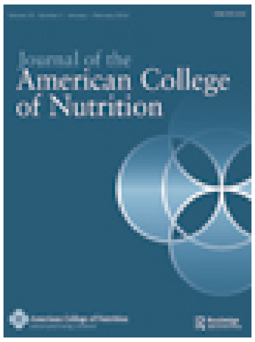

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Low-Income, Overweight and Obese Mothers as Agents of Change to Improve Food Choices, Fat Habits, and Physical Activity in their 1-to-3-Year-Old Children

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Original Research

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Deborah M. Klohe-Lehman, PhD, RD, Jeanne Freeland-Graves, PhD, RD, Kristine K. Clarke, PhD, MPH, RD, Guowen Cai, PhD, V. Saroja Voruganti, PhD, Tracey J. Milani, PhD, Henry J. Nuss, PhD, J. Michael Proffitt, PhD, Thomas M. Bohman, PhD

Division of Nutritional Sciences (D.M.K.-L., J.F.-G., K.K.C., G.C., S.V., T.J.M., H.J.N., J.M.P.), Addiction Research Institute, Center for Social Work Research (T.M.B.), University of Texas at Austin, Austin, Texas

Key words: mothers, children, obesity, prevention, intervention, low-income

Objective: To examine the effects of a weight loss program for mothers on the diet and activity of mothers and their 1–3 year old children.

Design: Overweight and obese mothers participated in an 8-week weight loss intervention encompassing diet, physical activity, and behavioral modification. Anthropometrics, demographic, dietary, and physical activity questionnaires were administered at weeks 0 and 8; anthropometrics were re-evaluated at week 24.

Subjects: Mothers (N=91) of a 1–3 year old child; body mass index (BMI) $\geq$ 25 kg/m^2; non-breastfeeding; age 18–45 years; income $<$ 200% of federal poverty index; Hispanic, African American, or white; and English-speaking were recruited from Special Supplemental Program for Women Infants and Children (WIC) and public health clinics.

Intervention Measures of Outcome: Weight loss in mothers and improvements in diet (reduction in calories, fat, snacks/desserts, sweetened beverages, and increases in fruit, vegetables) and activity in mothers and children.

Results: Weight loss in mothers was modest (−2.7 kg, $p < 0.001$) and sustained at week 24 (−2.8 kg, $p < 0.001$), and children gained in height and weight as expected for normal growth ($p < 0.001$). Initial energy intakes of children exceeded Estimated Energy Requirements (123%) and were reduced to acceptable levels post-intervention (102%, $p < 0.001$); additional beneficial changes in children's diets were decreased total (47.7 to 39.9 g/day) and saturated fat (19.2 to 16.6 g/day), high-fat snacks/desserts (1.6 to 0.9 servings/day), added fats (81.8 to 40.9% using), sweetened beverages (0.8 to 0.4 servings/day), and fast food consumption (11.6 to 6.6% of meals), and increased home-prepared meals (63.2 to 71.6% of meals) ($p < 0.01$ for all). Physical activity scores improved by 7% in children ($p < 0.05$). Comparable changes in food choices and activity also were seen in mothers.

Conclusion: Offering weight loss classes was a successful method of enticing low-income women to participate in an educational intervention that benefited their children. Overweight and obese mothers who modified their food choices and fat habits made comparable changes for their child.

INTRODUCTION

Pediatric obesity is paralleling the epidemic of obesity in adults. Of particular concern is the prevalence of overweight among infants (11%) and overweight/at risk in 2–5 year olds (22%) [1,2]. These rates are disproportionately higher in 0–23 month old African American [2] and 2– 5 year old Hispanic [1] children. Obesity is often more pronounced in low socioeconomic

Address reprint requests to: Jeanne Freeland-Graves, PhD, RD, The Bess Heflin Centennial Professor, Division of Nutritional Sciences, 1 University Station, A2700, The University of Texas at Austin, Austin, TX 78712. E-mail: jfg@mail.utexas.edu

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populations [3,4], and the increase in overweight has become a major nutritional problem in low-income, preschool children [5,6]. The main concern over child obesity is its associated co-morbidities, including hypertension, insulin resistance, and type 2 diabetes [7,8], as well as adverse social consequences [9,10].

Interventions should be initiated early in life, as food habits are formed at a young age [11] and excess weight becomes more difficult to treat as one becomes older [12]. Mothers should be the focus of interventions for childhood obesity, as they are the primary providers of food. Also, maternal body mass index (BMI) is a significant predictor of pediatric BMI in low-income, preschool children [13–15]. Thus, interventions in families with overweight and obese mothers are critical for preventing obesity in the child. Among all ethnicities, women of low-socioeconomic status are 50% more likely to be overweight [16] than those from higher incomes; however, the majority of weight loss programs are not designed for low-income mothers. Consequently, a great need exists for interventions tailored to this population.

Two studies have been conducted that involved weight loss in parents for the *prevention of obesity* in children [17,18]. The study by Epstein and colleagues [17] included 30 at-risk, non-obese 6–11 year olds with an obese parent. The 6-month intervention was delivered to both parents and children who were assigned to the following groups: (1) increase fruit and vegetables or (2) decrease high-fat/high-sugar group. At 1-year, anthropometric and dietary changes were more pronounced in the parents than the children. High-fat/high-sugar foods decreased for all groups; but the increase in fruits and vegetables was only significant in mothers in group 1. It appears that positive messages were more effective for improving diet and weight.

In 2003 Harvey-Berino and Rourke [18] pilot-tested the effectiveness of a 16-week obesity prevention program in overweight Native American parents of children 9-months to 3-years old (N = 40) who were participating in WIC. Parents were divided into two instructional groups: (1) parenting support or (2) obesity prevention plus parenting support. The "obesity prevention" component emphasized skills for improving eating and exercise behaviors in children. Parents in both groups slightly decreased their weight, but not significantly. Weight-for-height z-scores and energy intake of the children in the obesity prevention plus parenting support group declined, as compared to a slight increase in the parenting support alone group ($p=0.06$).

Numerous other studies have targeted parents for weight loss and role modeling, in combination with *obesity treatments* in older children [19–26]. Golan and colleagues [19,20] conducted an obesity treatment program among 60 obese 6–11 year olds who had at least one obese parent. Child weight loss was greater when parents were educated exclusively than when the child was treated alone. It was concluded that parents could act as agents of change to foster healthful behaviors in their children. A conceptual model for the familial approach to child obesity treatment was presented by Golan and colleagues [21]. In a study of 142 obese 8- to 12-year-old children and their parents participating in a family-based weight control program, parents with the greatest z-BMI change had children with greater z-BMI changes as compared to children with parents who lost less weight [22]. Similar results have been reported by other researchers who provided family-based obesity treatments [23–26]. The results from these studies indicate that when parents role model healthful behaviors their children are more likely to engage in similar behaviors. However, these programs differed from ours as the children in the present intervention were not undergoing obesity treatment.

Still others have developed programs for children without encouraging weight loss in the mother. These include obesity prevention for 3–4 month olds [27], cardiovascular disease risk reduction for 7–36 month olds [28], obesity treatment for 3–6 year olds [29], and fruit and vegetable promotion for 1–5 year olds [30–33]. These studies indicate that education of the parents improved consumption of fruits, vegetables, and low-fat foods; increased physical activity; and reduced television viewing in the children. Collectively, these interventions suggest that mothers can be agents of change for promoting healthy lifestyles in young children.

To date no studies were found in the literature that promoted weight loss in low-income, overweight and obese Hispanic, African American, and white mothers of 1–3 year old children as agents of change for their child. The purpose of this study is to examine the influence of a weight loss program on the diet and activity of these women their children.

MATERIALS AND METHODS

Design

Low-income, tri-ethnic overweight (BMI $\geq$ 25 kg/m^2) or obese (BMI $\geq$ 30 kg/m^2) mothers (N = 91) participated in an 8-week weight loss intervention. Main outcome measures were weight loss in mothers and improvements in diet (reduction in calories, fat, snacks/desserts, sweetened beverages, and increases in fruit, vegetables) and activity in mothers and children. Subjects were measured for height and weight at weeks 0, 8, and 24 (follow-up). Mothers completed demographic and dietary questionnaires [24-hour recalls, 2-day diet records, and food frequency questionnaires (FFQs)] for themselves and their child at weeks 0 and 8. Activity was assessed in children via a Toddler Behavior Assessment Questionnaire (TBQ). [34] and in mothers with pedometers worn for 3-day intervals at weeks 0 and 8.

Subjects

A convenience sample of mother-child pairs were recruited from WIC and public health clinics. Mothers with a healthy 1–3 year old child, BMI $\geq$ 25 kg/m^2, combined family income <

200% of federal poverty level, age $\geq$ 18 years old, literate in English, and not breastfeeding significantly (<5 minutes/day) were included in the study. Subjects were informed of the benefits and risks and informed consent was obtained. The Institutional Review Board of The University of Texas at Austin approved the protocol.

Determination of Weight Status

Height and weight in mothers and children were measured using a stadiometer (Perspective Enterprises, Portage, MI) and a calibrated digital scale (Model HS-100-A, Fairbanks Scales, St. Johnsbury, VT). Recumbent length was measured for children < 2 years. The child was placed lying on his/her back on a flat table with a tape measure securely adhered to the surface. Two trained people aided, one to hold the head of the child straight against a headboard, and the second to align the legs and position the feet at a 90° angle to the leg. A mark was placed on the tape measure at the bottom of the heel.

Height and weight (kg/m^2) were used to calculate BMI in mothers and children $\geq$ 2 years. In children $\geq$ 2 years old, BMI-for-age percentile levels were determined using Centers for Disease Control and Prevention (CDC) growth charts [35]. Weight classifications included: underweight, < 5^{th} percentile; normal weight, $\geq 5^{th}$ and < 85^{th}; at risk for overweight, $\geq 85^{th}$; and overweight/obesity, $\geq 95^{th}$. In children < 2 years old, weight-for-length was used, and children < 5^{th} percentile were classified as underweight; 5^{th}–95^{th}, as normal weight; and > 95^{th}, as overweight.

Demographic/Health Status

A 40-item general questionnaire contained information on age, income, education, ethnicity, parity, childbirth, and employment status [36]. Additional questions added specifically for this study included infant birth weight and length, notation of any minor obstetrical complications, Medicaid insurance status, and mother and child health histories.

Nutrient Intakes of Children

Nutrient intakes of the children were calculated using an average of three days of intake (one 24-hour recall and 2-days of diet records) for children as recorded by mothers. A trained registered dietitian administered the 24-hour recalls. Strategies to improve accuracy included the use of measuring utensils and food models to determine portion sizes and provision of detailed instructions for completion of an additional 2 days of food records (one week day and one weekend day). The diet records were reviewed/clarified with the subject to ensure completeness. Data from the recall and records were analyzed using Food Processor 7.71 (ESHA Research, Version 7.81, 2001).

Nutrients were adjusted using Software for Intake Distribution Estimation [37], as recommended by the Institute of Medicine [38]. This program removes within-person variance in nutrient intake to obtain better estimates of long-term, usual intake. Nutrient data does not include that from supplements, as we were interested in the nutrient intake from food sources alone. Also, only 10% of mothers gave their child supplements on a regular basis.

Estimated Energy Requirements (EERs) for children were based on age- and gender-specific equations that provided for energy balance, plus a factor for growth [39]. The proportion above/below the Acceptable Macronutrient Distribution Ranges (AMDRs) for % energy from macronutrients was determined. For nutrients with an Estimated Average Requirement (EAR), the EAR cut-point method identified the proportion with intakes below the EAR [38]. The Adequate Intake (AI) criteria were used for nutrients without an EAR. Vitamin A intakes (RE) were compared to the previous 1989 Recommended Dietary Allowances (RDAs) [40], as retinol activity equivalents (RAEs) from the dietary software were unavailable.

Food Choices of Mothers and Children

Food frequency questionnaires (FFQs) developed and validated for a tri-ethnic population of adults [41] and 1–3 year old children [42] determined servings/day of foods and food groups. Both FFQs were derived from the Health Habits and History Questionnaire [43], but were modified to include ethnic foods, low-fat foods, restaurant/fast foods, and supplements. The child FFQ, completed by the mother, was further modified to include age-appropriate foods and portions. Mean coefficients were 0.73 and 0.69 for reliability, and 0.45 and 0.41 for validity, in the mother [41] and child [42] FFQs, respectively.

Frequency was determined via a nine-point response scale ranging from "never or < once per month" to "2 + servings per day" for food items. Subjects were asked to identify the portion size consumed based on fractions of a medium serving, with a small serving designated as 1/2 the medium; a large, 1 1/2 times the medium; and an extra large, 2 times the medium serving. The FFQs were checked by a registered dietitian to ensure accuracy. Fractions of servings/day from the frequency responses were calculated and multiplied by the serving size (as a multiple of a medium serving). Food items with similar nutrient profiles were summed to determine total food group servings/day.

Physical Activity in Mothers

Mothers wore pedometers at weeks 0 and 8 (Model AE170, Accusplit, San Jose, CA) for 3 days (2 week days and one weekend day) to assess physical activity. The Accusplit AE170 model is the Yamex Digiwalker SW-701 sold with a different manufacturer's label. The Yamex Digiwalker SW-701 has been shown to be accurate [44] and to exhibit validity as evidenced by significant correlations with steps during walking ($r = 0.84$) and VO_2 max ($r = 0.75$) [45]. These pedometers do not need to be calibrated. Mothers recorded number of steps, calories burned, and time the pedometer was worn. Only the step data will be presented in this paper.

Physical Activity in Children

The activity scale of the Toddler Behavior Assessment Questionnaire (TBAQ) was used to determine activity in the children and was completed by the mother [34]. The full questionnaire (108 items) consists of several temperament scales, one of which is the 7-item activity scale used in this study. Cronbach's α for the activity scale was 0.71, and this scale has been validated in parents of toddlers [34]. The definition of activity level used in the TBAQ was "limb, trunk, or locomotor movement during a variety of daily situations, including free play, confinement, or quiet activities." The 7-point response options had values ranging from 1 (never) to 7 (always observed the behavior during the last two weeks), with a "does not apply" option available. Item values were summed and divided by total number of items with responses for a total score. Higher numbers designate greater activity.

Weight Loss Program

Registered dietitians taught eight weekly two hour classes that included a 15 minute weigh-in, 1 1/4 hour discussion and activities, and 30 minutes of low- to moderate-intensity exercise. The program promoted nutritious food choices and lifestyle changes for good health and weight loss in mothers, with additional components of behavioral modification and physical activity. Child care was available at the classes but transportation to/from the sessions was not. Classes ranged in size from two to 10 mothers.

Design for the weight loss program was grounded in basic concepts of the Social Cognitive Theory (SCT) (Fig. 1). Its premise is that an individual's health behavior can be attributed to an interaction of his/her cognitions, behaviors, and environment, and modification of any of these components will alter the individual's behavior [46]. Objectives of the interventions

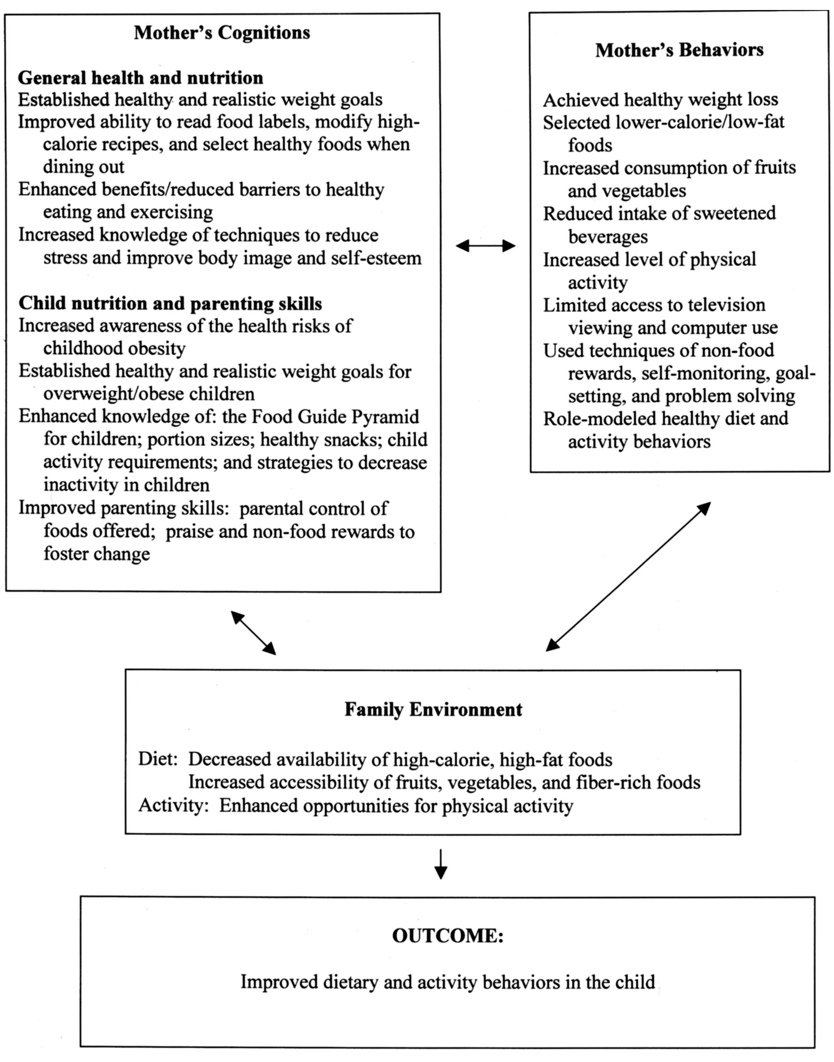

Fig. 1. Conceptual model for the prevention of child obesity using mothers as agents of change.

can be divided into two major categories: change in mother's cognitions and behaviors. Enhanced knowledge of general health, nutrition, and parenting skills should enable the mother to make behavior changes that affect the home environment to positively influence the child's diet and activity behaviors.

Cognitive-behavioral strategies used included self-monitoring, stimulus control, and contingency management. Self-monitoring techniques consisted of diet records and pedometers to measure steps/calories expended in activities. Participants identified triggers and alternatives to unhealthy eating (stimulus control). Prizes were given for obtaining goals and participants were encouraged to reward themselves for achievements (contingency management). Additional techniques included goal-setting, individualized feedback, parenting and coping skills, and relapse prevention.

The dietary component utilized well-balanced eating plans, discussion of health benefits of foods and nutrients, and development of culturally-sensitive meal planning skills. Interactive components were low-fat cooking demonstrations, modification of recipes, and the sharing of strategies found to be effective for weight loss. The Food Guide Pyramid and serving sizes for adults and children were taught with colorful handouts [47,48].

The relationship of physical activity to weight and methods to increase frequency/type were incorporated into most classes. In class physical activities included 30 minutes of walking, stair-climbing, exercise videos, and resistance exercises with light weights. Activities to share with their children also were discussed.

Prior to administration of the program, a focus group was conducted with 10 low-income, tri-ethnic mothers of young children. Mothers provided feedback on the proposed class topics and weight loss techniques.

Program Evaluation

A 23-item program evaluation form was administered at week 8. The form was developed specifically for use following this intervention and contained 18 questions to evaluate the usefulness of the class topics and techniques to promote weight loss. Response options were based on a 5-point scale, ranging from 1 ("strongly agree" or "very useful") to 5 ("strongly disagree" or "not useful/did not use"). Five additional open-ended questions were included for participants to describe aspects of the program and/or instructor's teaching that they liked most/least, as well as recommendations for improvement of the program or instructor's teaching effectiveness.

Statistical Analysis

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS 11.5, Chicago, IL, 2003). Frequencies, medians, and means were computed for descriptive purposes, and data examined for outliers and normality. Analysis of variance determined significant differences in continuous variables (i.e. age, BMI) by categorical variables (i.e. ethnicity, weight status). Paired-sample t-tests measured significant differences pre-post for continuous variables (i.e. nutrients, food items, food groups, and activity scores). Spearman correlations examined the relationship between mother and child change variables. Pearson correlations identified associations between consumption of select food groups (i.e. high fat foods, fast foods, sweetened beverages) and nutrient intakes or child's weight.

Additional analyses were conducted to examine the effects of demographic covariates (ethnicity, family income, mother's education level, mother's history of employment, mother living with spouse or partner, and age of mother and child) on the main outcome measures. Pre-post change variables (post minus pretest score) were computed for each outcome measure. Relationships between the outcome change variables and potential covariates were evaluated using univariate analysis of variance. The majority of outcome change variables were not affected by the covariates. Outcomes that were significantly related to a covariate are presented in the text.

RESULTS

Of the 235 mothers completing the first class, 106 finished the 8-week intervention (attended at least 7 of 8 classes and both pre- and post-study visits). An additional 15 subjects were excluded from the final analyses due to breastfeeding ($n = 10$) or failure to return all questionnaires ($n = 5$). Thus, the final sample size was 91. Factors influencing attrition in this program included lack of transportation, time, childcare, and family support; illness or death; work and family responsibilities; holidays; and stress. Drop-outs did not differ from intervention subjects in anthropometrics or demographics, but were more likely to be single ($p < 0.05$) and to have never worked ($p < 0.01$).

The 91 participants were tri-ethnic (62.6% Hispanic, 22.0% African American, and 15.4% white), obese (75.8%) and overweight (24.2%) mothers of 1–3 year olds. The most frequently reported income and education levels were $15,000–$29,999 (51.6%) and partial college (35.2%), respectively. Only 17.6% exclusively breastfed their child during infancy; 29.7% fed formula and 52.7% provided a combination. The mean age of the children was 2.1 years, with approximately equal numbers of boys and girls. According to CDC growth charts, 24% of 1-year olds were overweight, and 19.5% of 2–3 year olds were overweight (7.3%) or at risk (12.2%).

Following the 8-week intervention, mean weight loss in mothers was -2.7 ± 2.8 kg ($p < 0.001$), and mean BMI was reduced from 34.9 kg/m^2 to 33.9 kg/m^2 by week 8 ($p < 0.001$). This weight loss was sustained at week 24 (mean $= -2.8 \pm 4.9$ kg, $p < 0.001$; mean BMI $= 34.1$ kg/m^2). As expected for normal growth, the children gained slightly in height ($p <$

0.001) and weight ($p < 0.001$) during this study. Mean weight-for-height percentile levels for 1-year olds were 66, 66, and 74th percentiles at weeks 0, 8, and 24, respectively. The increase by week 24 was not significant ($p = 0.366$). Mean BMI-for-age percentile levels for 2–3 year olds were 56, 60, and 69th percentiles at weeks 0, 8, and 24, respectively. The increase by week 24 was significant ($p < 0.001$). Mothers with less than a high school education were more likely to have a child whose BMI-for-age percentile decreased (x = −12.4th percentile) than mothers with partial college (x = 11.2th percentile, $p < 0.01$) or college education (x = 8.0th percentile, $p < 0.05$), whose children experienced increases in BMI-for-age percentiles from week 0 to week 8.

Table 1 displays changes in macronutrient intake of children following the intervention in their mothers. At week 0, energy intakes were above the Estimated Energy Requirements and decreased significantly by week 8. Total fat intake declined; however, the reduction in saturated fat was significant only in 2–3 year olds. For other macronutrients, the majority of the sample was within the Acceptable Macronutrient Distribution Ranges. Mean fiber intake was less than the Adequate Intake.

The percentage of children meeting the Estimated Average Requirements (EARs) for select nutrients pre- and post-weight loss intervention in mothers is shown in Fig. 2. The percentage of children below the EARs at baseline was considerable for vitamins E (74.7%) and A (29.7%) and folate (22%). The percentage of children below the EAR at post-intervention did not change significantly for any nutrient. Vitamin D was less than the AI (~95%) and calcium was above (~151%) at both pre- and post-intervention. Nutrient data of the mothers are presented in a manuscript by Clarke and colleagues [Clarke KK, Freeland-Graves JH, Klohe-Lehman DM, Cai G, Voruganti VS, Proffitt JM, Hanss-Nuss H, Milani TJ, Bohman TM. A weight loss program for low-income mothers impacts their nutrition attitudes and dietary intakes. Manuscript submitted for publication.].

Table 2 displays food group servings/day from the FFQs. Following the weight loss intervention in mothers, intakes of breads, fruits/fruit juices, meats, snacks/desserts, and sweetened beverages declined in children. Vegetable and grain consumption were below Food Guide Pyramid recommendations (~58% and 45%, respectively). Although there was a significant decrease in vegetables post-intervention, this decline was negated when fried potatoes were excluded from the analysis. Mother's age was related significantly to change in child's vegetable intake. Younger mothers were more likely to have children who increased their consumption of vegetables, excluding fried potatoes ($r = -0.23$, $p < 0.05$). In addition, mothers who had never been employed had children with greater increases in fruit servings than those who had been, or were currently, employed (0.3 servings/day versus −0.6 servings/day, $p < 0.05$). Younger children also were more likely to increase fruit intake at week 8 than older children ($r = -0.34$, $p < 0.01$). Servings of snacks/desserts and

Table 1. Macronutrient Intake of Children Pre- (Week 0) and Post- (Week 8) Weight Loss Intervention in Mothers as Determined by 24-Hour Recall and 2-Day Diets

Nutrient	EAR, AI, or (AMDR)[b]	Macronutrient intake[a]			
		1 year olds[c]		2–3 year olds[d]	
		Week 0	Week 8	Week 0	Week 8
Energy (kcals)	917–1015; 1306–1398[e]	1151–1271[f]	1028–1038[f]***	1354–1620[g]	1181–1400[g]*
Carbohydrate (g) (% EN[h])	**100** (45–65)	141 (51)	126* (51)	200 (55)	163*** (54)
Protein (g) (% EN)	**11**[i] (5–20)	43 (15)	41 (17*)	51 (14)	49 (16***)
Fat (g) (% EN)	ND[j] (30–40)	43 (35)	38* (34)	53 (32)	43** (31)
Saturated fat (g)	ND	19	16	20	17*
Cholesterol (mg)	ND	175	179	186	186
Fiber (g)	19*	7	8	10	10

[a] Mean intake.
[b] Estimated Average Requirements (EARs) in **bold type**; Adequate Intakes (AIs) in ordinary type followed by an asterisk (*); Acceptable Macronutrient Distribution Ranges (AMDRs) in parentheses for carbohydrate, protein, and fat.
[c] N = 50.
[d] N = 41.
[e] Estimated energy requirement (EER) for 1–2 year olds = 917 kcals (girls) and 1015 kcals (boys); 3 year olds = 1306 kcals (girls) and 1398 kcals (boys).
[f] Mean energy intake for 1–2 year old girls and boys.
[g] Mean energy intake for 3 year old girls and boys.
[h] %EN = percent of total energy intake.
[i] 0.88 g/kg, based on mean weight of 12.8 kg.
[j] ND = not determined.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ for significant differences from week 0.

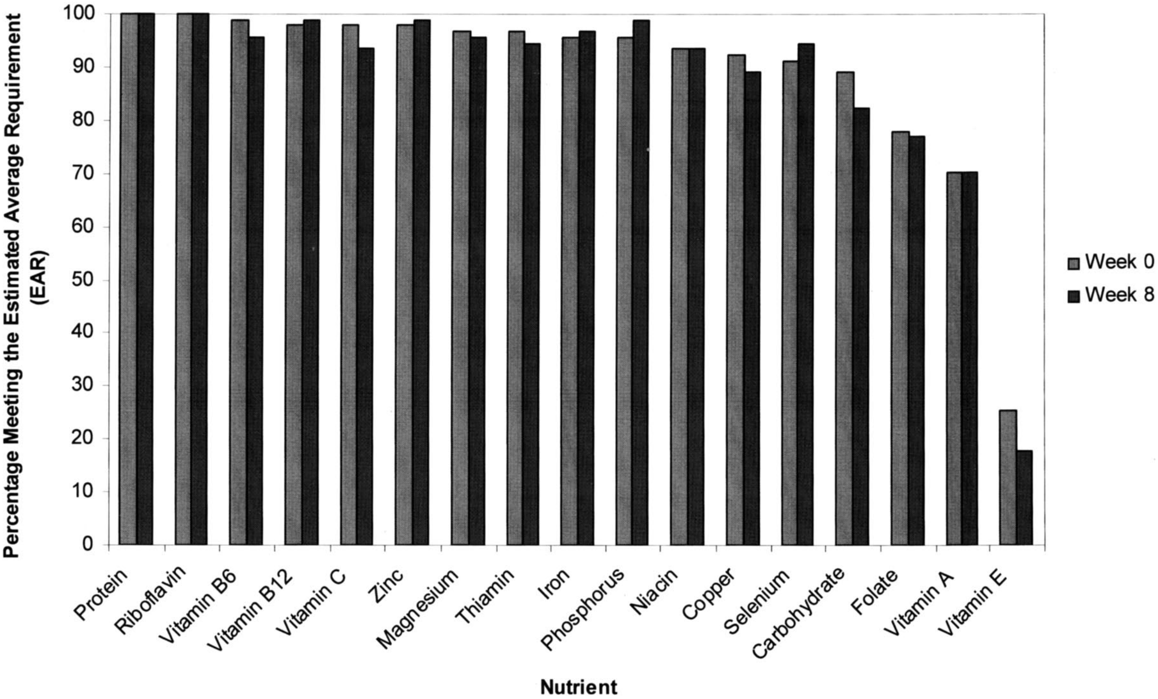

Fig. 2. Percentage of children meeting the Estimated Average Requirements (EARs) for select nutrients pre- (week 0) and post- (week 8) weight loss intervention in mothers.

sweetened beverages decreased by approximately half at post-intervention.

Changes in food group servings of children were similar to those in their mothers' diets, with the exception of low-fat dairy, fruit juices, and high-fat snacks/desserts (Table 2). These relationships remained when controlled for demographic co-variates. Fig. 3 illustrates the significant changes in individual foods in the mother's and child's diets.

At post-intervention, mothers used more non-fat cooking spray (from 19.7% to 68.2% using, $p < 0.001$), or low-fat/

Table 2. Servings Per Day of Food Groups Pre- (Week 0) and Post- (Week 8) Intervention and Correlations as Determined by the Food Frequency Questionnaire[a]

Food category	Mean servings of food groups per day				Mother-Child Correlation[b]
	Week 0		Week 8		
	Mother	Child	Mother	Child	
Bread, cereal, rice, and pasta	3.4 ± 2.5	3.1 ± 2.3	1.6 ± 1.1***	2.3 ± 1.9***	0.33**
Dairy	1.9 ± 1.6	2.9 ± 2.0	1.2 ± 0.9***	2.6 ± 1.7	0.27*
Regular dairy	1.6 ± 1.8	2.7 ± 2.1	0.7 ± 0.8***	2.3 ± 1.8	0.40***
Low fat dairy	0.2 ± 0.4	0.3 ± 0.6	0.4 ± 0.5*	0.3 ± 0.7	0.01
Fruits and fruit juices	2.6 ± 1.9	3.2 ± 2.4	2.3 ± 1.8	2.3 ± 1.9***	0.17
Fruits	1.8 ± 1.5	2.1 ± 1.7	1.9 ± 1.7	1.6 ± 1.5*	0.34**
Fruit juices	0.8 ± 0.8	1.0 ± 0.8	0.3 ± 0.4***	0.6 ± 0.6***	0.05
Meat, poultry, fish, beans, eggs	3.5 ± 2.9	2.6 ± 2.1	2.2 ± 1.4***	2.1 ± 1.8*	0.34**
Snacks, desserts, condiments, spreads: High fat	2.5 ± 2.2	1.6 ± 1.6	0.6 ± 0.6***	0.9 ± 0.8***	0.16
Snacks, desserts, condiments, spreads: Low fat	0.4 ± 0.4	0.9 ± 1.0	0.4 ± 0.4	0.7 ± 0.9*	0.28**
Sweetened beverages[c]	1.6 ± 1.5	0.8 ± 0.9	0.7 ± 1.0***	0.4 ± 0.5***	0.42***
Vegetables	3.6 ± 2.8	1.9 ± 1.5	3.3 ± 2.4	1.6 ± 1.2*	0.43***
Vegetables, excluding fried potatoes	3.3 ± 2.8	1.7 ± 1.4	3.2 ± 2.5	1.5 ± 1.2	0.43***

[a] N = 91.

[b] Spearman correlation between change in mother's food group servings and change in child's food group servings.

[c] Includes fruit drinks, sodas, ades, and sweetened teas.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ for significant differences from week 0 and for significant correlations.

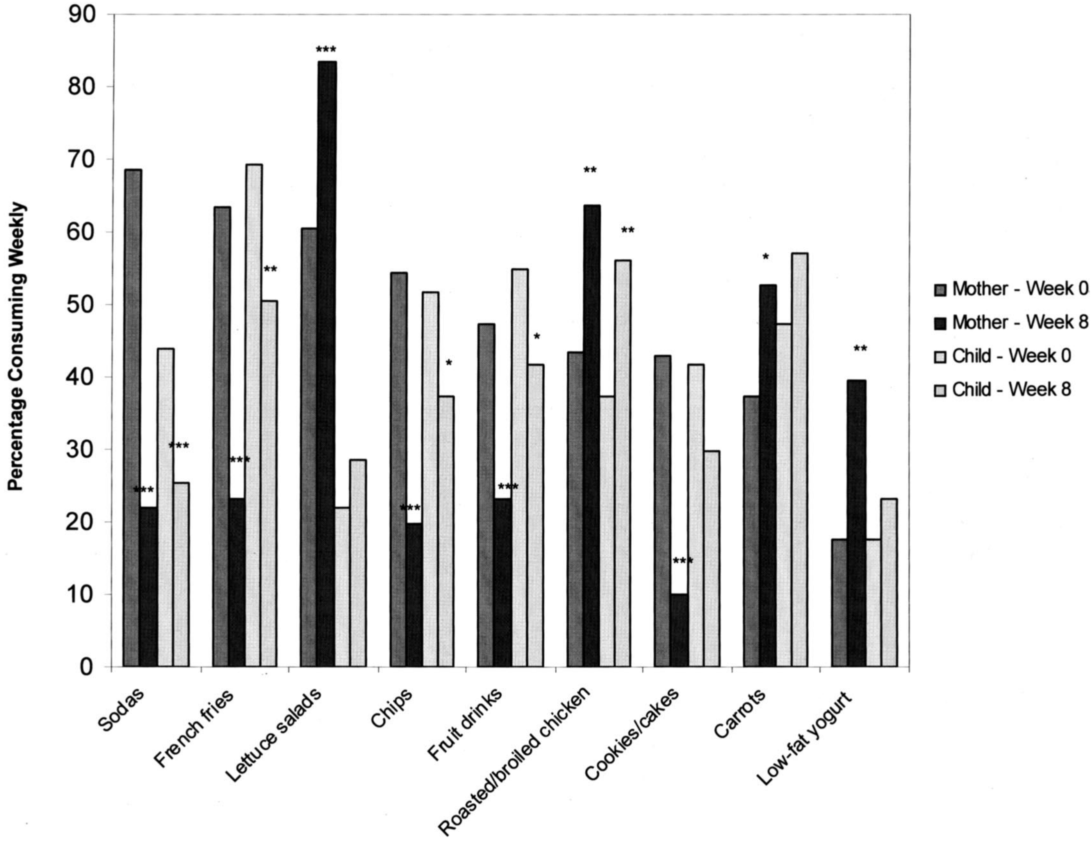

Fig. 3. Pre (week 0) - post (week 8) changes in mother and child consumption of select food items. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$ for significant differences at week 8.

monounsaturated fats in cooking foods for their child (from 28.8% to 63.6% using, $p < 0.01$), and less other fats (from 81.8% to 40.9% using, $p < 0.001$). Mothers and children also were less likely to eat from fast food restaurants (from 13.9% to 7.7% of meals, $p < 0.001$) and more likely to prepare meals at home (from 60.9% to 71.8% of meals, $p < 0.01$). Fast food consumption by children was related positively to energy ($r = 0.21$, $p < 0.05$) and sodium ($r = 0.24$, $p < 0.05$), and inversely to calcium ($r = -0.24$, $p < 0.05$) and vitamin D ($r = -0.33$, $p < 0.01$); however, fast foods were not associated with child weight ($r = -0.12$, $p = 0.254$).

The activity level of both mothers and children increased at post-intervention (Table 3). Overall activity was not related within mother-child pairs. By week 8, boys were more active than girls, and 1-year-olds and overweight/at risk children enhanced their activity level significantly.

The weight loss program was rated favorably by the participants. All mothers (100%) "strongly agreed" or "agreed" that the classes were well-organized and taught at an appropriate level; the instructors communicated information effectively; and they learned a great deal. Weekly weigh-ins, in-class exercise, and wearing the pedometers were given the highest scores, with 99%, 98%, and 96%, respectively, of participants rating each of these as "useful" or "very useful." Maintaining food records and following menus or meal plans were slightly less useful, with 89%, 86%, and 82% ratings, respectively. Mothers identified as "useful" all class topics. When asked what they liked most via open-ended questions, responses included: the group support and discussion, weigh-ins, in-class exercise, and cooking demonstrations. Specific recommendations to improve the program included: lengthen program duration and offer additional child care.

Table 3. Physical Activity Pre- (Week 0) and Post- (Week 8) Intervention in Mothers and Children

Category	N	Week 0	Week 8
Mothers[a]	84	6024	9869***
Children[b]	87	4.2	4.5*
Boys	43	4.4	4.7[t]
Girls	44	4.0	4.2[t]
1 year olds	46	3.9[t]	4.3**
2–3 year olds	41	4.5[t]	4.6
Healthy weight[c]	67	4.3	4.4
At risk/overweight[c]	20	4.0	4.8***

[a] Three-day average of steps as measured via pedometers.
[b] Based on the activity scale of the Toddler Behavior Assessment Questionnaire [Source: reference 34]. Maximum score possible is 7.
[c] Controlled for child's age and sex.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ for significant differences from week 0.
[t] $p < 0.05$ for significant differences between categories with same superscript.

DISCUSSION

This study suggests that mothers can act as positive agents of change to improve dietary behaviors in their 1–3 year olds. Mothers who modified their food choices and fat habits made comparable changes for their child. In this study the child's diet improved, in terms of reduced calories, fat, sweetened beverages and fast food consumption, and increased home-prepared meals. Others have reported correspondence between mother and child for nutrient intakes [49,50] and food preferences [51–54]. Although activity levels of both mother and child increased overall, they were not related, indicating mothers may not serve as agents of change for their child's activity at this young age.

In a similar pilot study of obesity prevention in Native American preschool children [18], calorie consumption also decreased. In their obesity prevention program, energy intakes of children's diets diminished by 26%, as compared to declines of 16% and 9% in our overweight/at risk and healthy weight children, respectively. Reduced energy intakes among children in this study were warranted, as 22% were overweight/at risk, and the final caloric intakes remained at, or slightly above, the Estimated Energy Requirements.

Total/saturated fat diminished post-intervention, but total fat remained within the recommendation of 30–40% of energy for children, presumably due to substitution of high-fat snacks/desserts, fast foods, and added fats with lower-fat choices. The problem with consumption of high-fat foods early in life is that it may lead to a learned preference [55] and contribute to cardiovascular disease risk and obesity. Several investigators have reported a positive relationship between total/percent energy from fat and child fatness in preschool [56–59]. Thus, interventions should promote moderation of total fat to 30–40% of energy and balance of high- and low-fat foods in diets of children.

Our program was successful at curtailing the intake of sweetened beverages. Excessive amounts of these beverages have been linked to obesity in school-age children and adults [60–62], but there was no association to obesity in our sample of 1–3 year olds or in a study of 2–5 year olds by Newby and colleagues [63]. This lack of association may be due to the young age, as intakes of sweetened beverages may be limited. For example, frequency of sweetened beverages was lower in this investigation (2.4 oz/day) and that by Newby and colleagues [63] (3.1 oz/day), both of which used FFQs, as compared to Rampersaud and colleagues [64] who utilized 24-hour recalls (5.7 oz/day). Although the link to obesity at this age may not be apparent, sodas/fruit drinks/ades could displace more nutritious beverages [65,66].

One behavioral change observed was consumption of more home-prepared meals, with fewer visits to fast food restaurants, in both mother and child. These modifications should improve nutritional adequacy of diets, a fast foods are associated with excess calories and fat, and less milk, fruit, and vegetables [67,68]. Also, home-prepared meals have been reported to be more nutritious [69,70].

The most frequently eaten foods by our children were analogous to other studies of 1–2 year olds in the Feeding Infants and Toddlers Study [71] and 1–3 year olds in the Continuing Survey of Food Intakes by Individuals [72]. Thus, the types of foods selected by toddlers do not appear to differ by socioeconomic status.

The small change in BMI of the mothers following the intervention is not surprising as others have reported similar weight loss among minority populations, including Sullivan and Carter [73] (0.2 kg), Mayer-Davis and colleagues [74] (1.2 kg), Domel and colleagues [75] (1.4 kg), Kumanyika and Charleston [76] (2.7 kg), and Kanders and colleagues [77] (2.9 kg). It was not the intent of this intervention to provide weight management for 1–3 year old children, but rather to measure child dietary and physical activity changes following a weight loss program in mothers. The children in this study remained within the same growth channel (50–75th percentile level), which is considered normal [78], and the percent of children overweight or at risk for overweight did not change significantly from week 0 to week 24. Our weight-for-height and BMI-for-age percentile changes are difficult to compare to the literature, as only one other obesity *prevention* study was found that measured percentile changes following an intervention in a similar age group [18]. In their study, weight-for-height z-scores decreased non-significantly in the obesity prevention plus parenting support group and increased non-significantly in the parenting support group at post-intervention. Although changes in weight-for-height, BMI-for-age, and percent overweight are common outcome measures in obesity prevention and treatment programs with older children [17,19,22–24], studies with preschool age children are more likely to target dietary improvements as main outcome measures instead [18,29,33].

It is interesting to note that mothers in the current study with lower education levels were more likely to have 2–3 year old children with BMI-for-age percentile decreases by week 24 than mothers with higher education levels, even though there were no significant differences in their initial BMI-for-age percentiles. Thus, mothers with the least education benefited most from the intervention as measured by decreases in their child's BMI-for-age.

Previous studies suggest that physical activity may protect against adiposity at a young age. For example, in a longitudinal study of 180 children, Crawford and Shapiro [79] found that physical inactivity was related to obesity as early as 6-months of age, and the association remained throughout childhood. Klesges and colleagues [58] documented that initial aerobic activity and increases in leisure exercises correlated negatively with BMI in a 3-year longitudinal investigation of 146 preschool children. As a consequence of our program, activity scores improved, particularly among overweight children, even after controlling for age-related developmental increases. In contrast, the intervention study by Harvey-Berino and Rourke [18] that targeted mothers did not find an increase in the activity levels of a similar age group of children. However, an accelerometer was used to assess activity; whereas, we used an activity scale whose limitations are recognized. Nonetheless, we believe that an emphasis on activity should be instituted at a young age to develop early patterns of active lifestyles.

In this study, overall physical activity was not related between mother-child pairs. Mothers who increased their activity did not necessarily have comparable improvements in their child's activity. This finding is similar to that observed in 3–5 years olds [80] and 5-year-old girls [81]. This association was positive only in older children 4–7 [82] and 7–12 years old [83]. Perhaps, parental activity is less influential at younger ages when children's activity levels are typically high.

Quantities of fruits, vegetables, and whole grains in the children's diets were sub-optimal throughout our program, despite intense efforts to encourage greater inclusion. We observed that mothers were more likely to eliminate foods deemed unhealthy, rather than to incorporate more nutritious choices. Presumably, the lack of improvement in vegetable intake of children was related to similar inadequacy in the mothers. Vegetable intakes have been reported to fall below Food Guide Pyramid recommendations in another study of ethnically diverse, low-income mothers [84]. Similarly, Epstein and colleagues [17] did not find an increase in fruits and vegetables in 6–11 year old, non-obese children with obese parents participating in a 6-month intervention to improve eating behaviors. In contrast, Koblinsky and colleagues [33] did document a rise in fruits and vegetables in 1–5 year old children following a nutrition education program for Head Start parents. Thus, immediate enhancement of fruit and vegetable consumption in children with mothers as role models may be challenging.

The large proportion of children with intakes of folate and vitamin E below the EARs may be attributed, in part, to inadequacies in the nutrient database for folate and vitamin E fortified foods. However, observation of the diet records revealed that the 1–3 year old children in this sample were not eating good sources of folate (i.e. spinach, broccoli, legumes, oranges) and vitamin E (i.e. vegetable oils, seeds, and nuts). In addition, the inadequacy of these nutrients from dietary sources was not ameliorated by supplements, as only 10% of the mothers gave their child vitamins/mineral pills on a regular basis. Quantities of these nutrients were comparable to, or slightly lower than, data reported by others [72,85–87].

The strengths of this study include a novel and timely approach to prevent obesity in 1– 3 year olds by using mothers as agents of change; multiple measures of food intake and activity; and a theoretically-based intervention. Limitations of the study are the short intervention and short follow-up and use of subjects as their own controls. A longer-term follow-up and re-evaluation of eating habits and anthropometrics is needed to examine the sustainability of the behavioral changes. In addition, it is conceivable that mothers may have biased their report of beneficial behavioral changes in their child at post-intervention; this possibility remains a challenge for studies relying on self-report data. These strengths and limitations should be considered when developing future studies of weight loss using low-income mothers as agents of change.

CONCLUSION

Targeting mothers as agents of change to improve dietary behaviors of their young children appears to be effective. Overweight and obese mothers who modify their food choices and fat habits will most likely make comparable alterations for their child.

The offer of a free weight loss class was a successful method of enticing low-income women to participate in an educational intervention that benefited their children. In the program evaluation, the most highly rated aspects were the interactive learning components (i.e., wearing pedometers, cooking demonstrations) and group support. Thus, obesity interventions should emphasize an abundance of hands-on activities, rather than just knowledge dissemination.

Effective strategies for the implementation of these weight loss interventions in public health settings are needed. Peer educators could be a feasible, cost-effective means for delivery of these programs in the community [88]. Provision of transportation and chid care could also improve retention.

One problem encountered was that some mothers focused more on eliminating foods considered to be unhealthy, rather than increasing more nutritious foods. Thus, emphasis should be placed on positive messages that stress inclusion of all foods in moderation, without labeling items as "good" and "bad" [89].

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