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Review Article

Breast-feeding and postpartum weight retention: a systematic review and meta-analysis

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Abstract
Objective: Weight gained during pregnancy and postpartum weight retention might contribute to obesity in women of childbearing age. Whether breast-feeding (BF) may decrease postpartum weight retention (PPWR) is still controversial. The purpose of our systematic review and meta-analysis was to investigate the relationship between BF and PPWR.
Design: Three databases were systematically reviewed and the reference lists of relevant articles were checked. Meta-analysis was performed to quantify the pooled standardized mean differences (SMD) of BF on PPWR by using a random-effect model. Heterogeneity was tested using the χ^2 test and I^2 statistics. Publication bias was estimated from Egger's test (linear regression method) or Begg's test (rank correlation method).
Results: Among 349 search hits, eleven studies met the inclusion criteria for the meta-analysis. Seven studies were conducted in the USA, one in Brazil, one in France, one in Georgia and one in Croatia. Compared with formula-feeding, BF for 3 to ≤6 months seemed to have a negative influence on PPWR and if BF continued for >6 months had little or no influence on PPWR. In a subgroup meta-analysis, the results did not change substantially after the analysis had been classified by available confounding factors. There was no indication of a publication bias from the result of either Egger's test or Begg's test.
Conclusions: Although the available evidence held belief that BF decreases PPWR, more robust studies are needed to reliably assess the impact of patterns and duration of BF on PPWR.

Keywords
Exclusive breast-feeding
Mixed feeding
Formula feeding
Postpartum weight retention
Obesity

Obesity is a growing problem on a global scale among populations in both developing and affluent countries. Pregnancy and the postpartum period is a time of increased maternal vulnerability to weight gain and body composition changes. Although many women have a desire to return to their pre-pregnancy weight after childbirth[1], very few achieve this goal[2–4]. Excessive postpartum weight retention (PPWR) can contribute to maternal long-term obesity and be associated with CVD, hypertension, diabetes and degenerative joint disease[5,6].

Although breast-feeding (BF) is associated with health benefits for both mother and baby[7,8], its role in postpartum weight management remains unclear. Theoretically, BF should decrease PPWR during the postpartum period as it utilizes energy, but in fact some women may gain weight during lactation[9]. Because of the hypothesized fat mobilization during lactation, BF is often considered as a factor that facilitates postpartum weight loss. However, given the many factors that may influence postpartum weight change, such as socio-economic status[10], ethnicity[11,12], pre-pregnancy weight[13–15], parity[16], gestational weight gain (GWG)[16] and lifestyle[17,18], the weight-reducing effects of postpartum lactation remain in dispute.

Some studies have shown that BF significantly reduces PPWR[19–26]. The energy needs of lactating women are about 2090 kJ/d greater than those of non-lactating mothers[13], which reflects the fact that producing more milk requires additional energy and, in the absence of restriction of food intake or changes in physical activity, should lead to greater weight loss. Other studies have

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reported no effect of BF on maternal anthropometry and body composition[27–30]. These differences may be due to the intensity and duration of BF, study population (source, size, location, loss to follow-up), how weight and weight retention were assessed, how BF was assessed and statistical methods.

To our knowledge, there have not been any quantitative attempts to further explore the possible BF–PPWR association. Given that obesity is considered to be a public health problem, a more clear understanding the role of BF in weight management is very necessary. Therefore, we carried out a systematic review and meta-analysis aiming to help clarify the association between BF and PPWR.

Methods

Search strategy and study selection

We performed a detailed search for studies that examined the association between BF and PPWR. A search of the literature was made by using Medline (PubMed, http://www.bdpubmed.com/), EMBASE (http://www.embase.com/) and Cochrane library (http://www.thecochranelibrary.com/) from their inception to October 2014 to identify relevant articles. References in key studies were reviewed to identify additional studies not indexed by Medline, EMBASE or Cochrane library.

We used the following search terms: ((‘Breastfeeding’ OR ‘formula feeding’ OR ‘bottle-feeding’ OR ‘lactation’ OR ‘non-lactation’) AND (‘weight loss’ OR ‘weight change’ OR ‘weight retention’ OR ‘body composition’) AND (‘postpartum’ OR ‘parturition’ OR ‘postnatal period’ OR ‘childbirth’) AND (‘mother’ OR ‘women’)).

Randomized controlled trials (RCT) and cohort studies were included, irrespective of sample size or follow-up duration. In addition, a hand search of reference lists of relevant and related articles was made to ensure a complete collection. The first step was a systematic review of all eligible studies on healthy women, the studies had to be published in English and report the association between BF and PPWR; in the second step a meta-analysis was conducted. Studies included in the meta-analysis had to meet the following inclusion criteria: (i) RCT or cohort study; (ii) examine infant feeding method in relation to the outcome; (iii) have data on weight change or weight retention; (iv) report both mean and standard deviation; (v) measurement of weight, rather than self-reported; and (vi) include BF (exclusive breast-feeding (EBF) or mixed breast-feeding (MF)) and formula-feeding (FF) groups. BF practices were defined as: (i) EBF, when the child received no water, tea, juice or food; (ii) MF, when the child received human milk, water, tea, juice but no food; and (iii) FF, when the child was not breast-fed.

Screening and data-extraction form

All search hits were exported to Endnote X4 (Thomson Reuters), which was used to organize the references and eliminate duplicates. Initially, two investigators (X.T. and Y. Li) independently screened the articles identified in the searches according to the predetermined criteria in order to select potentially relevant citations based on titles and abstracts; potential disagreements were resolved through consensus. For articles with relevant citations or with titles/abstracts that were not sufficient for deciding on inclusion criteria, the full-text articles were retrieved and evaluated. The following characteristics were extracted from the articles: (i) author; (ii) country; (iii) time period; (iv) sample size; (v) whether or not BF and weight retention were variables of interest; (vi) BF intensity and duration; and (vii) adjustment for potential confounding factors.

Assessment of study quality

Study quality was assessed based on: (i) follow-up rate (1 point for follow-up rate ≥75 %); (ii) clear definition of exposure and outcome about BF and PPWR (if definition or outcome was reported, then 1 point was awarded); and (iii) inclusion and exclusion criteria (if criteria were reported, then 1 point was assigned)[31]. Thus, the potential maximum score was 6 points; a high-quality study was defined as a study with ≥5 points. Two reviewers (X.T. and Y. Li) evaluated the quality of each study. A third reviewer (Q.W.) was designated to make a final decision if the initial two reviewers were unable to reach consensus.

Statistical analysis

We used the mean differences in weight loss of breast-feeders minus that of formula-feeders for meta-analysis. These differences were used to take account of the time dependency of weight change after pregnancy, which means that the effect variable is standardized mean difference (SMD). The pooled SMD and corresponding 95 % confidence intervals were calculated by using the inverse variances method[32,33]. We examined heterogeneity in results across studies by using the χ^2 test and I^2 statistics[33]. The null hypothesis that the studies are homogeneous was rejected if the P value for heterogeneity was <0·10 or I^2 was >50 %. When substantial heterogeneity was detected, the summary estimate on the basis of the random-effects model (using the method of DerSimonian and Laird[32]) was presented. Otherwise, the pooled estimate that was based on the fixed-effects model (using the inverse variance method[34]) was presented. Subgroup analyses were carried out by study design (RCT *v.* cohort studies), study quality (≥5 points *v.* <5 points), number of confounding factors adjusted for (<6 *v.* ≥6) and study population (Americans *v.* non-Americans). We conducted a sensitivity analysis by excluding each study one by one and recalculating the combined estimates on the remaining studies to assess the effect of individual studies on the pooled result. We used Egger’s test (linear regression method)[35] and Begg’s test (rank correlation method)[36] to evaluate potential publication bias. Meta-analysis was performed with the statistical software package Stata/SE version 9.

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Results

Identification of studies

The applied search strategy yielded 349 potentially relevant publications in Medline, EMBASE and Cochrane library. No additional articles were found in the citations of the relevant studies by manual search. The evaluation of the 349 publications is shown in Fig. 1.

Results of the systematic review

In total, twenty-six studies met the inclusion criteria of the systematic review; fifteen of them were not eligible for the meta-analysis[19,20,22,28,37–47] because they did not meet the inclusion criteria of the meta-analysis (see online supplementary material, Table S1). Most of the studies excluded from the meta-analysis had no control group[19,22,37,38,41,43,45]. Although six of these thirteen studies had both BF and the control group, they still did not meet the inclusion criteria[20,28,39,40,42,44]. The study by Cohen *et al.*[39] was a cross-sectional study, while the study by Mok *et al.*[20] was a case–control study. The cohort studies by Janney *et al.*[40] and Ota *et al.*[44] did not report the data of weight change, whereas the studies of Gigante *et al.*[42] and Walker *et al.*[28] did not report the standard deviation of the data. Nine of thirteen studies showed a protective effect of BF against PPWR[19,20,22,37,39–41,43,45], whereas the other four studies failed to achieve significance[28,38,42,44]. In addition, another two studies[46,47] were excluded because weight was not measured. Reasons for exclusion from the meta-analysis are shown in Table S1.

Results of the meta-analysis

Study characteristics and quality assessment

Eleven studies were eligible for the meta-analysis comprising more than 37 000 women included in the final analysis[15,48–57]. Table 1 shows characteristics of these studies and potential confounders, for which adjustment was made.

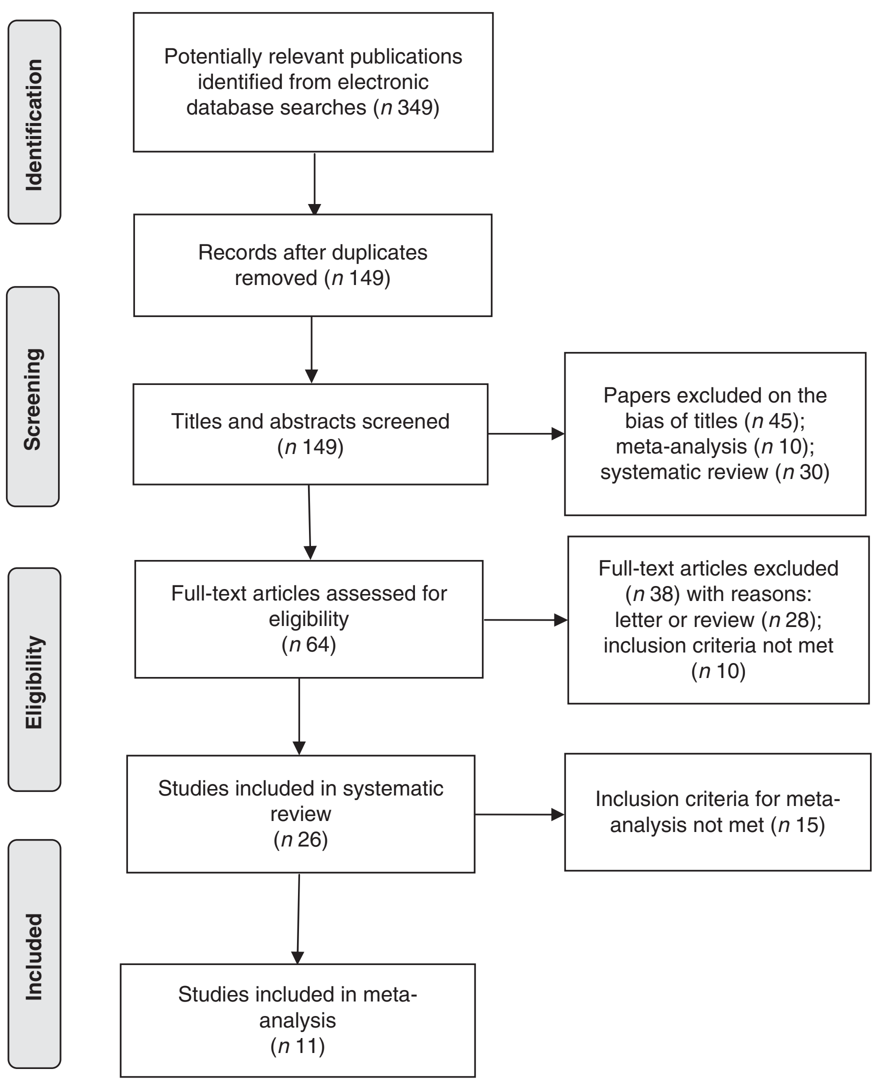

Fig. 1 Flow diagram of article selection according to PRISMA (Preferred Reporting Items for Systematic Reviews) guidelines

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Table 1 Characteristics of the studies that met the inclusion criteria of the meta-analysis

Author	Time of postpartum weight measurement	Sample size	Was BF associated with weight retention?	Was BF intensity examined?	Was BF duration examined?	Was weight measured?	Potential confounding factors adjusted for
Butte *et al.*[48]	3 months 6 months	76	N	N	Y	Y	Weight; height; BMI; FFM
Ly *et al.*[49]	4–7 months	110	Y	N	Y	Y	Age; parity; education, occupation; religion; quality of housing
Krause *et al.*[50]	3 months 6 months	28 660	Y	N	Y	Y	Age; parity, education; GWG; pre-pregnancy BMI
Hatsu *et al.*[51]	4 weeks 8 weeks 12 weeks	24	Y	Y	Y	Y	Age; race; education; marital status; parity; type of delivery
Okechukwu *et al.*[52]	1–6 months	527	Y	N	Y	Y	Age; parity; BMI; weight; height; MAC; length of gestation
Dewey *et al.*[53]	1–12 months	85	Y	Y	Y	Y	Age; education; height; parity; weight; pregnancy weight gain
Brewer *et al.*[15]	3 months 6 months	56	Y	N	Y	Y	Age; parity; pre-pregnancy weight; GWG; height
Dewey *et al.*[54]	4–12 months	141	Y	N	N	Y	BMI; weight; height
Kac *et al.*[55]	0·5 months 2 months 6 months 9 months	405	Y	N	Y	Y	Age; parity; education; pre-pregnancy weight; pre-pregnancy BMI
Wosje *et al.*[56]	3 months 6 months	82	Y	N	Y	Y	Age; weight; height; fat mass; GWG; pre-pregnancy BMI
Dujmovic *et al.*[57]	3 months 6 months	159	Y	N	N	Y	Age; height; education; pre-pregnancy weight; pre-pregnancy BMI

N, no; Y, yes; FFM, fat-free mass; GWG, gestational weight gain; MAC, mid-arm circumference.

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Seven studies were conducted in the USA, one in Brazil, one in France, one in Georgia and one in Croatia. Most individual studies were matched or adjusted for a wide range of potential confounders, including age, pre-pregnancy weight, pre-pregnancy BMI, education and parity. The results of individual studies are presented in the online supplementary material, Table S2. For the meta-analysis, we generated four categories covering similar postpartum time periods (see online supplementary material, Table S3).

As a whole, the methodological quality of the included trials was acceptable (see online supplementary material, Table S4). Study design and inclusion and exclusion criteria were mostly well recorded. An explicit definition for PPWR was reported in eleven articles. Nine of eleven studies had follow-up rates of 75 % or more. In cohort studies and in the RCT, the percentage of women lost to follow-up ranged from 0 to 10 %. Bias in weight measurement was unlikely in eleven studies.

Overall analyses

The homogeneity hypothesis was rejected by χ^2 test ($P<0{\cdot}05$, $I^2=96{\cdot}9$ %), thus we selected the random-effect model. There was non-significant effect (–0·09 kg; 95 % CI –0·76, 0·58 kg) at 1 to ≤3 months postpartum (see online supplementary material, Fig. S1). Compared with formula-feeders, breast-feeders lost 0·87 kg (95 % CI 0·57, 1·17 kg) more weight (Fig. 2). In addition, breast-feeders lost 0·37 kg more weight (95 % CI 0·14, 0·61 kg) than formula-feeders at 9 to ≤12 months postpartum (see online supplementary material, Fig. S3). This association was non-significant at 6–≤9 months postpartum (0·21 kg; 95 % CI –0·42, 0·83 kg; online supplementary material, Fig. S2). There was no indication of a publication bias from the result of either Egger's test ($P=0{\cdot}635$) or Begg's test ($P=0{\cdot}635$).

Subgroup and sensitivity analyses

The effects of BF on PPWR in subgroup meta-analyses are shown in Table 2. When stratified by study design, the analysis of RCT yielded an SMD of 0·57 kg (95 % CI 0·19, 0·94 kg), whereas the analysis on cohort studies yielded an SMD of 1·18 kg (95 % CI 0·74, 1·62 kg). In addition, the results did not change substantially after the analyses were stratified by some confounding factors (quality of studies, number of confounding factors adjusted for and study population).

In sensitivity analyses, we recalculated the combined results by excluding one study per iteration. The eleven study-specific SMD ranged from a low of 0·57 kg (95 % CI 0·19, 0·94 kg) to a high of 1·27 kg (95 % CI 0·37, 2·17 kg) and were similar without great fluctuation.

Discussion

A total of twenty-six epidemiological studies that consisted of three RCT and twenty-three cohort studies were included and eleven studies met the inclusion criteria of the meta-analysis. Seven studies were conducted in the USA,

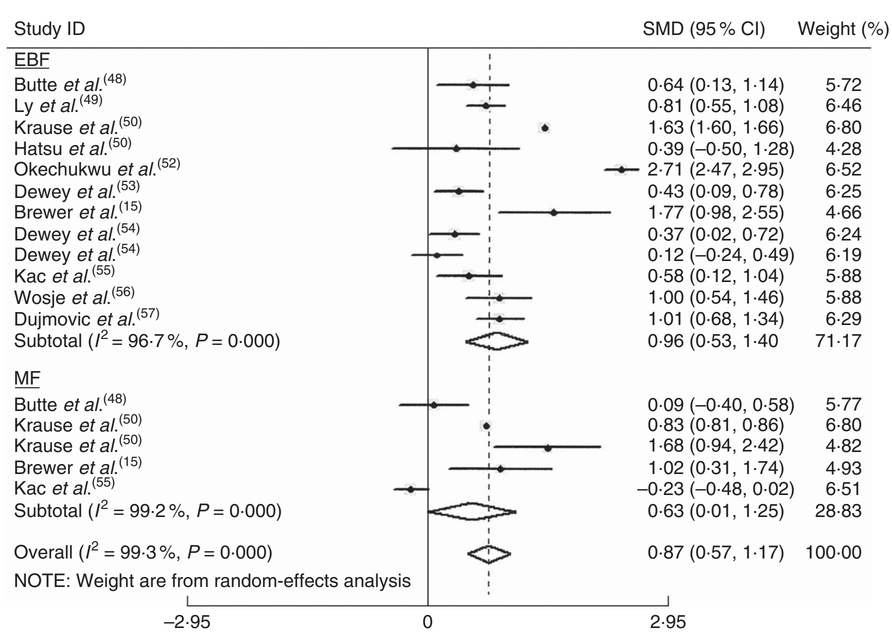

Fig. 2 Estimates for the standardized mean difference (SMD) of breast-feeding (EBF, exclusive breast-feeding; MF, mixed breast-feeding) *v.* formula-feeding on weight loss at 3–6 months postpartum. Study-specific SMD estimates are represented by grey squares, where the size of the square reflects the study-specific statistical weight (i.e. inverse of the variance), and their 95 % CI are represented by horizontal lines. The centre of the diamond presents the pooled SMD and its width represents the pooled 95 % CI. Dewey *et al.*[54] provided two results, one for primiparous mothers (effect size for primiparous mothers = 1) and one for mothers of low-birth-weight infants (effect size for mothers of low-birth-weight infants = 2)

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Table 2 Sensitivity analyses of studies included in the meta-analysis of breast-feeding on postpartum weight retention

Component	No. of studies	Pooled SMD	95 % CI
Study type			
RCT	3	0·57	0·19, 0·94
Cohort study	8	1·18	0·74, 1·62
Quality of studies			
≥5 points	10	1·10	0·55, 1·53
<5 points	1	0·71	0·45, 0·97
No. of confounding factors adjusted for			
<6	5	0·86	0·76, 0·94
≥6	6	1·13	1·60, 1·65
Study population			
Americans	7	0·79	0·19, 1·38
Non-Americans	4	1·27	0·37, 2·17

SMD, standardized mean difference; RCT, randomized controlled trial.

one in Brazil, one in France, one in Georgia and one in Croatia. The aim of the current systematic review and meta-analysis was to examine the evidence to date regarding the role of BF in PPWR. The available evidence held belief that BF decreases PPWR. The fact that we found an association between BF and PPWR at 6 months and not at 3 months postpartum may indicate that certain BF duration is necessary for the maximal effect to be observed. Lof and Forsum[(58)] showed that expansion of plasma volume during pregnancy can persist during at least the first month postpartum. They measured body water in healthy women before, during and after pregnancy and reported an average of 2 kg of fluid remaining at 2 weeks postpartum.

In theory, weight change is supported by negative energy balance due to either increased energy expenditure or reduced energy intake, or both. Although postpartum lactation increases energy expenditure significantly due to the production of milk in the mammary glands[(9)], it is also accompanied by increased energy intake[(53)], so PPWR cannot be explained merely by changes in energy expenditure or energy intake alone. Thus, we speculate that postpartum weight change may relate mainly to hormonal/metabolic changes induced by lactation. Indeed, after parturition, withdrawal of progesterone and the suckling of the breast by the infant facilitate the release of prolactin, thereby decreasing the level of oestrogen[(9)], which in turn enhances the mobilization of adipose tissue stores[(59)]. Furthermore, since prolactin also inhibits lipogenesis[(60)] and suppresses glucose uptake in adipose tissue[(61)], it is conceivable that the pregnancy-induced pattern of fat deposition may be reversed during lactation by the fluctuating hormones.

Although the majority of the studies included in the systematic review found significant associations between BF and PPWR, or significant differences in weight change between BF and FF women, it is difficult to make any firm conclusions, as many of the associations observed depended on the time at which the postpartum measurements were carried out. Among the studies that did show a positive influence of BF on weight loss, the associations tended to be relatively weak and were often confounded by other factors, such as GWG, physical activity and pre-pregnancy weight. Associations also appeared to be dependent on the duration and intensity of BF.

It appeared that for the majority of studies, BF for <3 months had little or no influence on weight change, whereas there was some evidence to suggest that BF, if continued for >6 months, may have a positive influence on weight change; but again this was not supported by all of the studies and in many of them the associations were only observed in women who continued BF until 12 months postpartum. However, our meta-analysis showed that compared with FF, BF for 3–6 months seemed to have a positive influence on weight change, and if BF continued for >6 months may have little or no influence on weight change. These differences may be due to the intensity and duration of BF, the population under study (source, size, location, loss to follow-up), how weight and weight retention were assessed, how BF was assessed and statistical methods. Nevertheless, the review provides a valuable insight into the studies to date and the findings should be useful in guiding the development of future studies.

In relation to definition of BF, it appeared that the assessment of exposure to BF differed from study to study: most of the studies compared women who breast-fed their infants with women who formula-fed infants, while a few studies compared women who have lactation with women who have non-lactation (Table 1). However, in a sensitivity analysis, homogeneity between the studies stratified by different definitions of feeding could not be rejected (Table 2).

On the other hand, there are a number of known predictors for PPWR, such as GWG[(16)], pre-pregnancy weight, physical activity and other lifestyle factors[(17)]. Because we cannot exclude residual confounding, so we could not draw any confirm conclusions regarding the role of BF in weight change. The effect of BF might not be a genuine risk factor for PPWR but rather reflect a common cause for PPWR.

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Irrespective of the underlying mechanisms, these data suggest that BF may help to reduce PPWR. A potentially beneficial effect of BF on PPWR needs to be balanced against other risks of PPWR. As pre-pregnancy weight and GWG were frequently cited as strong contributing factors to PPWR, observational studies should commence preconception with continued monitoring into the postpartum period, to capture the true trajectory of weight change.

Strengths and limitations

The possibility that BF may assist women in minimizing weight retention after pregnancy has long been controversial. Thus, a systematic review and meta-analysis was performed to examine the effect estimate of BF on PPWR. Broad search terms and multiple bibliographic databases were used in the searches to capture as many relevant papers as possible, and a robust systematic approach was used to select the final papers. To disentangle the effect of BF on PPWR, we studied both BF and FF postpartum. On the basis of results of our meta-analysis, we propose to use the term 'PPWR' only for weight retention within a limited postpartum period, for example up to 6 months or 9 months postpartum. However, because of the limitation of the data, the conclusion should be considered with caution. A large and well-designed study that addresses various patterns of BF in separate analysis by precise definitions of BF is warranted and several additional measurements, for example until 12 months or 24 months postpartum, would be necessary to provide any definitive findings.

In addition, a classical meta-analysis requires RCT. Randomization of BF on an individual level is not ethical, however. Unfortunately, there are no cluster-randomized controlled trials on BF and weight change in the literature.

Conclusions

Our meta-analysis showed that compared with FF, BF for 3 to ≤6 months seemed to have a negative influence on PPWR; however, BF continued for >6 months may have little or no influence on PPWR. As we cannot exclude residual confounding, it is difficult to draw any firm conclusions. More robust studies are needed to reliably assess the impact of patterns and duration of BF on postpartum weight retention.

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Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980015000828

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