

Diet and exercise weight-loss trial in lactating overweight and obese women¹⁻³

Fredrik Bertz, Hilde K Brekke, Lars Ellegård, Kathleen M Rasmussen, Margareta Wennergren, and Anna Winkvist

ABSTRACT

Background: Current evidence suggests a combined treatment of postpartum weight loss of diet and exercise. However, to our knowledge, neither their separate and interactive effects nor long-term outcomes have been evaluated.

Objective: We evaluated whether a 12-wk dietary behavior modification (D) treatment to decrease energy intake, physical exercise behavior modification (E) treatment to implement moderate aerobic exercise, or combined dietary and physical exercise behavior modification (DE) treatment compared with control (usual care) (C) reduces body weight in lactating women measured at the end of treatment and at a 1-y follow-up 9 mo after treatment termination.

Design: At 10–14 wk postpartum, 68 lactating Swedish women with a prepregnancy BMI (in kg/m²) of 25–35 were randomly assigned to D, E, DE, or C groups. Measurements were made at baseline, after the intervention, and again at a 1-y follow-up 9 mo later. A 2 × 2 factorial approach was used to analyze main and interaction effects of treatments.

Results: Weight changes after the intervention and 1-y follow-up were -8.3 ± 4.2 and -10.2 ± 5.7 kg, respectively, in the D group; -2.4 ± 3.2 and -2.7 ± 5.9 kg, respectively, in the E group; -6.9 ± 3.0 and -7.3 ± 6.3 kg, respectively, in the DE group; and -0.8 ± 3.0 and -0.9 ± 6.6 kg, respectively, in the C group. The main effects of D treatment, but not of E treatment, on weight were significant at both times ($P < 0.001$).

Conclusions: Dietary treatment provided clinically relevant weight loss in lactating postpartum women, which was sustained at 9 mo after treatment. The combined treatment did not yield significant weight or body-composition changes beyond those of dietary treatment alone. This trial was registered at clinicaltrials.gov as NCT01343238. *Am J Clin Nutr* 2012;96:698–705.

INTRODUCTION

Increasing overweight and obesity in young, adult women is a growing concern (1, 2), and reproduction is associated with persistent weight gain (3–5). Prepregnancy overweight and obesity and excessive gestational weight gain are risk factors for high postpartum weight retention (6), exacerbating a woman's initial condition with each pregnancy. In the postpartum period, many women wish to lose weight (7). With consideration of the unique opportunity provided by the increased energy requirements of lactation (8, 9), this is a time when providing lifestyle treatment could yield favorable outcomes.

Lifestyle treatment is consistent with the 2009 American guidelines for gestational weight gain that call for a radical

change in the care of women of childbearing age, including offering counseling on diet and physical activity to eliminate postpartum weight retention (10).

Unfortunately, it is unclear whether clinically relevant weight loss can be achieved in obese and overweight postpartum women and what form of treatment would be optimal. In addition, changes in maternal diet or exercise could negatively influence infant feeding patterns and growth because of energy and nutrient intakes becoming insufficient for milk production through reduced intakes or increased needs (9, 11). According to a Cochrane systematic review that was based on limited data (11), exercise alone is insufficient for weight loss, dietary restrictions alone or in combination with exercise can enhance postpartum weight loss, and combined treatment is thought to preserve lean body mass compared with dietary restriction alone and, therefore, is preferable. However, to our knowledge, only acute effects of dietary restrictions alone have been evaluated, and the sustainability of the achieved weight loss has not been evaluated. A meta-analysis revealed that about one-half of the weight loss achieved in successful weight-loss programs is regained 1 y after treatment termination (12). Thus, a study of the effects of both dietary restriction and exercise in a longer-term intervention is needed. In the current study, we report the results of a trial that consisted of a 12-wk treatment period and a 9-mo follow-up after treatment and included assessments of the separate and interactive effects of diet and exercise behavior modification treatments on weight and body composition during lactation in women who were overweight or obese before pregnancy. This study provides data to guide policy and clinical decision making to improve women's health at a critical time in the reproductive cycle.

¹ From the Department of Internal Medicine and Clinical Nutrition, University of Gothenburg, Gothenburg, Sweden (FB, HKB, LE, and AW); the Division of Nutritional Sciences, Cornell University, Ithaca, NY (KMR); and the Department of Obstetrics and Gynecology, Sahlgrenska University Hospital, Gothenburg, Sweden (MW).

² Supported by The Swedish Research Council (project grant K2009-70X-21091-01-3; primary investigator: AW) and the Swedish Council for Working Life and Social Research (project grant 2006-0339; primary investigator: AW).

³ Address correspondence to F Bertz, Department of Internal Medicine and Clinical Nutrition, University of Gothenburg, Box 459, SE-405 30, Gothenburg, Sweden. E-mail: fredrik.bertz@nutrition.gu.se.

Received March 28, 2012. Accepted for publication July 11, 2012.

First published online September 5, 2012; doi: 10.3945/ajcn.112.040196.

SUBJECTS AND METHODS

Study participants

Between 2007 and 2010, eligible women were recruited from 15 antenatal clinics in Gothenburg, Sweden. Inclusion criteria were as follows: self-reported prepregnancy BMI (in kg/m²) of 25–35, nonsmoking, singleton term delivery, intention to breastfeed for 6 mo, providing <20% of infant energy intake as complementary foods, birth weight of infant >2500 g, and no illness in the mother or infant. The upper BMI limit was set at 35 to limit the inclusion of women who might be unable to participate in the physical exercise behavior modification (E)⁴ treatment or who might be at risk of obesity-related conditions that require additional medical treatment. Women with mild allergies and stable, medicated hypothyroidism were eligible. The study was approved by the Regional Ethics Board in Gothenburg, Sweden. All participants provided written informed consent.

Study design

Women attended the research clinic for baseline measurements at 8–12 wk postpartum. At 10–14 wk postpartum, 68 women were randomly assigned to the following 4 intervention groups in a 2 × 2 factorial design: a control (usual care) (C) group, dietary behavior modification (D) group, E group, and dietary and physical exercise behavior modification (DE) group. Women were stratified on the basis of prepregnancy BMI <28.0 and ≥28.0, respectively. A blocked randomization (block size of 4) was used within each stratum. All possible permutations within a block were identified and selected for each stratum from random numbers in a random-number table. In all, 16 blocks of 4 (*n* = 64) were completed, and 2 blocks of 4 were partially used until a total of 68 women were randomly assigned. Group allocation was concealed to all until completion of baseline measurements. Time from childbirth to baseline measurements did not differ among groups (*P* = 0.854). The intervention lasted 12 wk. At the end of the intervention, all baseline measurements were repeated. At 1 y after baseline, all measurements except total energy expenditure (TEE) were repeated.

Intervention

Women in the D group received the D treatment, and women in the E group received the E treatment, for a total of 2.5 h of individual behavior modification counseling as follows: 1.5 h at the start of the intervention and 1 h at a follow-up home visit after 6 wk of intervention. Women in the DE group received the D and E treatments of a total of 5 h. Between visits, women were contacted biweekly with cell phone text messages to report body weight in the D group, number of brisk walks in the E group, and both body weight and number of brisk walks in the DE group and were also encouraged to adhere to the program. Women in the C group received usual care (no counseling, home visit, or text messages). The women in all 4 groups were asked not to

engage in other lifestyle-modification programs during the 12-wk intervention.

D intervention

A dietitian explained the dietary modification plan to achieve a reduction of 500 kcal/d (2092 kJ/d) with a nutrient composition according to the Nordic Nutrition Recommendations (carbohydrates: 50–60% of energy; fat: <30% of energy; and protein: 10–20% of energy) (13). The plan consisted of the following 4 key steps: limit sweets and snacks to 100 g/wk, substitute low-fat and low-sugar alternatives for regular foods, cover one-half of the plate with vegetables at lunch and dinner, and reduce portion sizes. The dietitian provided the women with a document that offered practical changes from the reported baseline diet in accordance with the 4 key steps and calculations of their potential effect on weight loss. The women were provided with a diet-plan booklet, including a checklist for weekly key step achievements, and an electronic body scale (Arko; EKS) for self-weighing 3 times/wk. The women were advised to introduce the key steps one at a time at a pace that facilitated weekly weight loss of 0.5 kg but not >1 kg. Strategies to manage the barriers to change and dietary concerns identified by the woman were established jointly. Counseling was provided at the research clinic, and follow-up counseling was provided at the homes of the women.

E intervention

A physical therapist explained the physical-exercise modification plan to implement a 45-min brisk walk 4 d/wk at 60–70% of the maximum heart rate. To obtain an accurate maximum heart rate, a bicycle ergometer test was performed until exhaustion (EBIKE Comfort; GE Medical Systems). The duration of walks was gradually increased in the first 4 wk. During week 1, three 30-min and one 45-min walks were performed; during week 2, two 30-min and two 45-min walks were performed; and during week 3, one 30-min and three 45-min walks were performed. The women were provided with an exercise-plan booklet, a heart-rate monitor (Polar FS2C; Polar Electro Oy), and an activity diary for self-monitoring. Walks were done with the baby in a carriage. Strategies for managing barriers to change and exercise-related concerns identified by the woman were established jointly. Counseling and follow-up counseling were provided at the homes of the women. On both occasions, a physiotherapist joined the women on their walks to ensure suitable walking paths.

After intervention

During the 9-mo period after the intervention, the women were instructed to live their lives as they themselves chose. The women were contacted once after 6 mo and asked about their health status and whether they still intended to attend the 1-y follow-up. Women who become pregnant during the first 8 mo of the follow-up were excluded from the 1-y follow-up measurements. Women who were <1 mo pregnant at follow-up were considered eligible because only minimal body weight and body-composition changes were likely to have occurred (8). Also, women who were unknowingly pregnant may have been included.

⁴Abbreviations used: C, control (usual care); D, dietary behavior modification; DE, dietary and physical exercise behavior modification; DXA, dual-energy X-ray absorptiometry; E, physical exercise behavior modification; REE, resting energy expenditure; TEE, total energy expenditure.



Study outcomes

The primary outcomes of the study were changes from baseline in body weight and body composition. Measures of treatment included energy intake and expenditure and daily steps. An involuntary cessation of breastfeeding, reduced breastfeeding duration, and inadequate child growth were indicators of adverse effects.

Primary outcomes

Measurements were taken after an overnight fast. Weight was determined to the nearest 0.1 kg by using an electronic scale with women wearing light underclothing (MC 180 MA; Tanita). Height was measured by using a wall-mounted stadiometer. Body composition was measured by using dual-energy X-ray absorptiometry (DXA) (Lunar Prodigy; GE Lunar Corp). Muscle mass was calculated from DXA (14).

Measures of treatment

Dietary intake

Women were provided with an electronic scale (HR2395; Philips) and instructed to weigh and record all foods and beverages consumed for 4 consecutive days that were jointly established to be representative of their habitual diets. Women were interviewed regarding their infants' intakes of complementary foods. Dietary intake was calculated with Dietist XP software (version 3.2; Kost och Näringsdata) by using the 2010 Swedish Food Database (www.slv.se) and data from food manufacturers.

TEE

TEE was measured by using the doubly labeled water method over a period of 15 d (15). The energy equivalence of the carbon dioxide excreted was calculated from estimated food quotients from the dietary registration (16).

Resting energy expenditure

Resting energy expenditure (REE) was measured with indirect calorimetry by using a Deltatrac II Metabolic Monitor ventilated-hood system (Datex-Ohmeda). The REE of each woman was measured after an overnight fast after subjects arrived by car or public transportation. The REE was determined from the last 25 min of a 30-min measurement awake in the supine position after a 30-min rest in a supine position.

Daily step count

The daily step count was measured during 5 consecutive days with a SenseWear Pro₂ Armband (version 6.03; BodyMedia Inc). The step count was analyzed with InnerView Professional software (version 5.1; BodyMedia Inc).

Indicators of adverse effects: breastfeeding and infant growth

The women were interviewed regarding breastfeeding and classified according to WHO definitions (17). Infants were weighed naked to the nearest 10 g by using an electronic scale

(model 336; Seca), and recumbent length was measured to the nearest 1 mm by using a measuring board (model 416; Seca).

Statistical analysis

The sample size needed was calculated on the basis of the predicted difference in body weight changes between dietary treatment and control groups (-6.0 ± 2.0 compared with -1.5 ± 2.0 kg, respectively). With the assumption of a dropout rate of 20%, 17 women per group were needed to detect a significant difference between the 2 groups with 80% power. With the use of a 2×2 factorial design, the power was increased further (18). The 2×2 factorial design included 2 levels [absence (-) or presence (+)] of each of 2 factors (D and E treatments), which led to the 4 intervention combinations in total (ie, C group: -/-; D group: +/-; E group: -/+; and DE group: +/+). This design allowed for analysis of both main effects of the D and E interventions and their interaction, which were analyzed by using 2-factor ANCOVA. The differences among groups at baseline were analyzed with 1-factor ANOVA, the chi-square test, and the Kruskal-Wallis nonparametric test. Analyses of intervention outcomes included all women who completed both baseline and postintervention body weight measurements. Analyses of the 1-y follow-up included all women who completed both baseline and 1-y body-weight measurements. The change in outcome variables was calculated as the value obtained at 12 wk and 1 y minus the baseline value. Statistical significance was indicated by $P < 0.05$. All statistical analyses were performed with SPSS software (version 19.0; IBM).

RESULTS

Study participants

A total of 68 women were randomly assigned to treatment or control groups; 62 women (91%) completed the intervention period, and 57 women (84%) remained to complete the 1-y follow-up (Figure 1). During the intervention period, 2 women were excluded (one woman from the E group because of pregnancy and one woman from the D group because of being prescribed a metabolism-affecting drug). One woman in the C group and one woman in the E group dropped out because they wanted weight loss, and one woman in the C group and one woman in the D group dropped out because of time constraints. Women who dropped out or were excluded for reasons other than pregnancy had a higher mean BMI and higher parity at baseline than did women who remained in the trial ($P = 0.006$ and $P = 0.005$, respectively). Between the intervention and 1-y follow-up, no women dropped out, but 5 women were excluded from measurements because of a new pregnancy. At baseline, the women excluded because of pregnancy did not differ from women who remained in the trial. In women who remained in the trial, baseline characteristics and anthropometric variables did not differ significantly in the 4 groups (Tables 1 and 2). According to biweekly cell phone text communications and follow-up questions, women in groups E and DE completed 83% of planned walks at the prescribed intensity during the treatment period, with no difference between the groups. Women in groups

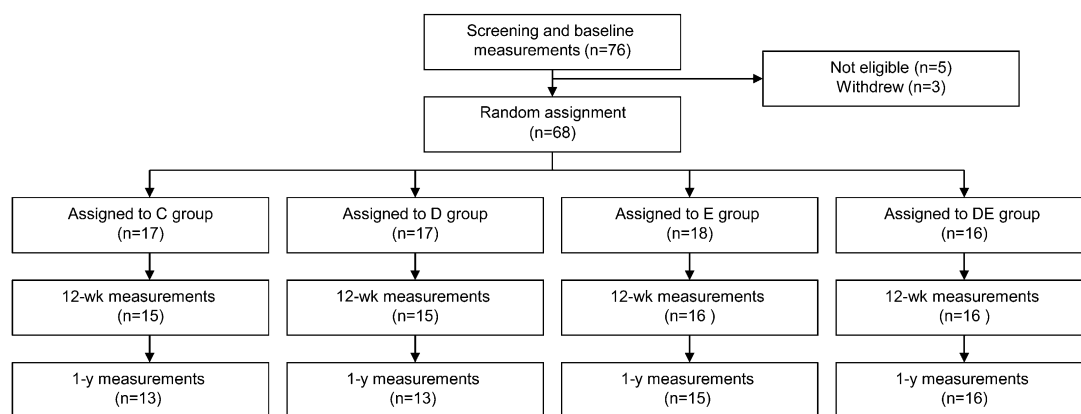


FIGURE 1. Screening, random assignment, and follow-up of the study participants in the Swedish dietary and exercise behavior-modification intervention trial in lactating overweight and obese women. C, control (usual care); D, dietary behavior modification; DE, dietary and physical exercise behavior modification; E, physical exercise behavior modification.

D and DE reported weighing themselves ≥ 2 times/wk during the treatment period.

mass. Neither the D nor E treatment led to significant changes in the daily step count or REE at 12 wk or 1 y (Table 2).

Effects of diet and exercise treatments

Treatment-implementation indicators

The D treatment, but not the E treatment, resulted in a significant reduction of reported energy intake at 12 wk ($P < 0.001$). At 1 y, a reduction of reported energy intake as a main effect of the E treatment, but not the D treatment, was shown instead ($P = 0.023$). The TEE at 12 wk was reduced as a main effect of D treatment, which may be explained by the reduction of body

Treatment outcomes

Only the D treatment, and not the E treatment, caused significant loss of weight and fat mass (both $P < 0.001$) at 12 wk and at 1 y ($P < 0.001$ and $P = 0.002$, respectively) (Table 2). After the 12-wk intervention, relative weight loss ($9.7 \pm 4.8\%$ in the D group and $8.4 \pm 3.8\%$ in the DE group) and relative fat mass loss ($18.4 \pm 9.4\%$ in the D group and $17.8 \pm 9.7\%$ in the DE group) were achieved as a significant main effect of the D treatment (both $P < 0.001$). At 1 y, relative weight loss ($11.8 \pm$

TABLE 1
Baseline characteristics of the study participants¹

Variable	Control group (n = 15)	Diet group (n = 15)	Exercise group (n = 16)	Diet and exercise group (n = 16)	P
Age (y)	32.2 \pm 4.6 ²	33.7 \pm 4.2	33.2 \pm 3.7	33.9 \pm 4.5	0.71
Parity	2 (1, 2) ³	2 (1, 2)	1 (1, 2)	1 (1, 2)	0.74
Education (n)					0.82
Short education at high school	2	0	2	1	
≤ 3 y beyond high school	2	3	3	4	
> 3 y beyond high school	11	12	11	11	
Marital status (n)					0.50
Married or cohabitating	13	15	15	16	
Single	1	0	1	0	
Couple with different residences	1	0	0	0	
Breastfeeding (n)					0.78
EBF	14	14	15	16	
PBF	0	0	0	0	
CBF	1	1	1	0	
NBF	0	0	0	0	
Infant measures					
Complementary foods (kcal/d)	4 \pm 14	9 \pm 36	2 \pm 8	0 \pm 0	0.78
Infant sex (F, M) (n)	8, 7	6, 9	8, 8	8, 8	0.90
Infant weight (g)	5729 \pm 744	5679 \pm 808	5866 \pm 618	5751 \pm 569	0.89
Infant length (cm)	58.9 \pm 2.6	59.1 \pm 2.5	60.4 \pm 2.2	59.6 \pm 1.9	0.26

¹ Significant differences between groups were determined by using 1-factor ANOVA for continuous variables, the chi-square test for normally distributed categorical variables, and the Kruskal-Wallis nonparametric test for nonnormally distributed categorical variables. To convert values from kilocalories to kilojoules, multiply by 4.184. CBF, breastfeeding with complementary foods; EBF, exclusive breastfeeding; NBF, nonbreastfeeding; PBF, predominant breastfeeding.

² Mean \pm SD (all such values).

³ Median; first, third quartiles in parentheses (all such values).

TABLE 2Effects of a diet and exercise intervention on treatment-implementation indicators and weight and body composition in lactating overweight and obese women¹

Variable	Control group (n = 15)	Diet group (n = 15)	Exercise group (n = 16)	Diet and exercise group (n = 16)	P		
					Diet main effect	Exercise main effect	Diet × exercise interaction
Treatment-implementation indicators							
Reported energy intake (kcal/d)							
Baseline	2654 ± 517	2441 ± 354	2844 ± 574	2643 ± 469	—	—	—
Change after intervention ²	-286 ± 298	-594 ± 388	-356 ± 471	-721 ± 527	<0.001	0.721	0.838
Change at 1 y ³	-332 ± 446	-562 ± 406	-870 ± 542	-858 ± 665	0.128	0.023	0.367
Steps per day							
Baseline	8361 ± 3742	8992 ± 2510	8874 ± 2732	9486 ± 3342	—	—	—
Change after intervention ^{4,5}	1962 ± 3422	628 ± 2778	1422 ± 1882	817 ± 3296	0.283	0.948	0.622
Change at 1 y	766 ± 3247	833 ± 2645	212 ± 2348	1588 ± 2652	0.083	0.793	0.182
Total energy expenditure (kcal/d)							
Baseline	2902 ± 439	2630 ± 290	2855 ± 400	2718 ± 371	—	—	—
Change after intervention	140 ± 376	108 ± 265	118 ± 235	-136 ± 326	0.015	0.090	0.213
Resting energy expenditure (kcal/d)							
Baseline	1545 ± 167	1455 ± 115	1564 ± 154	1474 ± 128	—	—	—
Change after intervention	-22 ± 109	-23 ± 97	3 ± 128	-39 ± 81	0.152	0.743	0.441
Change at 1 y	39 ± 148	17 ± 56	-8 ± 103	7 ± 119	0.537	0.398	0.580
Treatment outcomes							
Weight (kg)							
Baseline	85.5 ± 10.3	85.4 ± 10.0	88.3 ± 11.7	83.8 ± 7.3	—	—	—
Change after intervention	-0.8 ± 3.0	-8.3 ± 4.2	-2.4 ± 3.2	-6.9 ± 3.0	<0.001	0.910	0.110
Change at 1 y	-0.9 ± 6.6	-10.2 ± 5.7	-2.7 ± 5.9	-7.3 ± 6.3	<0.001	0.741	0.234
BMI (kg/m ²)							
Baseline	30.2 ± 3.4	30.0 ± 2.6	30.4 ± 3.1	29.9 ± 2.2	—	—	—
Change after intervention	-0.3 ± 1.1	-2.9 ± 1.5	-0.8 ± 1.0	-2.5 ± 1.0	<0.001	0.836	0.104
Change at 1 y	-0.3 ± 2.4	-3.6 ± 2.0	-0.9 ± 2.0	-2.6 ± 2.2	<0.001	0.716	0.202
Fat mass (kg)							
Baseline	37.4 ± 8.4	38.1 ± 6.8	37.9 ± 8.2	36.3 ± 5.4	—	—	—
Change after intervention	-0.7 ± 3.1	-6.9 ± 3.4	-1.8 ± 3.0	-6.2 ± 3.1	<0.001	0.867	0.273
Change at 1 y ⁶	-1.8 ± 6.2	-9.2 ± 5.6	-2.5 ± 5.9	-6.0 ± 7.0	0.002	0.462	0.280
Lean soft tissue mass (kg)							
Baseline	44.7 ± 4.7	43.9 ± 4.6	47.1 ± 5.5	44.2 ± 5.1	—	—	—
Change after intervention	0.1 ± 1.8	-1.3 ± 2.4	-0.6 ± 2.0	-0.5 ± 1.4	0.095	0.706	0.222
Change at 1 y ⁶	1.0 ± 2.5	-0.7 ± 1.5	-0.1 ± 2.1	-0.7 ± 1.5	0.010	0.373	0.479
Muscle mass (kg)							
Baseline	22.2 ± 2.4	22.1 ± 2.5	23.2 ± 2.6	21.9 ± 2.6	—	—	—
Change after intervention	0.4 ± 1.0	-0.6 ± 1.3	-0.5 ± 1.3	-0.5 ± 1.1	0.078	0.211	0.125
Change at 1 y ⁶	1.1 ± 1.5	-0.1 ± 0.9	0.2 ± 1.4	-0.4 ± 0.9	0.005	0.069	0.368

¹ All values are means ± SDs for group outcomes. Significant differences between groups at baseline were determined by using 1-factor ANOVA. Significant differences between treatment outcomes were determined by using 2-factor ANCOVA. To convert values from kilocalories to kilojoules, multiply by 4.184. At the 1-y follow-up, numbers of women were reduced in the control, diet, and exercise groups to 13, 13, and 15, respectively.

² In the control group, one woman did not complete dietary recordings at the end of the intervention (n = 14).

³ At the 1-y follow-up, numbers of women who completed dietary recordings were as follows: control group, n = 13; diet group, n = 12; exercise group, n = 15; and diet and exercise group, n = 15.

⁴ Data for one woman could not be retrieved in the control group (n = 14), exercise group (n = 15), and diet and exercise group (n = 15), respectively.

⁵ Data could be retrieved for only 4 d for one woman in the diet group.

⁶ Dual-energy X-ray absorptiometry scans to assess body composition were not performed on 2 women, both of whom were in the diet and exercise group, because they were pregnant (<1 mo).

6.7% in the D group and 8.5 ± 7.6% in the DE group) and relative fat mass loss (23.9 ± 14.8% in the D group and 17.5 ± 19.5% in the DE group) were sustained as a significant main effect of the D treatment (P < 0.001 and P = 0.002, respectively). There were no main effects of D and E treatments on muscle mass, lean soft tissue mass (nonadipose and bone mass as measured by DXA), or bone mineral content at 12 wk. At 1 y, the D treatment, but not the E treatment, had resulted in small but significant reductions of lean soft tissue mass and muscle

mass. However, this was expected because of the large reduction of body mass. There were no significant interactions between D and E treatments on any of these measures of treatment outcome at 12 wk or 1 y.

Infant growth and breastfeeding outcomes

There were no significant differences in infant weight and length gains between infants with mothers who took part in the D

TABLE 3Effects of a diet and exercise intervention on change in infant weight and length in lactating overweight and obese women¹

Infant growth measures	Control group (n = 15)	Diet group (n = 15)	Exercise group (n = 16)	Diet and exercise group (n = 16)	P		
					Diet main effect	Exercise main effect	Diet × exercise interaction
Infant weight gain after intervention (g)	1980 ± 555	2041 ± 411	2245 ± 525	2068 ± 548	0.627	0.246	0.357
Infant weight gain at 1 y (g)	5096 ± 1109	5158 ± 710	5216 ± 562	5025 ± 985	0.785	0.991	0.589
Infant length gain after intervention (cm)	8.2 ± 2.5	7.9 ± 1.4	8.0 ± 1.5	7.5 ± 1.4	0.218	0.772	0.406
Infant length gain at 1 y (cm)	20.9 ± 4.0	20.8 ± 1.9	20.1 ± 2.0	20.3 ± 2.6	0.754	0.766	0.950

¹ All values are means ± SDs for group outcomes. Significant differences between treatment outcomes were determined by using 2-factor ANCOVA. At the 1-y follow-up, numbers of mother-and-child pairs were reduced in the control, diet, and exercise groups to 13, 13, and 15, respectively.

or E treatment (**Table 3**). All weights and lengths of infants were within ±2 SD of the WHO infant-growth standards at all times. At 12 wk, 11% of the women practiced exclusive breastfeeding, 82% of the women practiced breastfeeding with complementary foods, and 6% of the women were not breastfeeding. At the 1-y follow-up, none of the women practiced exclusive breastfeeding, 7% of the women provided breastfeeding with complementary foods, and 93% were not breastfeeding. No significant associations between treatment groups and breastfeeding patterns were shown at 12 wk. At the 1-y follow-up, all women from the D and DE groups were not breastfeeding, whereas 2 women from the C and E groups were still breastfeeding with complementary foods, which led to a significant main effect of the D treatment on introducing nonbreastfeeding ($P = 0.030$). No women reported an involuntary decrease of milk or cessation of breastfeeding.

DISCUSSION

To our knowledge this is the first study to show, in a randomized design of reasonable duration, that dietary intervention provides significant and clinically relevant weight loss (19) in overweight and obese lactating women, and this weight loss was sustained 9 mo after intervention. In contrast to our assumptions, there were no interactive effects of dietary and exercise interventions on anthropometric outcomes. Weight loss was not improved, and lean soft tissue and muscle mass were not better preserved with the combination of dietary modification and moderate exercise treatment compared with dietary treatment only. At the 1-y follow-up, small but significant reductions of lean soft tissue mass and muscle mass, relative to the increase in control subjects, were detected as a main effect of the D treatment. However, these reductions were surprisingly low across treatments at both times compared with in previous research (11, 20). Contrary to the common pattern of substantial weight regain after a weight-loss treatment (12), the weight loss achieved in the D and DE groups was sustained at 1 y. Furthermore, an additional weight loss of 23% and 6% to 12-wk treatment results were noted at 1 y for the D and DE groups, respectively. With consideration that postpartum women, on average, retain 0.4–3.0 kg (3, 6), 20% of women retain >5 kg after a pregnancy (4), and postpartum weight retention >6 mo increases risk of long-term excess weight gain and development of type 2 diabetes and cardiovascular diseases (21), the potential benefits of initiating a dietary treatment such as the one described in this study are substantial.

A higher intensity and longer duration of breastfeeding reduces postpartum weight retention in women with BMI <35 and may facilitate a return to prepregnancy weight (22). The minimal weight loss observed in the C group (breastfeeding only) during intervention and follow-up did not contradict the idea that breastfeeding reduces postpartum weight retention in overweight and obese women. The weight change from prepregnancy to the 1-y follow-up was –5% and –7% in the D and DE groups, respectively, –1% in the C group, and an increase of 2% in the E group. In women who received the D treatment, 90% of women returned to their prepregnancy weight by 6 mo postpartum compared with 41% of women in the E and C groups combined (data not shown). In a previous study, women who received a combined intervention of diet and exercise for 10 wk lost 4.8 kg compared with 0.8 kg in control subjects and 48% compared with 21% of women, respectively, were within 1 kg of their prepregnancy weight after the intervention, but no longer-term data were gathered (23, 24). However, other authors showed no difference in weight change in a 9-mo combined diet-and-exercise intervention in comparison with control subjects (–0.90 compared with –0.36 kg, respectively) (25).

To implement D and E treatments, we used 2 individual counseling sessions per treatment. The remaining contact was handled by letter, e-mail, and cell phone text message. The dropout rate was low (9%), which indicated that this treatment format was acceptable to the women. Although group counseling has been proven effective in other groups (26), the Active Mothers Postpartum trial indicated that this may not be appropriate in postpartum women because of their time constraints and need for flexibility (25, 27). Self-weighing, which was used in our D and DE groups, and a physical activity diary, which was used in our E and DE groups, improve weight management (28). In our participants, self-monitoring and at-clinic measurements were important to reinforce motivation and adherence to our interventions. Also, most of our women were on maternity leave during the intervention, which was a circumstance that most likely aided in the implementation of treatments. The women who dropped out of the C and E groups, but not the D group, had higher baseline BMI and higher parity than did women who remained, which indicated that these factors could be related. The reasons stated for dropping out were “wanted weight loss” and “time constraints.” In all, this further emphasizes the need for understanding the particular situation for postpartum women when implementing treatments.

In our study, energy expenditure and the number of daily steps did not increase in women assigned to the exercise treatment,



neither during treatment nor during follow-up. The planned exercise sessions may have replaced normal physical activity. However, at baseline, all groups already met recommended levels of physical activity (13, 29) at >8000 steps/d (~75 min/d), and this level was maintained at both time points of follow-up. The TEE per kilogram of body weight, which was measured during treatment only, was higher than in normal-weight lactating Swedish women (30), which confirmed that these women were quite active. An additional increase of TEE as a means to increase the energy deficit to produce weight loss may be unrealistic because of the limited time of women (27). Similarly, a failure to increase TEE or to sustain increased energy-expenditure levels was shown in lactating women who participated in a trial of supervised aerobic training for 12 wk (31).

The breastfeeding pattern was not affected by treatments at 12 wk when the infants were 6 mo old. However, we noted that the introduction of nonbreastfeeding at 1 y, when the children were 15 mo old, was a significant main effect of the D treatment because 4 women who had not received the D treatment were still providing breastfeeding with complementary foods. None of the women reported an involuntary cessation of breastfeeding. Thus, this finding more likely reflects, rather than being an adverse effect of the D treatment, that more women in the C and E groups, for reasons unknown to us, chose to continue partial breastfeeding.

This study had some limitations. First, 97% of the women in our trial were white, and 73% of women had >3 y of education beyond high school. Although these results are relevant to many women, they are not generalizable to all lactating women. Research in more diverse populations is needed. Second, because the exercise treatment did not increase the TEE, the effect of adding exercise to normal activity could not be evaluated. Finally, we measured infant growth when the infants were transitioning from exclusive to partial breastfeeding with the addition of solid foods. Thus, the growth of the infants was not completely determined by maternal milk production, and thus, we can say only that we observed no adverse effects. This result is in line with previous studies that showed that short-term maternal weight reduction did not negatively affect infant growth or the quantity or quality of breast milk (23, 31, 32). The strengths of our study included its randomized design, which provided causal inference for our results; its relatively long intervention period, which helped us to detect an effect of the D treatment and the lack of adverse effects; and the 9-mo follow-up, which allowed for an evaluation of the sustainability of the treatment outcomes. Furthermore, the practical approach used for the D treatment makes it possible for other individuals to replicate this treatment at low cost.

Our results showed that the dietary treatment used in the study was sufficient to provide significant and clinically meaningful weight loss in lactating women, and weight loss was sustained 9 mo after the treatment ended. Physical exercise treatment alone did not increase the TEE or weight loss. The combined treatment did not yield significant weight or body-composition changes beyond those of dietary treatment alone. In lactating women, such as our participants, who already meet recommended levels of physical activity, physical exercise treatment should not be prioritized for weight loss. However, in less active women, this strategy should be explored further. Our results show the usefulness of dietary treatment to enhance weight loss in lactating women to achieve and sustain a healthy weight and, thus, aid in

the improvement of the health of women at a critical time in the reproductive cycle.

The authors' responsibilities were as follows—AW, HKB, FB, MW, and KMR: created the study concept and design; FB, HKB, and AW: conducted the research; FB: analyzed data, wrote the manuscript, and had primary responsibility for the final content of the manuscript; and FB, AW, HKB, KMR, and LE: interpreted results and critically revised the manuscript. None of the authors had a conflict of interest.

REFERENCES

1. Siega-Riz AM, Laraia B. The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. *Matern Child Health J* 2006;10:S153–6.
2. Socialstyrelsen. [The National Board of Health and Welfare.] *Folkhälsorapporten [National Health Report] 2005*. Stockholm, Sweden: Edita Norstedts Tryckeri; 2005 (in Swedish).
3. Harris HE, Ellison GT. Do the changes in energy balance that occur during pregnancy predispose parous women to obesity? *Nutr Res Rev* 1997;10:57–81.
4. Gunderson EP, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. *Epidemiol Rev* 2000;22:261–74.
5. Rössner S, Ohlin A. Pregnancy as a risk factor for obesity - lessons from the Stockholm Pregnancy and Weight Development Study. *Obes Res* 1995;3(suppl 2):267S–75S.
6. Gore SA, Brown DM, West DS. The role of postpartum weight retention in obesity among women: a review of the evidence. *Ann Behav Med* 2003;26:149–59.
7. Bastian LA, Pathiraja VC, Krause K, Namenek Brouwer RJ, Swamy GK, Lovelady CA, Østbye T. Multiparity is associated with high motivation to change diet among overweight and obese postpartum women. *Womens Health Issues* 2010;20:133–8.
8. Butte NF, King JC. Energy requirements during pregnancy and lactation. *Public Health Nutr* 2005;8:1010–27.
9. FAO. Human energy requirements In: Report of a Joint FAO/WHO/UNU Expert Consultation. Rome, Italy: FAO Food and Nutrition Technical Report Series; 2001.
10. Institute of Medicine/National Research Council. *Weight gain during pregnancy: reexamining the guidelines*. Washington, DC: National Academy Press, 2009.
11. Amorim AR, Linne YM, Lourenco PM. Diet or exercise, or both, for weight reduction in women after childbirth. *Cochrane Database Syst Rev* 2007;3:CD005627.
12. Anderson JW, Konz EC, Fredereich RC, Wood CL. Long term weight-maintenance: a meta-analysis of US studies. *Am J Clin Nutr* 2001;74:579–84.
13. Nordic Council of Ministers. *Nordic Nutrition Recommendations 2004. Integrating nutrition and physical activity*. Copenhagen, Denmark: Norden, 2004.
14. Kim J, Heshka S, Gallagher D, Kotler DP, Mayer L, Albu J, Shen W, Freda PU, Heymsfield SB. Intermuscular adipose tissue-free skeletal muscle mass: estimation by dual-energy X-ray absorptiometry in adults. *J Appl Physiol* 2004;97:655–60.
15. Slinde F, Ellegård L, Grönberg AM, Larsson S, Rossander-Hulthen L. Total energy expenditure in underweight patients with severe chronic obstructive pulmonary disease living at home. *Clin Nutr* 2003;22:159–65.
16. Black AE, Prentice AM, Coward WA. Use of food quotients to predict respiratory quotients for the doubly-labelled water method of measuring energy expenditure. *Hum Nutr Clin Nutr* 1986;40:381–91.
17. WHO. *Indicators for assessing infant and young child feeding practices: conclusions of a consensus meeting held 6–8 November 2007 in Washington DC*. Geneva, Switzerland: WHO Press; 2008.
18. Snedecor G, Cochran W, eds. *Statistical methods*. 7 ed. Ames, Iowa: The Iowa State University Press, 1980.
19. *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary*. Expert Panel on the Identification, Evaluation, and Treatment of Overweight in Adults. *Am J Clin Nutr* 1998;68:899–917.
20. Garrow JS, Summerbell CD. Meta-analysis: effect of exercise, with or without dieting, on the body composition of overweight subjects. *Eur J Clin Nutr* 1995;49:1–10.



21. Rooney BL, Schauburger CW. Excess pregnancy weight gain and long-term obesity: one decade later. *Obstet Gynecol* 2002;100:245–52.
22. Baker JL, Gamborg M, Heitmann BL, Lissner L, Sørensen TI, Rasmussen KM. Breastfeeding reduces postpartum weight retention. *Am J Clin Nutr* 2008;88:1543–51.
23. Lovelady CA, Garner KE, Moreno KL, Williams JP. The effect of weight loss in overweight, lactating women on the growth of their infants. *N Engl J Med* 2000;342:449–53.
24. Lovelady C. Balancing exercise and food intake with lactation to promote post-partum weight loss. *Proc Nutr Soc* 2011; 70:181–4.
25. Østbye T, Krause KM, Lovelady CA, Morey MC, Bastian LA, Peterson BL, Swamy GK, Brouwer RJ, McBride CM. Active Mothers Postpartum: a randomized controlled weight-loss intervention trial. *Am J Prev Med* 2009;37:173–80.
26. Spahn JM, Reeves RS, Keim KS, Laquatra I, Kellogg M, Jortberg B, Clark NA. State of the evidence regarding behavior change theories and strategies in nutrition counseling to facilitate health and food behavior change. *J Am Diet Assoc* 2010;110:879–91.
27. Carter-Edwards L, Østbye T, Bastian LA, Yarnall KS, Krause KM, Simmons TJ. Barriers to adopting a healthy lifestyle: insight from postpartum women. *BMC Res Notes* 2009;2:161.
28. Burke LE, Wang J, Sevick MA. Self-monitoring in weight loss: a systematic review of the literature. *J Am Diet Assoc* 2011;111:92–102.
29. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Med Sci Sports Exerc* 1998;30:975–91.
30. Forsum E, Kabir N, Sadurskis A, Westerterp K. Total energy expenditure of healthy Swedish women during pregnancy and lactation. *Am J Clin Nutr* 1992;56:334–42.
31. Dewey KG, Lovelady CA, Nommsen-Rivers LA, McCrory MA, Lönnerdal B. A randomized study of the effects of aerobic exercise by lactating women on breast-milk volume and composition. *N Engl J Med* 1994;330:449–53.
32. Lovelady CA. The impact of energy restriction and exercise in lactating women. *Adv Exp Med Biol* 2004;554:115–20.

