig 2). Heterogeneity was not found to be a concern (see Fig 1). In a sensitivity analysis with the trial by McCrory\textsuperscript{16} omitted (short intervention), the results did not change substantially and remained nonsignificant (difference in mean weight gain = 8.52 [95% confidence interval: −211.33 to 228.38, \(P = .94\)]). Another sensitivity analysis where only trials that included exercise interventions\textsuperscript{15,18} were included (ie, interventions with dietary components were excluded) revealed no significant difference in infant weight gain (difference in mean weight gain = 33.07 [95% confidence interval: −232.88 to 257.74, \(P = .82\)]) between exercise (n = 28) and control groups (n = 23).

Gain in Body Length
Only 1 trial\textsuperscript{17} revealed data on infant gain in length; therefore, meta-analysis was not performed; there was no significant difference between the diet plus exercise group (mean = 7.8, SD = 2.0) and controls (7.3, SD = 1.7) over 10 weeks.

Maternal Body Weight
Analyses (3 trials with 4 comparisons) revealed that participants randomly assigned to exercise had lower body weight than comparators at follow-up (difference in mean weight = 1.40 kg [95% confidence interval: −3.05 to −0.26, \(P < .10\)]) when using a random effects model. Significant heterogeneity was found (\(\chi^2 = 76.37; \ degrees\ of\ freedom = 3, P < .001, I^2 = 96\%\)).

Adherence
Attendance at exercise classes or adherence to exercise intervention guidelines was reported to be very good in all of the included trials. McCrory\textsuperscript{16} reported the diet plus exercise group exercised an average of 86 minutes per session on 9 of the 11 intervention days. Lovelady\textsuperscript{18} reported that the intervention group was able to complete an average of 83.4% (range = 60.4%–100%) of the aerobic training sessions and 94.2% (range = 81.2%–100%) of resistance training sessions. In another Lovelady trial\textsuperscript{17} all participants in the intervention group except 1 were able to exercise 4 times a week. Dewey\textsuperscript{15} reported the average frequency of exercise was 4.5 times per week.

DISCUSSION
There are multiple health benefits associated with both breastfeeding and participation in regular exercise and therefore it is likely that many women might want to engage in both. A frequently asked question by mothers is “Can I exercise and breastfeed my baby?” Consistent with several earlier observational studies,\textsuperscript{13,19} this report provides initial evidence that participating in exercise while breastfeeding does not adversely affect infant weight gain. However, although these finding might appear initially encouraging, consideration should be given to the fact that only 4 small trials were eligible for inclusion. There was insufficient data to make any conclusions regarding infant gain in length, but the 1 study that assessed this indicated no detrimental effects.

The quality of trials was generally acceptable with 3 trials scoring 4 points and 1 trial scoring 5 points (out of 7). Only 1 trial included intention to treat analysis; this omission from the remaining studies may have influenced the impact of exercise on infant weight gain such that those women who dropped out of the exercise interventions may have done so because they stopped breastfeeding and/or because their infants were not gaining weight. That said, dropout was low (n = 17) and
<table>
<thead>
<tr>
<th>Study</th>
<th>Recruitment Procedures</th>
<th>Number of Participants</th>
<th>Inclusion Criteria</th>
<th>Intervention</th>
<th>Control or Comparator</th>
<th>Outcome and Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewey et al 1994&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Recruited 6–8 wk postnatally via letters to new parents</td>
<td>38 women randomly assigned, 33 completed (noncompleters; control = 4, intervention = 1). Data reported for completers only</td>
<td>Exclusively breastfeeding, sedentary, delivered healthy infants at term</td>
<td>12-wk moderate-hard intensity aerobic exercise program on 3–5 d per wk</td>
<td>Aerobic exercise no more than once per wk during the intervention period</td>
<td>Infant wt at baseline (6–8 wk postnatally) and follow-up (18–20 wk postnatally)</td>
</tr>
<tr>
<td>McCrory et al 1999&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Recruited 8–16 wk postnatally via doctors, childbirth classes, and letters to new parents</td>
<td>67 randomly assigned, 1 (diet + exercise) did not complete study, but data included up until point of withdrawal</td>
<td>Exclusively breastfeeding, delivered healthy infant at term</td>
<td>11 d intervention period. Diet group (35% net energy deficit: 60% by dietary restriction and 40% by additional exercise). Exercise involved light-moderate intensity aerobic exercise each day</td>
<td>Comparator a: Control</td>
<td>Infant wt at baseline and follow-up by using electronic scales. The report does not state when follow-up took place, but we have assumed it is day 12 because it is the case with other outcome measures.</td>
</tr>
<tr>
<td>Lovelady et al 2000&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Recruited 4 wk postnatally in women with BMI 25–30</td>
<td>48 randomly assigned (27 diet + exercise and 21 control) and 40 completed. Noncompleters: 6 diet + exercise and 2 control. Data reported for completers only</td>
<td>Exclusively breastfeeding, sedentary, delivered healthy infant at term weighing at least 2500 g</td>
<td>10 wk of restriction of energy intake and moderate-hard intensity aerobic exercise 4 times per wk. Sessions were supervised</td>
<td>Control group instructed not to restrict their energy intake or perform vigorous aerobic exercise more than once per wk</td>
<td>Infant wt gain (digital scales) and gain in length assessed weekly throughout the study. Final follow-up for outcomes occurred at the end of the 10-wk intervention (14 wk postnatally).</td>
</tr>
<tr>
<td>Lovelady et al 2009&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Recruited 3 ± 2 wk postnatally at childbirth, parenting classes, and flyers at hospitals</td>
<td>24 women recruited and completed baseline assessment. Four women did not complete study. Data reported for 20 women who completed study</td>
<td>Exclusively breastfeeding, sedentary, BMI 20-30</td>
<td>16-wk home-based supervised moderate-hard intensity aerobic exercise (3 times per wk) and strength program (3 times per wk) over 6 d</td>
<td>Instructed not to perform aerobic or core/resistance strength exercise</td>
<td>Infant wt gain. Report does not clearly state when infant wt was assessed; we assumed it was at the same time as other outcomes at 21 ± 2 wk postnatally.</td>
</tr>
</tbody>
</table>
Evidence has suggested that pregnancy is a risk factor for obesity and during the postnatal period many women retain more weight than they should; regular exercise would facilitate the weight loss process, as does breastfeeding. Our findings revealed that mothers who exercised while breastfeeding were lighter (about 1.4 kg) than those who did not exercise although this result was marginally nonsignificant. Although this difference is rather modest, the interventions were relatively short in duration (between 11 days to 20 weeks after birth); participation in exercise over a longer period of time could lead to an even greater difference. Of interest here, this reduction in maternal body weight seems to have occurred in the exercise group without any corresponding detrimental effect on the growth of infants, although this finding is subject to heterogeneity.

Our findings should be considered in light of the potential limitations and

**TABLE 2** Assessment of Methodological Quality of Included Studies

<table>
<thead>
<tr>
<th>Quality Characteristics</th>
<th>Dewey et al 199415</th>
<th>Lovelady et al 200017</th>
<th>Lovelady et al 200918</th>
<th>McCrory et al 199816</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was randomization performed?</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>2. Were the groups similar at baseline regarding important prognostic indicators?</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3. Were the eligibility criteria specified?</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>4. Was the outcome assessor blinded?</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5. Was allocation concealment adequate?</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>6. Were point estimates and measures of variability presented for the primary outcome measures?</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>7. Did the analysis include an intention to treat analysis?</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>√</td>
</tr>
<tr>
<td>Total score (out of 7)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**FIGURE 2**

Forest plot for the effects of exercise versus comparators on infant weight gain (in grams). Study weighting based on sample size. Note: McCrory (1999a): exercise plus dietary restriction versus control; McCrory (1999b): exercise plus energy restriction versus diet only

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Limited to only 10% of those randomly assigned, and therefore dropout is unlikely to have substantially influenced the results. Furthermore, closer inspection of the reasons for dropout indicated that only 1 participant dropped out because of low milk production. One participant dropped out because of mastitis preventing breastfeeding, 5 because they were no longer able to breastfeed exclusively as they were returning to work, and the other 7 were for reasons unrelated to breastfeeding.
strengths of methods and analyses used in the review. To maximize the data available, all trials were included regardless of whether exercise was a single or co-intervention. It is possible that findings could be different when exercise is considered alongside dietary based interventions than when exercise is considered alongside dietary interventions than when offered as a standalone intervention.24

However, sensitivity analysis for exercise-only intervention trials did not change the findings. Trials varied in terms of intervention length, and this could impact the findings, such that over longer periods of time exercise may have a cumulative detrimental effect on infant growth, although sensitivity analysis according to trial length does not suggest this was the case. Both of the sensitivity analyses are based on small numbers and therefore should be considered with this in mind. Trials generally advocated moderate intensity exercise interventions, and it is not known whether exercise at more vigorous intensities would have different effects to those reported here. This review also has several strengths that should be highlighted. To our knowledge, this is the first meta-analysis of this question and therefore it has the opportunity to make a unique contribution to knowledge. Only data from RCTs were included because this provides the best level of evidence on which to make conclusions, and this study has been able to provide some initial guidance on a question that has remained unanswered and unclear for some time.

CONCLUSIONS

Based on limited evidence, we found that breastfed infants whose mothers exercised did not gain less weight than infants of sedentary mothers. Although these findings are encouraging and suggest exercise and breastfeeding are compatible, this analysis was based on data from only 170 breastfeeding women. Therefore a large high quality trial is now needed to substantiate these findings. A trial that includes data on infant body length, breastfeeding frequency/duration, infant fussiness, milk volume, and milk composition would be worthwhile.

REFERENCES


114 Daley et al

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