Effect of Exercise Training on Loss of Bone Mineral Density during Lactation

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Abstract:

Purpose: During lactation, women transfer approximately 200 mg of calcium per day to breast milk. For 6 months, this is equivalent to 3%–9% of bone mineral density (BMD) loss at trabecular-rich sites. Bone mass usually returns to prepregnancy levels with cessation of lactation but not in all women. Therefore, the purpose of this study was to determine whether exercise slows bone loss from 4 to 20 wk postpartum (PP).

Methods: At 4 wk PP, women were randomized to either an exercise group [EG, n = 10, weight bearing aerobic exercise (3 d·wk^{-1}, 45 min·d^{-1}) and 3 d·wk^{-1} of resistance exercise] or a control group (CG, n = 10, no exercise) for 16 wk. Body composition and BMD were measured by dual-energy x-ray absorptiometry at the lumbar spine (LS), hip, and total body. Maximal strength and predicted maximal oxygen consumption (V·O_{2max}) were determined by 1-repetition maximum and submaximal treadmill test, respectively. Repeated-measures ANOVA was used to test for time and time by group differences.

Results: EG lost significantly less LS BMD than CG (-4.8 ± 0.6% vs -7.0 ± 0.3%, P < 0.01). There were no significant differences in total body and hip BMD. Both groups lost fat mass (EG = -2.9 ± 0.7 kg, CG = -1.8 ± 0.4 kg); however, EG lost less lean body mass (-0.7 ± 0.3 vs -1.6 T 0.3 kg, P = 0.05). Maximal strength increased by 34% to 221% for all exercises in EG, whereas CG changed j5.7% to 12%. Predicted V·O_{2max} increased in both groups (EG = 11.4 ± 2.0, CG = 6.9 ± 1.7%).

Conclusions: These results suggest that resistance and aerobic exercise may slow bone loss during lactation.

Keywords: Bone mass | Resistance exercise | Breastfeeding | Body composition

Article:

More than 35 million American women either have or are at risk for osteoporosis (17). Many factors determine women's risk for osteoporosis, such as diet, exercise, and smoking. Bone mineral losses during pregnancy and lactation may also affect women's bone status as they enter menopause. Approximately 200 mg of calcium per day is lost from maternal bones for milk production during lactation (20). This transfer of calcium results in 3%–9% loss of bone mineral density (BMD) at trabecular-rich sites during a 6-month period (10). Loss of BMD during lactation is much greater than the average loss of 1%–2%$\cdot$yr^{-1} observed after menopause (10). BMD losses seem to be greatest in the first 5 months of lactation, with recovery to normal BMD levels once lactation ceases (10). Particularly problematic is that bone density does not return to prepregnant levels in all women, even after menses resumes (21). Susceptible women include those nursing multiple babies, adolescent mothers, and women in the later childbearing years who may not be able to regain lost bone mass before the onset of menopause (8). Lactation may be a contributing factor for postmenopausal osteoporosis in women whose bone density does not completely recover to prepregnancy levels upon weaning; however, results of studies are inconclusive (20). In fact, recent epidemiological research suggests higher bone density in women who breastfed their infants compared with women who did not (18).

Normal bone remodeling occurs for a period of 4–8 months; however, during lactation, the remodeling is accelerated and occurs within 3–4 months (8). During lactation, high prolactin and low estrogen levels promote bone resorption. At 6 months postpartum, exclusively breastfeeding women have prolactin levels that remain elevated (7), which supports continued calcium losses from the bone to breast milk. Return of menses, with the accompanying increase in estrogen levels, has been shown to decrease bone losses during lactation (9,22).

Weight bearing exercise in nonpregnant, nonlactating women with normal estrogen status has been shown to increase BMD in the lumbar spine and femoral neck by increased mechanical stress on bones (3,23,24). Studies with postmenopausal women not using hormone replacement therapy have found exercise to be beneficial for preservation of bone and reversal of bone loss (4,12). Specifically, research has shown that induction of bone growth is greatest when the exercises are site-specific and deliver direct force into the bone (4,12).

Studies examining strength-training effects on BMD during lactation are limited. Drinkwater and Chesnutt (6) observed decreases in femoral neck BMD in six active women during 6 months of lactation. A major limitation of this study was the small sample size and the lack of a comparison group of nonexercising lactating women. Little and Clapp (13) saw no effect of exercise on the inhibition of bone mineral loss in lactating women who participated in self-selected recreational exercise (mostly aerobic). All participants (both exercisers and nonexercisers) lost femoral neck and lumbar spine BMD at 3 months postpartum.

Minimizing bone losses during lactation may improve bone density after weaning and decrease the risk of osteoporosis later in life. Previous reports demonstrated that aerobic exercise was safe during lactation and did not negatively impact breast milk volume and composition or infant growth (5,15). Recently, the American College of Sports Medicine (ACSM) published a Roundtable consensus statement, ‘‘Impact of Physical Activity during Pregnancy and Postpartum on Chronic Disease Risk’’ (19). The authors concluded that there is a great need for prospective, randomized, exercise interventions to examine the outcomes of mothers and their children in the prevention of chronic diseases. Thus, the purpose of this study was to investigate the effects of resistance and aerobic exercise on BMD in exclusively breastfeeding women.

METHODS

Participants. Healthy (free from chronic disease), nonsmoking, sedentary, exclusively breastfeeding women with a body mass index (BMI) of 20–30 $kg \cdot m^{-2}$ at 3 wk postpartum were studied. Participants were recruited through childbirth and parenting classes offered at the local hospital and flyers posted at obstetricians’ offices. Women were excluded if the birth was a cesarean delivery or if they exercised more than 2 $d \cdot wk^{-1}$ during the prior 3 months. Before admission into the study, all women obtained medical clearance from their physician. Sample size was calculated on the basis of changes in lumbar spine BMD reported by Little and Clapp (13). Calculations estimated that a final sample size of 20 (10 per group) would provide significant power to detect a 10% difference in change in BMD between groups. The project was approved by the Institutional Review Board of the University of North Carolina at Greensboro. Written informed consent was obtained from all participants. Baseline measurements were completed before random assignment to the intervention (exercise group, EG) or control group (CG). The randomization was stratified by parity because loss of bone density during lactation may be different between primiparous and multiparous women.

Body composition and bone density. Body composition [fat and lean body mass (LBM)] and BMD were measured at 3 ± 2 and 21 ± 2 wk postpartum using dual-energy x-ray absorptiometry (DXA; Delphi A Version 12.3; Hologic, Bedford, MA). Quality control was performed with a spine phantom before the machine was used each day. A whole-body phantom was performed three times per week. Step phantom and air scanning were also performed once per week. Women were placed in a supine position, then an x-ray beam scanned the entire body at 1-cm intervals. DXA measurement sites included total body, lumbar spine (L1–L4), and hip (femoral neck, trochanter, and Ward triangle). Weight and height were measured with light clothing and without shoes on a stationary beam balance and stadiometer.

Assessment of cardiorespiratory fitness and strength. To assess cardiorespiratory fitness of the participants, a modified Balke protocol (1) using a submaximal graded treadmill test was used. Subjects wore an HR monitor (Polar Electro Oy, Kempele, Finland) throughout the exercise bout, and resting HR (RHR) was measured immediately before exercise. Submaximal HR was determined for each subject using the HR reserve formula [(220 - age - RHR) $\times$ 85% + RHR] (1). Participants warmed up on the treadmill for 2 min, and then speed was increased to a brisk walking or jogging pace (approximately 2.5–4.0 mph) and remained constant throughout the test. HR and perceived exertion were recorded every minute. Treadmill grade was increased by 2.5% every 2 min, and the test was terminated when participants reached 85% of their predicted maximal HR. Predicted oxygen consumption ($\dot{V}O_2$) was determined using the formulas of the ACSM (1):

Walking: $(3.5\ mL\ O_2 \cdot kg^{-1} \cdot min^{-1}) + (speed\ (m \cdot min^{-1} \times 0.1)) + (grade \times m \cdot min^{-1} \times 1.8)$
Jogging: $(3.5\ mL\ O_2 \cdot kg^{-1} \cdot min^{-1}) + (speed\ (m \cdot min^{-1} \times 0.2)) + (grade \times m \cdot min^{-1} \times 0.9)$.

The predicted oxygen consumption at the maximal HR ($\dot{V}O_{2max}$) was calculated with a linear regression equation, with HR as the independent variable and oxygen consumption as the dependent variable.

Muscular strength was assessed by the 1 repetition maximum (1-RM) method as described by ACSM, after completion of the submaximal treadmill test (1). Exercises included squats, bench press, standing military press, stiffleg dead lifts, high pulls, and bent-over dumbbell row. Handheld adjustable weights were used for all 1-RM testing and the at-home exercise protocol. Participants were instructed on proper technique for each 1-RM exercise and performed 5 to 10 repetitions to practice the lift at 40%–60% of perceived maximum. After 2–3 min of rest, the weight was increased with each lift until the participant could no longer safely complete the repetition with full range of motion and proper technique or requested to stop. The handheld adjustable weights were increased in total increments of 5-, 10-, and 20-lb weights (2.5, 5, and 10 lb per hand). The final weight lifted with proper technique was recorded as the participant's 1-RM for that exercise. In addition, endurance was measured by the number of minutes participants were able to do wall sits and abdominal planks and by the number of push-ups and abdominal crunches they performed.

Assessment of dietary intake. Dietary intake was determined by 24-h recall over the telephone using the Nutrition Data System for Research (University of Minnesota) software, on two randomly selected days in the week before randomization and during the last week of the intervention period. Before the participants were telephoned for their interview, they were given handouts of two-dimensional visual food portions. These tools aided in determining portion sizes of food consumed. Results of nutrient analyses are the average of the 2-d intakes for each measurement period.

Exercise intervention. After baseline measurements, women were randomly assigned to either an EG or a CG. Women in the intervention group completed a 16-wk homebased exercise program that focused on increasing core strength of the body (i.e., abdominal and back muscles by resistance training, 3 d·wk-1) and aerobic exercise 3 d·wk-1. Research assistants traveled to the home 3 d·wk-1 to train mothers in the exercise program and to ensure exercise compliance during the study.

Because the participants were sedentary at the onset of the exercise program, the aerobic and resistance exercises increased gradually in duration and intensity. At the beginning of the intervention, when aerobic exercise duration was short, aerobic and resistance trainings were completed on the same day. The aerobic program consisted of brisk walking at an intensity of 65%–80% of the woman's predicted maximum HR. Women wore HR monitors to confirm that they were exercising at the prescribed intensity. Duration of exercise increased from 15 to 45 min by increasing the time spent in their target HR range by 5 min·d-1 for the first week and by 3 min·d-1 thereafter. Once aerobic exercise duration was greater than 30 min, subjects trained aerobically 3 d·wk-1 and did resistance exercise on alternating days for a total of 6 d·wk-1 of training. Research assistants supervised only the resistance exercise at this point in the intervention. Each exercise session was preceded by a 5-min warm-up and ended with a 5-min cool-down period.

The resistance program focused on exercises that involved direct force through the axial skeleton. Exercises included squats, bench press, standing military press, stiffleg dead lifts, high pulls, push-ups, bent-over dumbbell row, wall sits, abdominal plank, and abdominal crunches. All of these exercises were completed in the home with handheld weights and exercise balls. Women were instructed on the proper form for all exercises and were also given a video demonstrating the exercises and written explanations of the exercises with figures representing the proper form. Progression of the resistance exercise was based on their 1-RMand occurred in three stages. The first stage was familiarization and lasted for the first week, with one set for all exercises at 60% of 1-RM. There was a 45- to 60-s rest between each exercise with 10–15 repetitions per exercise. Weeks 2 through 6 began with alternating days of the split routine as follows: day 1—squats, bench press, standing military press, abdominal crunches, and wall sit; day 2—stiff-leg dead lifts, push-ups, high pulls, bent-over dumbbell row, and abdominal plank. Exercises were performed at 70% of 1-RM, with 10–15 repetitions per set, three sets, 3-0-3 tempo, with 45- to 60-s rest between exercises. The final stage, weeks 7 through 16, continued alternating days of the split routine at 85% of the 1-RM, with five to eight repetitions per set, four to five sets, at a 2-0-2 tempo, with a 2-min rest between each exercise. The stability balls were used to progress the women from floor sit-ups and bench press to stability ball sit-ups and bench press.

Compliance with aerobic exercise was assessed by comparing the recorded minutes of the previous session of aerobic exercise from the HR monitors with the participants' exercise logs. Research assistants observed all resistance sessions in the home. We counted the number of exercise sessions completed for the aerobic and resistance exercises separately and divided the number completed by the total number of planned sessions (48 to complete during the 16 wk for each aerobic and resistance exercise) to obtain percentage compliance.

Women in the CG were instructed not to perform resistance exercise or aerobic exercise. They were allowed to walk their babies in strollers at a casual pace (not faster than 2 mph). They were offered the exercise program after they completed the baseline and end point measurements. This incentive aided in recruitment and encouraged participation in random assignment. Participants in both groups were asked to exclusively breastfeed their babies during the study. All women that regularly gave their infants more than 4 oz of formula per day were disqualified from the study. All mothers were given a multivitamin supplement without minerals. Women in both groups were instructed not to restrict their calorie intake.

Statistical analysis. Data were analyzed with JMP software (Version 5.1.1; SAS, Cary, NC). Values are reported as means $\pm$ SEM. Baseline characteristics of the two groups were compared with use of Student's t-test or W2 test. Repeated-measures ANOVA was used to test for time and time by group differences for BMD, body composition, strength and cardiorespiratory fitness, and dietary changes during the 16-wk intervention. Statistical significance was set at $P \leq 0.05$.

TABLE 1. Participants' baseline characteristics.

	CG (n = 10)	EG (n = 10)
Age (yr)	31.6 ± 0.9	31.1 ± 1.0
Parity		
Primiparous	4	5
Multiparous	6	5
Prepregnancy wt (kg)	60.6 ± 3.1	62.7 ± 3.7
Baseline wt (kg)	68.7 ± 3.9	68.7 ± 3.2
Height (cm)	165.8 ± 2.5	162.2 ± 1.7
BMI ($kg \cdot m^{-2}$)	24.8 ± 0.9	26.1 ± 1.0

Data are means ± SEM.

TABLE 2. BMD at baseline and end point and percent change after the intervention.*

	CG (n = 10)			EG (n = 10)		
	Baseline	End point	% Change	Baseline	End point	% Change
Whole body						
BMD ($g \cdot cm^{-2}$)	1.07 ± 0.03	1.06 ± 0.03	-0.8 ± 0.3	1.09 ± 0.02	1.09 ± 0.02	-0.6 ± 0.4
Lumbar spine						
BMD ($g \cdot cm^{-2}$)	1.07 ± 0.04	1.00 ± 0.03	-7.02 ± 0.6	1.05 ± 0.04	1.00 ± 0.04	-4.8 ± 0.3†
Total hip						
BMD ($g \cdot cm^{-2}$)	0.95 ± 0.04	0.93 ± 0.03	-2.2 ± 0.9	0.96 ± 0.03	0.93 ± 0.03	-2.8 ± 0.8

Values are means ± SEM.
* Significantly different over time, $P < 0.05$.
† Significantly different from CG, $P < 0.01$.

RESULTS

Twenty-four women were recruited and completed baseline measurements. Four women (n = 1 in CG and n = 3 in EG) did not complete the study because they were not able to exclusively breastfeed their infants throughout the 16-wk period. There were no significant differences in their baseline characteristics compared with the women who completed the study. The characteristics of participants were not significantly different between groups (Table 1). Women were not obese and were either non-Hispanic white (n = 19) or Asian (n = 1). We did not measure breast milk volume or composition. However, weight gain of infants was similar in both groups (EG = 2.7 ± 0.2 vs CG = 2.9 ± 0.2 kg). Eight women started hormonal birth control (progesterone-only pill or intrauterine device, n = 3 in CG and n = 5 in EG). Two women (one in each group) resumed menses during the study period. After the study, at approximately 1 yr postpartum, nine women reported weaning their infants from 24 to 48 wk (mean ± SEM = 40 T 9 wk) postpartum and 11 were still breastfeeding.

Losses of lumbar spine BMD were significantly less in those in the EG compared with those in the CG (Table 2). Statistical power for the given effect size of mean change in lumbar spine

BMD was 85%. Both groups lost total body and hip BMD, but the differences were not significant between groups.

No significant differences in cardiorespiratory fitness or muscular strength were observed between groups at baseline. Both groups experienced an increase in predicted $\dot{V}$O2max during the study period (Table 3). However, there was no significant difference in percent change between groups. The women in the EG increased muscular strength and endurance significantly more than those in the CG did in all exercises (Table 3). Women were 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 the resistance training sessions.

Total body mass lost was not significantly different between groups (Table 4). There was a trend for those in the EG to have lost significantly less LBM than those in the CG (P = 0.05). Percent body fat decreased in both groups during the intervention period, with the EG showing a greater change in percentage of body fat than the CG; however, this was not significant (P = 0.09).

Both groups decreased energy (kcal) intake over time; however, this was not significant between groups (Table 4). Protein, calcium, and vitamin D intakes did not significantly change over time or between groups.

TABLE 3. Muscular strength and endurance and cardiorespiratory fitness at baseline and end point and percent change after the intervention.

	CG (n = 10)			EG (n = 10)		
	Baseline	End point	% Change	Baseline	End point	% Change
Squats (lb)	66 ± 4.6	74 ± 6.5	12 ± 3.5	59 ± 3.1	85 ± 4.3	46 ± 8.0*†
Bench press (lb)	43 ± 4.3	44 ± 5.0	1 ± 1.4	37 ± 1.5	59 ± 2.3	63 ± 10.0†
Abdominal plank (s)	69± 12.7	60 ± 9.3	-3 ± 11.8	61 ± 16.1	116 ± 20.3	203 ± 78.8†
Military press (lb)	35 ± 2.9	36 ± 2.4	5 ± 5.2	33 ± 1.5	44 ± 2.2	34 ± 6.3†
Dead lift (lb)	66 ± 4.6	71 ± 6.9	7 ± 4.7	57 ± 3.0	92 ± 3.6	63 ± 4.1*†
Push-ups (n)	11 ± 2.1	14 ± 2.3	66 ± 51.0	10 ± 2.0	26 ± 3.0	221 ± 62.6†
High pulls (lb)	42 ± 2.9	44 ± 4.0	4 ± 4.1	40 ± 2.6	62 ± 2.9	58 ± 6.8†
Dumbbell row (lb)	44 ± 4.5	45 ± 2.7	8 ± 8.8	38 ± 4.7	66 ± 4.0	89 ± 14.5†
Wall sit (s)	36 ± 4.6	38 ± 9.0	-6 ± 12.9	27 ± 5.7	57 ± 10.2	161 ± 37.4†
Crunches (n)	61 ± 22.7	63 ± 26.8	-2 ± 8.0	51 ± 11.5	106 ± 28.7	128 ± 26.1†

Predicted $\dot{V}O_{2max}$ (L·min^{-1})	2.21 ± 0.2	2.24 ± 0.2	1.2 ± 2.0	2.13 ± 0.1	2.24 ± 0.1	5.2 ± 1.7
Predicted $\dot{V}O_{2max}$ (mL·kg^{-1}·min^{-1})	32.4 ± 1.5	34.4 ± 1.3	6.9 ± 1.7	31.1 ± 1.2	34.7 ± 1.5	11.4 ± 2.0*

Values are means ± SEM.
* Significantly different over time, P < 0.05.
† Significantly different from CG, P < 0.05.

TABLE 4. Body composition and diet at baseline and end point and percent change after the intervention.

	CG (n = 10)			EG (n = 10)		
	Baseline	End point	% Change	Baseline	End point	% Change
Weight (kg)	68.7 ± 3.9	65.2 ± 4.1	-3.5 ± 0.5	68.7 ± 3.2	65.1 ± 3.5	-3.6 ± 0.8*
LBM (kg)	45.6 ± 1.9	44.0 ± 2.0	-1.6 ± 0.3	45.2 ± 1.5	44.5 ± 1.6	-0.7 ± 0.3*†
Fat mass (kg)	23.1 ± 2.2	21.2 ± 2.4	-1.9 ± 0.4	23.5 ± 2.3	20.5 ± 2.6	-2.9 ± 0.7*
% body fat	33.1 ± 1.6	31.8 ± 1.8	-4.3 ± 1.8	33.6 ± 2.0	30.6 ± 2.4	-9.5 ± 2.2*
Energy (kcal)	2112 ± 161	1690 ± 119	-422 ± 138	2109 ± 176	1923 ± 125	-187 ± 124*
Protein (g)	74.0 ± 4.9	78.9 ± 4.2	4.9 ± 6.8	86.6 ± 6.3	75.3 ± 7.4	-11.2 ± 6.6
Calcium (mg)	1125 ± 120	944 ± 111	-176 ± 150	1360 ± 176	1209 ± 178	-152 ± 155
Vitamin D (Kg)	4.3 ± 0.7	4.5 ± 0.5	0.2 ± 0.5	6.3 ± 1.0	6.4 ± 1.2	0.03 ± 0.9

DISCUSSION

These results suggest that 16 wk of resistance and aerobic exercises minimize losses of lumbar spine BMD during lactation. The lumbar spine is composed of highly metabolic trabecular bone, which has a much higher turnover rate, as compared with the whole body, and is more susceptible to rapid mineralization and losses (9). To our knowledge, this is the first published study to investigate the effects of both resistance and aerobic exercises on BMD in a randomized study of exclusively breastfeeding women. Little and Clapp (13) detected no effect of exercise on changes in BMD in lactating women who participated in self-selected recreational exercise (walking, running, aerobic, step aerobics, stair machine). Those women were compared with nonexercising lactating women during the first 3 months postpartum. Both groups lost BMD at the femoral neck and the lumbar spine. The nonexercisers had greater losses at the lumbar spine than the exercisers, but the difference was not significant. The authors hypothesized that the mode and duration of exercise might not have provided a sufficient stimulus for bone remodeling.

Drinkwater and Chesnutt (6) observed decreases in the femoral neck but not in the lumbar spine BMD in six female athletes during lactation. They compared lactating women to a group of exercising, nonpregnant, nonlactating women. Decreases in BMD observed in the lactating women were not seen in the comparison group. Although this study did not have a nonexercising lactating group as a CG, the lack of BMD loss in the lumbar spine in the athletes suggests that exercise may have provided a protective effect against bone loss in that area.

The exercise program developed for this study was 16 wk in duration. Strength training programs should be a minimum of 8 wk in duration to allow for neural adaptations after which muscular hypertrophy will occur (2). The first week of our program was designed to familiarize the participants to the program and decrease the likelihood of injury. By week 5, the aerobic portion of the program was at full intensity. Although a program longer than 16 wk may be more effective, it was not feasible for this study. Introduction of solid foods to the infant normally begins around 4–6 months; our focus was the first 5 to 6 months of exclusive breastfeeding to measure the greatest turnover of maternal bone that occurs during this time frame. At the onset of lactation, the bone turnover cycle is shortened from the usual 4–8 to 3–4 months (11); therefore, the 16 wk of this intervention allowed for a full cycle of bone turnover to occur. The main focus of the resistance exercise program was to target the core and stimulate bone growth at the lumbar spine and hip. The exercises were primarily performed in a single plane and may not have provided adequate multiplane stress at the joints to stimulate greater bone growth.

The exercise program was effective in increasing strength and muscle endurance in all areas assessed; however, there was no significant difference between groups in the improvement of cardiorespiratory fitness. This may be because of the lower compliance of aerobic compared with resistance exercise sessions. Research assistants monitored exercise 3 $d \cdot wk^{-1}$, usually during the strength training sessions. Some participants exercised aerobically less than three times a week, which is the minimum needed to see significant improvements in cardiorespiratory fitness. Another possible explanation for the lack of significant difference between groups is that the CG also improved in cardiorespiratory fitness. The intervention began at 4 wk postpartum, and all women were still recovering from birth and were likely to increase fitness between baseline and end point measurements. The control women were allowed to walk their babies at a casual pace not faster than 2 mph. However, they may have walked at a higher intensity. In addition, weight loss in both groups contributed to the improvements in predicted relative $\dot{V}O_{2max}$. The EG group did improve their predicted absolute $\dot{V}O_{2max}$ by 5.2% compared with 1.2% in the CG. However, the level of significance was $P = 0.10$. The small sample size and the indirect method used to measure cardiorespiratory fitness may be other factors contributing to the lack of significant findings.

Exercising women had improvements in body composition. Mean weight loss was not significantly different between groups; however, the decrease in percent body fat was greater in the exercising women ($P = 0.09$). Exercising women were able to maintain most of their LBM, whereas the CG lost LBM ($P = 0.05$). Although it may have been expected that exercising women would have gained muscle mass, this may have been masked by postpartum fluid losses (i.e., at baseline, women may have appeared to have more LBM because they had not lost all of the excess fluid retained from pregnancy). Lof and Forsum (14) measured body water distribution by bioimpedance spectroscopy in healthy women before, during, and after pregnancy. The women gained 17.5 ± 6.7 kg of body weight during the first 32 wk of pregnancy, and at 2 wk postpartum, body weight was still 6.1 ± 5.7 kg over the prepregnancy body weight. Approximately 7 kg of total body water was gained during the first 32 wk of pregnancy, with approximately 2 kg remaining at 2 wk postpartum. Similar findings were seen by Lukaski et al. (16). Expansion of plasma volume and blood volume during pregnancy leads to an altered fluid status or excessive fluid accumulation. The altered fluid status from pregnancy can persist during the first month postpartum, which may lead to an overestimation of LBM in DXA measurements. Therefore, the net loss of LBM (0.7 kg) in the women from the EG may have been an effect of fluid changes and a decrease in BMD versus a decrease in muscle mass. However, we did not measure body water changes, which would have provided some insight into LBM changes.

This was not a diet intervention, and participants in both groups were instructed not to change their dietary intakes. Although there was a decrease in energy intake in both groups during the study, there were no differences in protein, calcium, and vitamin D intakes between groups or changes over time. Therefore, it is likely that dietary intake did not confound the results. Future studies should investigate the effects of a diet and exercise intervention on bone mineral and body composition changes during lactation.

In conclusion, women who participated in a 16-wk resistance and aerobic training program lost significantly less lumbar spine BMD than nonexercising controls did. The exercise program was also successful in improving body composition by decreasing body fat and maintaining LBM. Additional research is needed to determine whether these beneficial effects of exercise continue after weaning, resulting in higher BMD and decreasing the risk of osteoporosis in later life.

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