Review Paper

The physical effects of exercise in lactating women: A review

KATYA MEYERS, MEE YOUNG HONG

School of Exercise and Nutritional Sciences, San Diego State University, San Diego, United States of America

ABSTRACT

This review was conducted to better understand the physical effects of exercise in lactating, postpartum women—specifically on weight loss, changes in body composition, and bone mineral density. Prior research indicates that despite high motivation, many women struggle to lose the weight gained during the gestation period. There has been limited research on physical activity in the lactating women largely due to concerns about reduced milk supply and infant health. Female competitive athletes, in particular, seek to understand postpartum physical changes and factors affecting their return to pre pregnancy fitness. A review of the literature was conducted by searching PubMed and Medline for human studies related to weight loss, body composition, and/or bone mineral density in exercising, lactating postpartum females. Of 179 studies identified, 36 full-text articles were screened, and 12 met the inclusion criteria. Exercise with caloric restriction was associated with weight loss in lactating females. Exercise was positively correlated with decelerated trabecular bone loss and improved body composition due to preservation of fat free mass. Mothers should be encouraged to exercise during the postpartum period, as benefits to both mother and child outweigh the risks. However, medical professionals should counsel on reasonable expectations, particularly regarding weight loss.

Keywords: Breastfeeding; Exercise; Weight loss; Body composition; Bone mineral density.

Cite this article as:
Meyers, K., & Hong, M.Y. (2021). The physical effects of exercise in lactating women: A review. *Journal of Human Sport and Exercise*, *16*(4), 740-751. https://doi.org/10.14198/jhse.2021.164.01

Corresponding author. *School of Exercise and Nutritional Sciences, San Diego State University, 5500 Campanile Dr. San Diego, CA, 92182-7251. United States of America. https://orcid.org/0000-0003-1262-0074*
E-mail: mhong2@sdsu.edu
Submitted for publication February 07, 2020.
Accepted for publication April 03, 2020.
Published October 01, 2021 *(in press* April 24, 2020)
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2021.164.01

INTRODUCTION

The postpartum period is a time of physical and emotional change for the mother. Many women are interested in engaging in or resuming exercise during the postpartum period, both as a means of stress reduction, as well as to return to preconception weight and fitness (Durham *et al*., 2011; Sundgot-Borgen *et al*., 2019; Wiltheiss *et al*., 2013). While some studies have addressed the health effects of physical activity during pregnancy, fewer studies have examined the effects of physical activity during the postpartum period, particularly of breastfeeding mothers. The aim of this review is to examine the findings of existing studies in order to better understand how the effects of exercise and lactation, two sources of high energetic demands, coincide during the postpartum period. In particular, the effects of exercise on weight loss, body composition, and bone mineral density in lactating females are examined through a current review of the literature. As more and more women strive to balance the roles of motherhood and fitness, this review aims to provide insight into how to attain optimal outcomes for both.

Breastfeeding has proven benefits for both mother and child. Children who are breastfed have demonstrated lower incidence of obesity, infections, and chronic disease (Hui *et al.*, 2019). Mothers who breastfeed have demonstrated increased bonding, lower rates of breast cancer, and retain less weight long term (Del Ciampo & Del Ciampo, 2018). However, while breastfeeding has been touted as a simple and effective weight loss method, multiple studies have raised doubts as to whether breastfeeding is actually associated with weight loss or lower weight retention (Durham *et al*., 2011; Walker & Freeland- Graves, 1998; Wiltheiss *et al*., 2013). Even in studies that have reported an association, it appears to be slight, with an average weight difference of 0.5kg in breastfeeding versus non breastfeeding mothers (Dewey, 2004). Durham et al., (2011) found that the majority of overweight/obese mothers they studied initially believed that breastfeeding helped encourage weight loss. However, the belief that breastfeeding promotes weight loss did not increase rates of initiation of breastfeeding. It was actually associated with lower frequency and shorter duration of breastfeeding when maintained over time. This emphasizes the need of setting accurate and realistic expectations for weight loss during the postpartum time.

The association between physical activity and weight loss during the postpartum period has been studied (Olin & Rössner, 1996; Sampselle *et al.*, 1999). Similar to exercise at other points in a female's life, it is associated with numerous maternal benefits, including less weight retention. However, these studies were not specific to the breastfeeding population. While both lactation and increased physical activity burns calories, the association with weight loss or less weight retention—an often-presumed benefit of exercise at other periods of a woman's life—has not been established in postpartum, lactating women (Dewey, 1998; Lovelady, 2011). Other benefits of exercise, such as preservation of fat free mass and slowing of lactation-induced bone mineral density loss, have also been studied, though results are not consistent (Larson-Meyer, 2002).

The postpartum period is a critical time for weight-management, as weight retention during this time is significantly associated with long term obesity (Durham *et al*., 2011; Gore, Brown & West, 2003). Weight loss and return to preconception body composition is a topic of concern for many mothers, particularly competitive athletes. Recent decades have shown a dramatic increase in the number of females participating in both competitive and recreational sport well into their reproductive years and beyond; however, insight into how pregnancy and postpartum changes may impact a return to sport remains limited. (Lovelady, 2011; Sundgot-Borgen *et al*., 2019; Walker & Freeland- Graves, 1998). Despite high motivation, mothers are confronted with many barriers during this time, such as lack of time, partner support, and shortage of childcare (Vernon, Young-Hyman & Looney, 2010; Walker & Freeland- Graves, 1998). The aim of this review is to better understand the patterns and mechanisms governing weight loss and changes in body composition in lactating females engaged in physical activity during the postpartum period. This will ensure that benefits of exercise beyond weight loss are emphasized, and that realistic weight loss expectations are set, so as not to increase anxiety during an already stressful time period.

METHODS

Design

An integrative review of the existing literature was conducted to evaluate the impact of exercise on weight loss, body composition, and bone mineral density in lactating females. An integrative review was utilized to allow for diverse methodologies, including reviews and randomly controlled trials. Approval from the institutional review board was not necessary, as our study did not involve participation of any human subjects.

Setting

The selected studies took place between 1990 and 2019, with the last search conducted May 2019. The participants were largely selected from U.S. populations, with several trials conducted in North Carolina. Two studies were internationally based (Sweden and England).

Sample

A previously established review protocol does not exist and is not available for separate online review. However, the guidelines duplicated as follows: a thorough search of bibliographic source PubMed was conducted using the following search terms: lactation/breastfeeding, weight, body fat, bone mineral density, exercise/physical activity and postpartum/post partum. A secondary search, using bibliographic data was conducted.

Inclusion criteria for full-text review were as follows: (a) Study designs included randomized controlled trials, review studies, and cross-sectional intervention studies. (b) Studies were designed to include women that were primarily breastfeeding at the beginning of the trial; however, depending on the duration and specifics of the study, not all women continued exclusive breastfeeding throughout the trials. (c) The study must have included an exercise component, though it may have also included a dietary intervention in tandem. (d) Outcome measures must have included weight, body fat percentage, and/or bone mineral density. Other common outcome measures included prolactin levels, VO_{2max}, and strength. The initial search yielded 179 articles. Title and abstract were reviewed to identify 36 relevant articles. Full text versions of these articles were read to verify that they met the inclusion criteria (exclusive breastfeeding at beginning of the trial, interventional or quasi-interventional exercise component) or included such studies in its review. In total, 12 articles were found which met the inclusion criteria.

Measurements

Eight articles were found which addressed weight change in postpartum, lactating women in response to exercise. Weight was reported in kilograms (kg) and included both researcher recorded and self-reported weight measurements. Seven articles addressed body composition changes, and reported changes in body fat percentage, and three articles assessed bone mineral density effects in response to exercise. Some articles addressed more than one outcome measure (e.g., weight change and body composition changes were tracked in the same study).

RESULTS

Weight loss and exercise in lactating women

While numerous studies have examined weight loss in the postpartum period, few have specifically examined the breastfeeding population or controlled for breastfeeding in their results, despite the significant metabolic contribution of lactation to energy needs and hormonal regulation. In total, there were eight trials included for review that examined the effects of exercise on weight loss in exclusively lactating women. Of these, five papers were randomized controlled trials (Bertz, Winkvist & Brekke, 2015; Dewey, 1998; Lovelady *et al.*, 2009; Lovelady *et al.*, 1995; McCrory *et al.*, 1999; Zourladani *et al.*, 2015), two were review papers (Dewey, 1998; Lovelady, 2011), and one was a case control study (Lovelady, Lonnerdal & Dewey, 1990). The population size studied was relatively small, ranging from *N* = 16 (Lovelady, Lonnerdal & Dewey, 1990) to *N* = 68 (Bertz, Winkvist & Brekke, 2015). For the randomized studies, the intervention was begun at between 4 and 24 weeks postpartum, and with the exception of one study (Bertz, Winkvist & Brekke, 2015), only women who were exclusively breastfeeding at the beginning of the trial were included. Exercise interventions ranged from 12-16 weeks in length, with the exception of one study (McCrory *et al.*, 1999), which examined the short-term effects of dieting, as compared to dieting plus exercise. In this study, the caloric intake was reduced fairly significantly to 65% of estimated energy needs, lending itself to a shorter protocol duration. Exercise prescriptions varied slightly but fell in the range of 45-60 minutes/day, 3-5 sessions/week, at an intensity of 50-70% of max heart rate. Interventions consisted of largely aerobic exercise protocols with two of these additionally prescribing resistance training (Lovelady *et al.*, 2009; Zourladani *et al.*, 2015).

Each of the six experimental trials and both review papers concluded that exercise had no significant effect on either short term or long-term weight loss (Table 1). In all studies examining prescribed exercise compared to no prescribed exercise, there was no significant difference in the amount of weight loss between the two groups. Studies that included a diet intervention demonstrated significant weight loss findings. However, when they examined the additive effect of diet plus exercise, versus diet alone, there was no additional weight loss. In fact, Bertz, Winkvist & Brekke, (2015) found the diet plus exercise group lost less weight than diet alone (-6.9±3.0 kg vs. -8.3±4.2kg) with similar findings observed (-1.9kg vs. -1.7kg) during an 11-day intervention (McCrory *et al.*, 1999).

Proposed mechanisms related to lack of significant weight loss

There are several proposed mechanisms for explaining why exercise is not associated with additional weight loss in lactating women. First, women who engage in exercise interventions decrease total energy expenditure (TEE) by conserving energy in overall daily living activities (e.g., spend more time sitting due fatigue or lack of energy) (Bertz, Winkvist & Brekke, 2015; McCrory *et al.*, 1999). Furthermore, Lovelady et al., (1995) reported similar resting metabolic rates for both exercise and control groups.

Second, women increased their energy intake to compensate and/or overcompensate for increased exercise-induced energy needs based on behavioural cues. Dewey (2004) found an average daily energy difference of approximately 1761 kJ (421 kcal) in their exercise versus control group. However, intake in the exercise group was 1377 kJ (329 Kcal) higher, resulting in a nearly identical deficit and matching net weight loss. Lovelady et al., (2009) added resistance training to an aerobic physical activity intervention. Similar to Dewey (2004), the exercise group had a higher daily intake, which yielded the same net weight loss. It was unclear from existing research whether the increase in energy intake was due to behavioural cues ("*working out burns calories, so I should eat more*") or increased hunger cues due to the exercise. In support of the first explanation, Dewey (2004) measured a difference in caloric intake before the exercise intervention began, with the exercise group consuming more before training commenced, perhaps in anticipation of beginning a workout regimen.

Table 1. The effects of exercise on weight loss in lactating postpartum females.

Author & Year	**Study Population**	**Exercise Intervention**	**Weight Loss Due to Exercise? Y/N**
Bertz *et al.*, 2015	68 lactating Swedish women 10-14 weeks PP with BMI 25-35	12-week Diet, Exercise, or Diet + Exercise. Exercise = 45' walk 4 d/ wk. at 60-70% Max HR	No. Diet and Diet + Exercise reported significant weight loss at both 12 wk. and 1 yr. follow up. Diet + exercise lost less weight than diet alone. Exercise alone loss was not significant.
Dewey, 1998	Varied (review article)	Varied	No. Exercise does not increase weight loss without caloric restriction.
Dewey, 2004	33 previously sedentary women, exclusively breastfeeding @ 6 weeks PP. Exercise (n = 18) or control (n = 15).	Exercise Only: 12 weeks @ 45'/day, 5x/week @ 60-70% HRR	No. Weight & body fat decreased significantly (p < .001), but no difference in exercise vs. control
Lovelady, 2011	varied (review article)	Varied	No. Weight loss not enhanced by exercise.
Lovelady *et al.*, 1990	Well-nourished exercising (n = 8) and sedentary (n = 8) women 9-24 weeks PP & exclusively breastfeeding	Self-administered exercise. Criteria = 5 x/week of 45 min/d @ 70% of predicted HR max. Exercising > 6mo.	No. Increased caloric intake to more than compensate for expenditure
Lovelady *et al.*, 2009	20 exclusively breastfeeding women @ 4 weeks PP	16 weeks of 45min/day 3x/week of aerobic exercise + 3x/week of RT	No. Weight loss was not significantly different
McCrory *et al.*, 1999	12 +/- 4 weeks PP, exclusively breastfeeding women assigned for 11 days to diet (n = 22), diet + exercise (n = 22) or control (n = 23)	Exercise was prescribed in terms of a target HR range 50-70% of max; self-supervised aerobic activity.	No. There was not a significant difference of weight lost in diet, as compared to diet + exercise group.
Zourladani *et al.*, 2014	37 primiparous, lactating women	12 week 50-60' aerobic/strength/stretching 3x/week	No. Decrease was not significant

A third explanation proposed for the lack of exercise-attributable weight loss in lactating postpartum women is an alteration in hormonal regulation. Prolactin is known to have appetite-enhancing effects (Dewey 2004; Grattan, 2001); it has been suggested that the appetite-stimulating effect of prolactin creates a demand for increased energy intake to help balance the high demands of milk energy output, which prior research has demonstrated to be equivalent to approximately 595 kcal/day in the first 3 months for fully breastfeeding mothers. Lactating mothers have shown an increase in serum prolactin levels that is highest for the first few months of an infant's life, and levels slowly declined as the infant began consuming other foods (Pickering *et al.*, 2013). Exercise and periods of high stress have demonstrated an independent prolactin enhancing effect in non-lactating women (Hale *et al.*, 1983; Shangold, Gatz & Thysen, 1981) and the additive effect may be responsible for an increased intake that effectively cancels out the energy expenditure of exercise among lactating postpartum women that eat *ad libitum*. Not all studies reported prolactin levels, and this is an area for future research. McCrory *et al.*, (1999) demonstrated elevated prolactin serum levels in both the diet and diet and exercise group, which could be a result of a higher percentage of caloric reduction than tested in other trials. Dewey (2004) also demonstrated a numerical increase in prolactin levels, although the result was not statistically significant. Investigators suggested that an increase in prolactin due to exercise could be short term in duration, and thus the measurement time point is important. Another proposed explanation for the lack of significance in the study was that the prolactin response varied according to suckling behaviour, which was less in the exercise group due to a higher proportion of (smaller) female infants.

Table 2. The effects of exercise on body composition in lactating postpartum females.

Author & Year	**Study Population**	**Exercise Intervention**	**Decrease in Body Fat % Due to Exercise?**
Bertz *et al.*, 2015	68 lactating Swedish women 10-14 weeks PP with BMI 25-35	12-week Diet, Exercise, or Diet + Exercise. Exercise = 45' walk 4 d/ wk. at 60-70% Max HR	No. relative fat mass loss (18.4 ± 9.4% in the D group and 17.8 ± 9.7% in the DE group) were achieved as a significant main effect of the D treatment (both p < .001). Exercise only did not have significant effect.
Colleran *et al.*, 2012	27 lactating postpartum women @ 4 weeks PP	45' walking/ 30' RT 3x/week for 16 weeks	Yes. Exercise group lost less lean body mass (-0.7 + /-0.3 vs -1.6 +/- 0.3kg, p = .05)
Dewey, 1998	Varied (review)	Varied	Yes. Greater fat free mass preserved in exercise group vs. diet
Lovelady *et al.*, 1990	Well-nourished exercising (n = 8) and sedentary (n = 8) women 9-24 weeks PP & exclusively breastfeeding.	Self-administered exercise. Criteria > 5 x/week of 45 min/d @ 70% of predicted HR max. Exercising > 6mo.	Yes. Case control Study. Body fat % lower for exercising vs sedentary women
Lovelady *et al.*, 1995	Sedentary, exclusively breastfeeding women @ 6-8 weeks PP.	12 weeks of 45min/day 5x/week of aerobic exercise	No. Weight & body fat decreased significantly (p < .001), but no difference in exercise vs. control
McCrory *et al.*, 1999	12 +/- 4 weeks PP, exclusively breastfeeding women assigned to diet (n = 22), diet + exercise (n = 22) or control (n = 23)	Exercise was prescribed in terms of a target HR range 50-70% of max for 11 days. self-supervised walk/jog/aerobics/bike/swim or stationary machines	Yes. Fat loss enhanced and fat free mass conserved in the diet + exercise, as opposed to diet alone. Diet + exercise resulted in lower body fat, as compared to control or diet alone.
Zourladani *et al.*, 2014	37 primiparous, lactating women	12 week 50-60' aerobic/strength/stretching 3x/week	Yes (p = .007)

D: Diet; DE: Diet and exercise; HR: Heart rate; RT: Resistance training.

Exercise on body composition in lactating women

Seven studies were included in the analysis of the impact of exercise on body composition (Table 2). Study designs consisted of five randomized interventions, one review (Dewey, 1998), and one case control study comparing sedentary and competitive athletes in which exercise was self-prescribed, so long as it met a minimum standard of duration and intensity (Lovelady, Lonnerdal & Dewey, 1990). Of the studies evaluated, all but two (Bertz, Winkvist & Brekke, 2015; Lovelady *et al.*, 1995) reported significant findings in regard to exercise and improved body composition by reducing body fat and preservation of fat free mass. These two studies reported a decrease in body fat; however, it was either not statistically different from the sedentary group (Lovelady *et al.*, 1995) or was found to be attributable to the effects of diet (Bertz, Winkvist & Brekke, 2015).

Proposed mechanism related to improved body composition

In addition to increasing appetite, elevated prolactin levels also enhance fatty-acid use during high intensity exercise by increasing the sensitivity of adipose tissue and muscle cells to insulin (Dewey, 2004). Thus, one proposed mechanism for the changes in body fat is that elevated prolactin leads to an increased utilization of fat as a source of energy, thus preserving lean body mass.

When considering changes in body composition, the type of exercise included in the intervention is important. Resistance training is known to increase lean body weight. The two studies which did not find that exercise significantly reduced body fat both lacked a resistance training component (Bertz, Winkvist & Brekke, 2015; Lovelady *et al.*, 1995). Studies which included 3 prescribed sessions/week of resistance training showed an increase of lean body mass (Colleran, Wideman & Lovelady, 2012; Zourladani *et al.*, 2015). Other studies did not control the type of exercise performed; thus, it is reasonable to infer that it may have included a resistance exercise component (McCrory *et al.*, 1999; Lovelady, Lonnerdal & Dewey, 1990).

Effects of exercise on bone mineral density in lactating women

Decreased bone mineral density due to lactation is a concern for lactating females. A loss of up to 200 mg of calcium/day during lactation has been measured (Lovelady *et al.*, 2009). Kovacs (2005) reported that the highest rate of bone loss at lumbar and hip sites is 1-3% per month—over 10 times the rate of postmenopausal women with osteoporosis. Thus, interventions to control bone loss during the postpartum period are warranted.

Table 3. The effects of exercise on bone mineral density in lactating postpartum females.

Author & Year	**Study Population**	**Exercise Intervention**	**BMD Change due to exercise? Y/N**
Colleran *et al.*, 2012	27 lactating postpartum women @ 4 weeks PP	45' walking/ 30' RT 3x/week for 16 weeks	No. Equivalent amounts of BMD change in intervention + control. However, intervention also included a diet component, which can lead to increased decline in BMD.
Little & Clapp, 1998	20 lactating women engaged in either regular exercise (n = 11) or control (n = 9) during first 3 mo. PP.	varied (self-selected exercise)	No. Although $V0_{2max}$ differed significantly, no significance was found for weight or BMD.
Lovelady *et al.*, 2009	20 lactating postpartum women @ 4 weeks PP (identical study design; results combine to increase power)	45' walking/ 30' RT 3x/week for 16 weeks	Yes. Less lactation induced bone loss at lumber spine (4.8% vs 7%). Hip BMD was unaffected

Three studies examined the role of exercise in preserving bone mineral density in lactating females (Table 3). One study demonstrated a clear protective effect of exercise on trabecular rich bone sites (4.8% bone loss in the exercise group versus 7% in the non-exercise group at the lumbar spine), with no effect on hip or total body bone mineral density. Colleran *et al.*, (2012) examined the role of caloric restriction and exercise on lactating females and found no difference in lactation-induced bone loss as compared to the control. However, weight loss in the intervention group was achieved through a combination of diet and exercise. As the rate of bone loss is often increased during periods of caloric restriction and weight loss, equivalent rates of bone loss may have still represented a protective exercise effect by compensating for the diet induced bone loss (Shapses & Riedt, 2006). In a third study, which was cross-sectional, Little *et al.*, (1998) found a slight increase in the amount of bone loss in non-exercising lactating women versus an exercising group; however, the difference was not significant. They proposed that the non-significant difference may have resulted from not controlling participants' normal exercise patterns. Specifically, investigators classified anyone who exercised for more than 20 min/day at an intensity of > 50% of VO_{2max} 3 sessions/week as an "*exerciser*", compared with controls who exercised less. It is possible that non-significant findings of the bone loss between exercisers versus non-exercisers were due to the lack of resistance training, or that the lack of structure in the self-designed training was either too variable, created an insufficient stimulus for bone remodelling, or was not distinct from the control group.

Proposed mechanism related to preserving bone mineral density

As the lumbar spine is a site of rapid bone remodelling, it was proposed that 16 weeks of weight bearing activity and resistance training (Lovelady *et al.*, 2009) created a stimulus that led to preservation of bone mineral density in the spine. This finding was consistent with earlier studies that have demonstrated turnover in the axial skeleton, which has been shown to be faster than in the appendicular skeleton. It was unclear from the results of this study whether the improved bone mineral content was a result of a reduction in the rate of bone cell turnover or an increase in osteogenesis, as both have been noted (Hayslip *et al.*, 1989).

DISCUSSION

Exercise confers a host of benefits for both mother and child. However, based on prior studies evaluated in this review, the evidence is relatively strong that increased physical activity is not correlated with weight loss in lactating, postpartum females. Despite the lack of weight loss, there was moderately strong support for other benefits of exercise that were examined in this review included improved body composition through preservation of lean body mass, as well as improved bone mineral density or slowing of lactation-induced bone loss in trabecular rich sites. Other benefits of exercise in the postpartum period that have been evaluated but are outside the scope of this study include improved cardiovascular fitness, increased VO_{2max}, improved lipid profiles, lower rates of postpartum depression, and reduced stress (Larson-Meyer, 2002).

The lack of association between exercise and weight loss in lactating women is different from results that have been reported in the general postpartum period, which reported significant weight loss findings with similar exercise interventions (Boardley *et al.*, 1995; Ölin & Rössner, 1996; Sampselle *et al.*, 1999). However, these general postpartum studies were not conducted on exclusively breastfeeding mothers and did not attempt to examine the differences in breastfeeding versus bottle feeding or partial breastfeeding, with n/a regards to weight loss. Prior research indicates that lean lactating women will experience a decrease in milk energy output when in negative energy balance (Dewey, 1998). Due to the metabolic cost of exercise, it is reasonable to consider that there may be energy conserving forces at play in order to prevent negative energy balance decreases in milk energy output. Further research is needed to unravel this interaction, and studies of bottle-feeding mothers may be useful. In the meantime, health care providers, such as physicians involved in postpartum care, should provide reasonable expectations concerning exercise induced postpartum weight loss.

Limitations

There are several limitations to this review. First, the included studies used varying definitions of breastfeeding. Breastfeeding status often changes throughout the course of a study, even for subjects who do intend to breastfeed exclusively (Bertz, Winkvist & Brekke, 2015), and the studies included applied different definitions to breastfeeding. Some allowed limited complementary bottle feeding, while others did not. Additionally, as infants began to consume solid food it is likely there was increased variability in breastfeeding rates. Secondly, in several studies, weight was self-reported, creating the potential for systematic reporting error. Also, weight measurements are sensitive to timing. For example, up to several weeks post-delivery, weight is highly variable due to the high amounts of fluid retention. Inconsistent timing of weight collection may have impacted the accuracy of data. Thirdly, a number of studies used self-monitoring exercise and/or did not follow an exact exercise prescription; this likely introduced both variability and lower rates of compliance. Additionally, exercise protocols varied by duration, intensity, and whether or not a resistance training component was included. Furthermore, heart rate monitoring or predictive equations were used to calculate TEE, which is less accurate than other methods, namely doubly labelled water (Larson-Meyer, 2002; Lovelady, Lonnerdal & Dewey, 1990). Finally, the majority of the studies were conducted on previously sedentary and/or overweight or obese populations. Care should be used when generalizing to less well-nourished and/or more athletic populations. For example, competitive athletes' greater energy expenditure may impact milk volume, especially for leaner women, and particularly if combined with caloric restriction. Only one small study (Lovelady, Lonnerdal & Dewey, 1990) examined the association between lactation and physical changes, such as weight loss, body composition, and bone mineral density in competitive athletes. As more recreational and professional female athletes are extending rigorous athletic training well into reproductive years, this is an area of research that merits further study.

CONCLUSION

The postpartum period is a time of immense change for women and represents an important opportunity to influence lifelong behaviours that will influence maternal health, as well as the health of the baby. Clear research-based recommendations are needed. Based on available prior research, we did not find an association between exercise and weight loss in exercising, lactating women. However, exercise recommendations should not be abandoned in this population because exercise confers many other benefits. To achieve weight loss, exercise should be paired with caloric restriction in lactating women, at least in the early postpartum period. Larger studies are needed, including those with more active populations as direction of future research.

AUTHOR CONTRIBUTIONS

KM and MYH conceptualized the review; KM performed literature search and wrote the first draft; MYH reviewed and edited the original draft. All authors have read and agreed to the published version of the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ACKNOWLEDGEMENT

The authors thank Dr. David Kahan for careful reading and editing of our manuscript.

REFERENCES

Bertz, F., Winkvist, A., & Brekke, H. K. (2015). Sustainable weight loss among overweight and obese lactating women is achieved with an energy-reduced diet in line with dietary recommendations: results from the LEVA randomized controlled trial. Journal of the Academy of Nutrition and Dietetics, 115(1), 78-86. https://doi.org/10.1016/j.jand.2014.05.017

Boardley, D. J., Sargent, R. G., Coker, A. L., Hussey, J. R., & Sharpe, P. A. (1995). The relationship between diet, activity, and other factors, and postpartum weight change by race. Obstetrics & Gynecology, 86(5), 834-838. https://doi.org/10.1016/0029-7844(95)00283-w

Colleran, H. L., Wideman, L., & Lovelady, C. A. (2012). Effects of energy restriction and exercise on bone mineral density during lactation. Med Sci Sports Exerc, 44(8), 1570-1579. https://doi.org/10.1249/mss.0b013e318251d43e

Del Ciampo, L. A., & Del Ciampo, I. R. L. (2018). Breastfeeding and the Benefits of Lactation for Women's Health. Revista Brasileira de Ginecologia e Obstetrícia/RBGO Gynecology and Obstetrics, 40(06), 354-359. https://doi.org/10.1055/s-0038-1657766

Dewey, K. G. (1998). Effects of maternal caloric restriction and exercise during lactation. The Journal of nutrition, 128(2), 386S-389S. https://doi.org/10.1093/jn/128.2.386s

Dewey, K. G. (2004). Impact of breastfeeding on maternal nutritional status. In Protecting Infants Through Human Milk (pp. 91-100). Springer, Boston, MA. https://doi.org/10.1007/978-1-4757-4242-8_9

Durham, H. A., Lovelady, C. A., Brouwer, R. J., Krause, K. M., & Østbye, T. (2011). Comparison of dietary intake of overweight postpartum mothers practicing breastfeeding or formula feeding. Journal of the American Dietetic Association, 111(1), 67-74. https://doi.org/10.1016/j.jada.2010.10.001

Gore, S. A., Brown, D. M., & West, D. S. (2003). The role of postpartum weight retention in obesity among women: a review of the evidence. Annals of Behavioral Medicine, 26(2), 149-159. https://doi.org/10.1207/s15324796abm2602_07

Grattan, D. R. (2001). The actions of prolactin in the brain during pregnancy and lactation. In Progress in brain research (Vol. 133, pp. 153-171). Elsevier. https://doi.org/10.1016/s0079-6123(01)33012-1

Hale, R. W., Kosasa, T., Krieger, J., & Pepper, S. (1983). A marathon: the immediate effect on female runners' luteinizing hormone, follicle-stimulating hormone, prolactin, testosterone, and cortisol levels. American journal of obstetrics and gynecology, 146(5), 550-554. https://doi.org/10.1016/0002-9378(83)90801-3

Hayslip, C. C., Klein, T. A., Wray, H. L., & Duncan, W. E. (1989). The effects of lactation on bone mineral content in healthy postpartum women. Obstetrics and Gynecology, 73(4), 588-592.

Hui, L. L., Kwok, M. K., Nelson, E. A. S., Lee, S. L., Leung, G. M., & Schooling, C. M. (2019). Breastfeeding in Infancy and Lipid Profile in Adolescence. Pediatrics, 143(5), e20183075. https://doi.org/10.1542/peds.2018-3075

Kovacs, C. S. (2005). Calcium and bone metabolism during pregnancy and lactation. Journal of mammary gland biology and neoplasia, 10(2), 105-118. https://doi.org/10.1007/s10911-005-5394-0

Larson-Meyer, D. E. (2002). Effect of postpartum exercise on mothers and their offspring: a review of the literature. Obesity research, 10(8), 841-853. https://doi.org/10.1038/oby.2002.114

Little, K. D. (1998). Self-selected recreational exercise has no impact on early postpartum lactation-induced bone loss. Medicine and science in sports and exercise, 30(6), 831-836. https://doi.org/10.1097/00005768-199806000-00009

Lovelady, C. (2011). Balancing exercise and food intake with lactation to promote post-partum weight loss. Proceedings of the Nutrition Society, 70(2), 181-184. https://doi.org/10.1017/s002966511100005x

Lovelady, C. A., Bopp, M. J., Colleran, H. L., Mackie, H. K., & Wideman, L. (2009). Effect of exercise training on loss of bone mineral density during lactation. Med Sci Sports Exerc, 41(10), 1902-1907. https://doi.org/10.1249/mss.0b013e3181a5a68b

Lovelady, C. A., Nommsen-Rivers, L. A., McCrory, M. A., & Dewey, K. G. (1995). Effects of exercise on plasma lipids and metabolism of lactating women. Medicine and science in sports and exercise, 27(1), 22-28. https://doi.org/10.1249/00005768-199501000-00005

Lovelady, C., Lonnerdal, B., & Dewey, K. G. (1990). Lactation performance of exercising women. The American Journal of clinical nutrition, 52(1), 103-109. https://doi.org/10.1093/ajcn/52.1.103

McCrory, M. A., Nommsen-Rivers, L. A., Molé, P. A., Lönnerdal, B., & Dewey, K. G. (1999). Randomized trial of the short-term effects of dieting compared with dieting plus aerobic exercise on lactation performance. The American journal of clinical nutrition, 69(5), 959-967. https://doi.org/10.1093/ajcn/69.5.959

Ölin, A., & Rössner, S. (1996). Factors related to body weight changes during and after pregnancy: the Stockholm Pregnancy and Weight Development Study. Obesity research, 4(3), 271-276. https://doi.org/10.1002/j.1550-8528.1996.tb00545.x

Pickering, L. K., Morrow, A. L., Ruiz-Palacios, G. M., & Schanler, R. J. (Eds.). (2013). Protecting infants through human milk: Advancing the scientific evidence (Vol. 554). Springer Science & Business Media. https://doi.org/10.1007/978-1-4757-4242-8

Sampselle, C. M., Seng, J., Yeo, S., Killion, C., & Oakley, D. (1999). Physical activity and postpartum well- being. Journal of Obstetric, Gynecologic, & Neonatal Nursing, 28(1), 41-49. https://doi.org/10.1111/j.1552-6909.1999.tb01963.x

Shangold, M. M., Gatz, M. L., & Thysen, B. (1981). Acute effects of exercise on plasma concentrations of prolactin and testosterone in recreational women runners. Fertility and sterility, 35(6), 699-702. https://doi.org/10.1016/s0015-0282(16)45568-8

Shapses, S. A., & Riedt, C. S. (2006). Bone, body weight, and weight reduction: what are the concerns?. The Journal of nutrition, 136(6), 1453-1456. https://doi.org/10.1093/jn/136.6.1453

Sundgot-Borgen, J., Sundgot-Borgen, C., Myklebust, G., Sølvberg, N., & Torstveit, M. K. (2019). Elite athletes get pregnant, have healthy babies and return to sport early postpartum. BMJ Open Sport & Exercise Medicine, 5(1). https://doi.org/10.1136/bmjsem-2019-000652

Vernon, M. M., Young-Hyman, D., & Looney, S. W. (2010). Maternal stress, physical activity, and body mass index during new mothers' first year postpartum. Women & Health, 50(6), 544-562. https://doi.org/10.1080/03630242.2010.516692

Walker, L. O., & Freeland- Graves, J. (1998). Lifestyle factors related to postpartum weight gain and body image in bottle- and breastfeeding women. Journal of Obstetric, Gynecologic, & Neonatal Nursing, 27(2), 151-160. https://doi.org/10.1111/j.1552-6909.1998.tb02605.x

Wiltheiss, G. A., Lovelady, C. A., West, D. G., Brouwer, R. J., Krause, K. M., & Østbye, T. (2013). Diet quality and weight change among overweight and obese postpartum women enrolled in a behavioral intervention program. Journal of the Academy of Nutrition and Dietetics, 113(1), 54- 62. https://doi.org/10.1016/j.jand.2012.08.012

Zourladani, A., Zafrakas, M., Chatzigiannis, B., Papasozomenou, P., Vavilis, D., & Matziari, C. (2015). The effect of physical exercise on postpartum fitness, hormone and lipid levels: a randomized controlled trial in primiparous, lactating women. Archives of gynecology and obstetrics, 291(3), 525-530. https://doi.org/10.1007/s00404-014-3418-y