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Many women enter pregnancy already overweight or obese, and then gain weight in excess of what is recommended by the Institute of Medicine. Evidence shows that excessive weight gain during pregnancy can lead to higher postpartum weight retention. And postpartum weight retention is a significant risk factor for long-term weight gain. The aims of the current study were related to diet quality during the postpartum period. The first aim was to determine predictors of diet quality during the early postpartum period; the second aim was to determine whether mothers in a behavioral intervention program significantly improved their diet quality, reduced energy intake, and lost more weight compared to participants in the control group; and the third aim was to determine if diet quality during the early postpartum period predicted weight change from 6 to 16 months postpartum for overweight and obese postpartum women.

For the present study, data were used from 400 overweight/obese postpartum women enrolled in an intervention study that focused on reducing postpartum weight retention through healthier eating habits. Women randomized into the intervention group received monthly kits in the mail, motivational counseling, and were invited to attend one group educational session. Anthropometric measurements and 24-hour dietary recalls were collected at baseline and endpoint. Diet quality was analyzed using the Healthy Eating Index-2005 (HEI-2005).

Results indicated a suboptimal diet quality for these participants at baseline, with an average HEI-2005 score of 64.4. Factors that significantly predicted diet quality at baseline were infant feeding status, income, and BMI (r^2=0.20). After the intervention, both the intervention and control groups reported a decrease in energy intake (253 kcal and 236 kcal, respectively) and weight loss (1.9 (5.5) kg and 1.0 (5.3) kg, respectively). In addition, there were no significant differences in changes in diet quality between groups. Baseline dietary quality did not predict weight change from 6 to 16 months postpartum. However, total energy intake at baseline was a significant predictor of weight change, along with work status and breastfeeding duration/intensity. Total energy intake, rather than just diet quality, should be addressed in weight loss interventions for overweight/obese postpartum women.

DIET QUALITY AND WEIGHT CHANGE AMONG OVERWEIGHT AND OBESE POSTPARTUM WOMEN ENROLLED IN A BEHAVIORAL INTERVENTION PROGRAM

by

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CHAPTER I

INTRODUCTION

Obesity in the United States has reached alarming levels, with 34% of the population falling into this category [1]. One group that is at an increased risk for becoming overweight or obese is women of childbearing years. Gaining excessive weight during pregnancy and retaining weight after delivery are factors that contribute to weight gain in this population [2]. According to a recent report, an estimated 46% of women in 2004 gained more weight during pregnancy than what is recommended by the Institute of Medicine [3]. Evidence shows that excessive weight gain during pregnancy can lead to higher postpartum weight retention. The average weight retention during the postpartum period tends to be between 0.5 and 3 kg [4], although studies have concluded that 14%-25% of postpartum women retain more than 4.5 kg [5, 6]. This indicates that the amount of weight actually retained can be highly variable and some women may be more at risk for retaining the weight gained during pregnancy than others. Several risk factors have been identified for significant postpartum weight retention, including higher pre-pregnancy weight, excessive weight gain during pregnancy, smoking cessation during pregnancy, and not breastfeeding [4].

Rooney and Schauberger found that failure to lose excess pregnancy weight by 6 months postpartum was a significant predictor for long-term weight gain [2]. Their results showed that women who lost the weight that they gained during pregnancy by 6 months postpartum were only 2.4 kg heavier ten years later compared to 8.3 kg heavier for those who still had weight retention 6 months after giving birth [2]. Therefore, intervening during the postpartum period to help women lose the excess weight they gained during pregnancy may have a positive impact on long-term weight maintenance. One way to encourage weight loss with this population is by promoting the consumption of a healthy diet. The goal is that eating a healthy diet will be positively associated with weight loss during the postpartum period.

For the present study, data were used from 400 overweight and obese postpartum women who were enrolled in a behavioral intervention study focused on reducing postpartum weight retention through healthier eating habits. The women were randomized into either the intervention or control group. The women in the intervention group received monthly kits in the mail to encourage making healthier dietary choices. The women also received motivational counseling and were invited to attend one group educational session. The women in the control group received minimal care. At baseline and after the intervention period, anthropometric measurements were collected from the participants. Research staff also called the participants to collect two 24-hour dietary recalls at each time point.

To determine the effectiveness of the intervention, the dietary quality of each participant's diet at baseline and after the intervention period was analyzed. The Healthy Eating Index-2005 (HEI-2005) was used for this analysis, which is a tool used to assess the quality of an individual's diet based on the 2005 Dietary Guidelines for Americans

[7]. Since two days of dietary information were collected at baseline and endpoint for this study, an overall dietary quality score was calculated based on the average of the two days at each time point for all the participants.

The first aim of this study was to determine predictors of diet quality during the early postpartum period. The following variables were tested: age, body mass index (BMI), depression screen, education level, income, lactation status, marital status, maternal work status, parity, race, and smoking status. The hypothesis was that mothers with a lower BMI, are not depressed, are more educated, have a higher income, are currently breastfeeding, married, Caucasian, or are currently not working will have a higher diet quality score.

The second aim of this study was to determine whether mothers enrolled in a behavioral intervention program significantly improved the quality of their diet, reduced energy intake, and lost more weight from baseline to endpoint compared to the participants in the control group. It was hypothesized that the participants from the intervention group will have significantly improved the quality of their diet, reduced energy intake, and lost more weight from baseline to intervention, compared to the control group.

The third aim of the study was to determine if baseline diet quality, baseline energy intake, and lactation status predicted weight change from 6 to 16 months postpartum. The following variables were tested: group assignment (control or intervention), baseline kilocalories, baseline HEI-2005 score, baseline body weight, lactation score, household income, work status, race, parity, education level, age, smoking status, depression screen, and marital status. It was hypothesized that women who had a higher diet quality, consumed less energy, and who breastfed for a longer time/higher intensity would have lost the most weight.

This thesis will review literature that has examined dietary quality of postpartum women as well as literature that has described interventions aimed to reduce postpartum weight retention. Recent research that has used the Healthy Eating Index-2005 to measure diet quality will also be reviewed. Following the review of literature, a manuscript is included that reports the current study's methods, results, and discussion. Lastly, the tables, figure, and epilogue are included.

CHAPTER II

REVIEW OF THE LITERATURE

Dietary quality of postpartum women

The quality of a mother's diet may have an effect on weight retention during the postpartum period. However, few studies have examined the quality of mother's diets during the postpartum period. To address the quality of one's diet, food consumption is often compared to recommendations set forth by the government, such as the Food Guide Pyramid or Dietary Guidelines. The following information describes research that has investigated the diet quality of women during the postpartum period.

Fowles and Walker investigated the dietary quality of 100 women during the postpartum period [8]. For this study, all BMI classes were represented in the sample of predominantly white women. Women were asked to complete a short food frequency questionnaire (FFQ) that included questions about typical servings consumed of each of the food groups in the Food Guide Pyramid. Analyses were completed to compare the servings consumed to the recommendations of the Food Guide Pyramid. The authors considered the dietary quality to be healthy if the individual consumed the recommended servings for at least 2 of the 5 food groups in the Food Guide Pyramid. The results showed that only 44% of the women had a healthy diet quality. Overall, over half of the women consumed adequate servings of meat and milk (79% and 66% respectively), and half of the women consumed adequate fruit (51%). However, very few mothers ate the recommended servings for grains and vegetables according to the Food Guide Pyramid (14% and 24% respectively). The following variables were tested to determine whether they were related to dietary quality: gestational weight gain, attitude towards postpartum weight, age of baby at time of data collection, maternal age, number of children, maternal educational level, and employment status. The results showed that only breastfeeding was significantly positively correlated with healthy dietary quality ($p<0.0001$). Also, they reported that dietary quality was not related to postpartum weight retention 3 to 6 months after childbirth. Overall, this study illustrates that many postpartum women's diets are suboptimal, as shown by the low percentage of women meeting the Food Guide Pyramid recommendations.

A study by **George et al** also examined dietary quality of postpartum women [9]. In this study, the diets of 146 low-income mothers (31.5% white, 30.1% African American, and 38.4% Hispanic) were compared to the recommendations set forth by the 2000 Dietary Guidelines for Americans, using the dietary guidelines index tool. The women completed a semi-quantitative FFQ and psychosocial questionnaire at 1 year postpartum. Based on the serving recommendations for food groups, less than 30% of the women met the recommended amounts for the total grains, whole grains, vegetable, fruit, and milk categories. The food group with the highest compliance was the meat group, with 65% of the women meeting the amount of servings recommended by the Dietary Guidelines. Less than 7% of the women met the recommendations for fat and saturated fat consumption. Average total fat and saturated fat consumption was 38.8% ±

0.5% and 13.6% ± 0.2%, respectively, of total calories consumed. The average sodium levels consumed were 3600 ± 129 mg/day, which is well above the recommendation of ≤2400 mg sodium/day. Dietary guidelines index scores did not differ based on demographic factors, but significantly different scores were noted with some psychosocial factors. Better dietary quality was recorded for women who reported less stress, depressive symptoms, weight-related distress, neglect of self-care, and perceived barriers to weight loss ($p<0.05$). Similar to the last study by Fowles and Walker, this again shows that many postpartum women's diets are lacking foods from important food groups, especially the fruits and vegetables.

Another study also conducted by **George et al** compared the diet quality of low-income postpartum women, but this time in relation to what their diet was during their pregnancy period [10]. In this study, 204 women were recruited 0-1 day after giving birth, and were asked to complete a FFQ for their food choices during pregnancy at 6 weeks postpartum, and then were asked to complete another FFQ at 6 months postpartum. The comparison of the women's food choices over time indicated that the average daily servings of grains, vegetable, and fruit decreased ($p<0.01$), while added sugars and percent fat increased ($p<0.05$). When comparing the women who were breastfeeding at 6 months postpartum to those who were not, the women who breastfed ate more fruits ($p<0.05$) and vegetables ($p<0.02$) than the women formula feeding their infant. Women who breastfed at 6 months showed significantly higher intake of fruit and a lower percentage of calories from fat during pregnancy compared to those women who were not breastfeeding at 6 months postpartum. This longitudinal study was able to show that although women may be more conscientious of what they eat during pregnancy, they may not continue similar habits into the postpartum period, especially women who are not breastfeeding.

A study by **Mackey et al** aimed to assess the diets of 52 normal weight postpartum women, all of whom were breastfeeding [11]. At 3 and 6 months postpartum, 2-day food records were collected from the participants. The nutrient status of their diets was compared to the Recommended Dietary Allowance (RDA) values provided for lactating women. The results indicated that on average these women were deficient in the following nutrients: calcium, zinc, folate, and vitamins B-6, D, and E. This suggests that lactating women may need to pay special attention to their diets to ensure they are consuming foods that are rich sources of the above nutrients.

The first study conducted to look at dietary quality and nutrient intakes for overweight and obese postpartum women was conducted by **Durham et al** [12]. Dietary recalls were conducted with 450 women that enrolled in the study; two 24-hour dietary recalls were completed for 428 women, and one 24-hour dietary recall was collected for the other 22 women. All women were included in the final analysis. The women were categorized by infant feeding status: fully breastfeeding, combination feeding (mixture of breast milk and formula), or formula feeding. After controlling for total calorie consumption, nutrient intakes did not differ between groups for infant feeding status. All groups were likely to consume inadequate amounts of folate and vitamins A, C, and E, compared to the estimated average requirements (EAR). Average intake levels of two other nutrients, calcium and vitamin D, were also below the adequate intake (AI) levels.

Similar to the last study with normal weight postpartum women, overweight and obese postpartum women are also at risk for inadequate consumption of important nutrients.

The studies indicate that many postpartum women are lacking adequate quantities of important nutrients and/or servings from some of the food groups. Besides the longitudinal studies by George et al [10] and Mackey et al [11] that collected dietary information at two time points, the other studies are cross-sectional by design and illustrate a single snapshot of the diets of postpartum women. None have looked at dietary quality in conjunction with an educational intervention to see if a dietary-focused intervention is effective in improving the quality of a mother's diet over time. It has been proposed that improving dietary quality in postpartum women will have positive effects on postpartum weight loss. Only one cross-sectional study compared the quality of the mother's diet to postpartum weight retention to test whether there is a direct correlation between amount of weight retained and diet quality [8]. Although no relationship was found in this particular study, more research is needed to examine the relationship between diet quality and postpartum weight retention.

Studies using the Healthy Eating Index-2005 (HEI-2005) to analyze diet quality

In addition to the methods used in the previously described studies to determine diet quality, the Healthy Eating Index (HEI) is a tool that can be used to analyze diet quality. The HEI measures diet quality based on how closely the diet adheres to the recommendations set forth by the Dietary Guidelines. The benefit of using this approach is that it evaluates the quality of an individual's diet rather than just the total amount of calories consumed. The original HEI was created in 1995 to measure diet quality reflective of the 1990 Dietary Guidelines for Americans [13]. When the Dietary Guidelines were revised in 2005, the HEI was reconstructed to better reflect the new guidelines. The new Healthy Eating Index 2005 (HEI-2005) differs from the original HEI in that it is based on energy density rather than total quantities of the foods consumed.

The HEI-2005 is comprised of 12 components that correspond to the 2005 Dietary Guidelines. The components are: total fruit; whole fruit; total vegetables; dark green and orange vegetables and legumes; total grains; whole grains; milk (dairy); meat and legumes; oils; saturated fat; sodium; and energy from solid fat, alcoholic beverages and added sugars (SoFAAS). A score is assigned to each component, which contributes to the overall HEI-2005 composite score. Legumes are added to the dark green and orange vegetables and legumes component only after the maximum score is earned for the meat and legumes component. The HEI-2005 has been validated as an accurate and reliable measure of diet quality [14].

Healthy Eating Index-2005 with postpartum women

To date, only one study has been conducted using the HEI-2005 to measure diet quality for postpartum women. **Shah et al** examined diet quality for 125 low-income overweight or obese women 0-4 months postpartum [15]. The participant's diets were assessed using the combination of a 24-hour dietary recall and 2-day food record. HEI-2005 scores were generated for the diets of each participant to determine the quality of their overall diet. The results revealed that the average HEI-2005 score was 51.4±0.9 out of a possible 100 for the participants' dietary quality. This suggests that their diets do not closely adhere to the 2005 Dietary Guidelines. Their quality was lowest for the fruit, vegetable, whole grains, sodium, and SoFAAS (solid fat, alcohol, and added sugar) components. In addition to collecting dietary information, anthropometrics and blood samples, including serum lipid levels, were collected from each participant during the same time period as the dietary intake collection. The generated HEI-2005 scores were compared to the participant's anthropometric measures and lipid levels to determine whether any correlation exists. The HDL cholesterol levels were positively correlated ($p<0.05$) and total cholesterol and LDL cholesterol were negatively correlated with the quality of the diet ($p<0.05$ for both). After adjusting for the number of calories consumed, the HEI-2005 scores were able to predict both BMI and body weight for the participants ($p<0.05$ for both). The study suggests that HEI-2005 may be able to predict other health markers.

Healthy Eating Index-2005 with other populations

A study conducted by **Duffy et al** in 2009 also used the HEI-2005 to evaluate diet quality of low-income females [16]. However, enrollment was not limited to postpartum women. In this study, women aged 19-50 y, all of whom utilized the food pantry in their county of residence, were eligible to participate. Anthropometric measures were collected for a total of 55 participants and they were each asked to complete a 24 hour dietary recall. The researchers then used HEI-2005 to assign a diet quality score to each of their diets. In general, the diet quality was poor, with an average score of 42.8 out of a possible 100, and the obesity rate was high, indicating a possible association between diet quality and rates of obesity. A limitation of the study was that only one 24 hour recall was conducted for all participants, so day-to-day variation in individual's diets could not be accounted for.

Another cross-sectional study was published by **Tsigga et al** that examined dietary quality of 100 Greek women that were pregnant and between the ages of 18 and 42 [17]. The aim was to determine whether there were differences in diet quality based on the woman's body weight before and during pregnancy. A dietitian conducted three 24-hour food recalls, on consecutive days, with each of the participants. The HEI-2005 scores were then generated for the average of the diets. The mean HEI-2005 score of the entire sample was 66.9. The participants who were underweight or normal weight before pregnancy had a significantly higher HEI-2005 score during pregnancy compared to those women who were overweight before pregnancy (67.2 and 67.1 vs. 66.6) ($p<0.05$). In addition to the analysis using pre-pregnancy weight status, an analysis was conducted using the women's weight status during pregnancy. This analysis indicated that the underweight and normal weight participants during pregnancy had a significantly higher HEI score than the obese pregnant women ($p<0.05$). It was found that HEI-2005 scores were negatively associated with both pre-pregnancy and pregnancy BMI ($p<0.003$ and $p<0.001$, respectively), which means that the higher the BMI, the lower the HEI-2005 score. Further analyses found that adequate HEI-2005 scores (≥ 80) were associated with living in a rural setting and being underweight or normal weight during pregnancy. Low scores (< 60) were associated with being overweight or obese during pregnancy, being obese before pregnancy, and living in an urban area.

A study published by **Kuczmarski et al** in 2010 examined the quality of diets for middle aged American men and women in relation to depression scores [18]. The study population consisted of 1,118 low-income African American and Caucasian adults, ranging in age from 30-64 years. Their diets were assessed using the 24-hour dietary recall method on two non-consecutive days. An HEI-2005 score was then calculated for each collected diet to evaluate the quality of the participant's diets. Additionally, a trained professional assessed symptoms of depression for each participant and a depression score was assigned. Diet quality scores and the depression scores were compared to see if there was any correlation. The results revealed that HEI-2005 scores were inversely related to depression scores ($p<0.0001$). This indicates that the more depressed an individual feels, the lower their diet quality will be. Because mothers may experience postpartum depression, this may be one factor that affects the quality of their diet during the postpartum period.

HEI-2005 has been used for a number of cross-sectional studies to measure diet quality of individuals in a population at a particular time point, including postpartum women. Studies have determined its ability to predict BMI and body weight [15], and its correlation with obesity [16]. Lower HEI-2005 scores are correlated with higher rates of obesity [16]. Another study showed an inverse relationship between HEI-2005 scores and depression [18]. However, no intervention study has used HEI-2005 to investigate changes in diet quality over time with overweight and obese postpartum women.

Interventions to reduce weight retention in postpartum women

Few intervention studies have been conducted with postpartum women to reduce postpartum weight retention and encourage women to return to their pre-pregnancy weight. A recent review indicated that interventions with either a diet component, or a combination of diet and exercise components are effective for promoting weight loss after giving birth [19]. Ferrari et al determined that although patients may follow their healthcare provider's advice about making dietary changes and increasing physical activity, the advice alone was not be enough to induce changes that resulted in weight loss [20]. Instead, individual counseling sessions and care given beyond the typical 6 wk postpartum was recommended. The following information describes postpartum interventions that have attempted to reduce postpartum weight retention among women.

Dusdieker et al enrolled 33 fully breastfeeding postpartum women in a study to determine the effects of an energy restriction intervention on weight loss [21]. The women had to have a BMI > 19 kg/m^2 and have an infant between 1-3 months old to be eligible for the study. The goal was for the women to restrict their calories by 25% compared to their estimated energy requirements for maintaining weight. The goal was to lose 0.45 kg/wk for 10 weeks. The intervention included strategies to reduce fat intake and behavior therapy that intended to focus on the mothers setting personalized goals and keeping records of their food consumption and weight, and having a dietitian provide positive reinforcement to the mothers. The mothers were weighed every week by the researchers to monitor their progress. The results showed that the average weight loss over the 10 weeks for the women who completed the study was 4.8 kg, which was significant from baseline ($p<0.05$). This suggests that a moderate weight loss of 0.45 kg/wk is feasible for new mothers who restrict their calories. On average, the mothers also significantly reduced their hip and waist circumferences and the sum of three skinfold-thickness measurements. Limitations of the study were that there was no control group, and that one-third of the participants dropped out of the study.

In 1998, **Leermakers et al** conducted the first randomized study that intervened with women during the postpartum period in an attempt to reduce postpartum weight retention [22]. The study consisted of 90 women who had given birth in the previous 3-12 months and were at least 6.8 kg heavier than their pre-pregnancy weight. The study participants were randomly assigned to the intervention (n=47) or control (n=43) group for a period of 6 months. The intervention included: two group sessions (held at baseline and at month 2), 16 correspondence packets sent out via mail, and regular telephone calls made by the research staff. The group sessions provided information about starting weight loss and aerobic exercise programs. The correspondence materials included topics on exercise, nutrition, and behavior changes. Each packet also included an assignment to be completed and returned by the participant. The topics of nutrition and exercise were discussed with the participants during regular telephone calls. The results of the study indicated that the correspondence-based intervention strategy was effective in reducing weight retention during the postpartum period for the study participants. The intervention participants lost an average of 7.8 kg compared to 4.9 kg for the control group ($p=0.03$). Also significant, 36% of the participants in the intervention returned to their pre-pregnancy weight, compared to only 11.5% of participants in the control group

($p<0.05$). It is important to note, however, that there was a 27% drop-out rate for the participants in this study.

Similarly, a study by **Lovelady et al** also intervened with postpartum women using diet and exercise to encourage postpartum weight loss [23]. At 4 weeks postpartum, there were 40 overweight, fully-breastfeeding women that were randomly assigned to the intervention or control group, and that completed the study. Based upon the average of their estimated energy requirement and their average intake at baseline, the women in the intervention group were asked to reduce their calorie intake by 500 calories. They were also prescribed an exercise plan that involved structured exercise for 45 minutes/day for 4 days/week, with a researcher present to measure compliance. The women in the control group were not to change their diet or begin an exercise regimen during the duration of the 10 week study. At the completion of the intervention period, the women in the intervention lost significantly more weight than the control group (-4.8 ± 1.7 kg vs. -0.8 ± 2.3 kg) ($p<0.001$). The intervention group also lost a significant amount of fat mass from baseline to completion ($p<0.01$), whereas there was no change for the control group. Again, this study shows through diet and exercise, a moderate weight loss of about 0.45-0.5 kg per week is attainable for postpartum women to lose excess weight retained from pregnancy.

More recently, a pilot study was conducted by **Kinnunen et al** to determine the effects of individual counseling with mothers 2 to 10 months postpartum to promote changes in diet and physical activity, and ultimately to determine whether it can reduce postpartum weight retention [24]. There were a total of 85 primiparas postpartum women who participated in the study, of which 48 were in the intervention group and 37 were in the control group. The study was conducted in six child health clinics located in Finland, where three served as intervention sites and the other three served as the control sites. The participants in the intervention group received individual counseling from a public health nurse during five routine visits with their child at the child health clinic, between months 2 and 10 of their postpartum period. The participants in the control group received usual care from the public health nurse at their health clinic.

The first counseling session for the intervention included 20-30 minutes of information on increasing leisure time physical activity. The participant's current physical activity was assessed and a weekly plan was devised and written for the participant to encourage increased physical activity levels. Throughout the study, structured exercise classes were offered once a week for the participants. Also, topics regarding diet were included during the second through the fifth counseling session to help the participants lose the weight that they had gained during their pregnancy. The topics included: following a regular meal pattern, eating at least 5 servings of fruits and vegetables per day, consuming high-fiber breads, and reducing the consumption of sugary snacks.

The results of the study indicated that the intervention group significantly increased their consumption of high fiber bread by 16% compared to the control group at both 5 months and 10 months postpartum ($p<0.01$ at both time points). No other major changes in the diet were found between the intervention and control groups. No significant differences were found in physical activity between the two groups. However, in spite of the seemingly similar results, more mothers in the intervention group returned to their pre-pregnancy weight compared to the control group (p=0.06). Therefore, it is possible that the food frequency questionnaire (FFQ) may not have been able to detect that the intervention group actually did reduce the number of total calories they consumed, or that the physical activity questionnaire did not accurately estimate the participants' daily activity. It could also be speculated that other factors besides diet and exercise influenced the results, such as breastfeeding duration or pre-pregnancy BMI of the participants. However, these variables were not measured or controlled for in the study. Therefore, it is unknown whether the information from the intervention led the intervention participants to return to their pre-pregnancy weight.

Another study also investigated the effects of individual counseling on diet and physical activity on weight retention in postpartum women. This study, published by **Huang et al** in 2009, aimed to determine whether it was more beneficial to begin an intervention to prevent weight retention during pregnancy, rather than during the postpartum period [25]. The 189 Taiwanese women who participated in the study had an average BMI of 21 (BMI range= 17-37) and were randomly divided into three groups. Group 1 (n=61) received the intervention beginning at gestational week 16 and lasting until 6 months postpartum. Group 2 (n=64) received the intervention starting at birth and it also lasted until 6 months postpartum. Group 3 (n=64) remained the control group and received usual care.

The individual counseling sessions for group 1 were conducted with a nurse during routine clinical visits. There were a total of six sessions, three during pregnancy, one at birth, and two during the post-partum period (at 6 weeks and 3 months). During the first session, the nurse and participant established a goal for the participant's gestational weight gain and postpartum weight retention. During that session and each subsequent session, information on diet and physical activity in relation the pregnancy and postpartum periods was discussed. Group 2 received the same information and goal-setting as group 1, but starting 24-48 h post-birth instead of during pregnancy. Therefore, the participants in group 2 received a total of three counseling sessions instead of six like group 1.

The results indicated that group 1 significantly reduced their gestational weight gain compared to groups 2 and 3 ($p<0.001$). Also, group 1 had significantly reduced weight retention at six months postpartum compared to the other two groups ($p<0.001$). Although not statistically significant, gestational weight gain and weight retention were lower for group 2 when compared to the control group as well. Therefore, it is possible that individual counseling beginning during pregnancy may be more beneficial in lowering weight retention during the post-partum period for women, but that counseling started after birth may also provide positive results.

A study conducted by **Ostbye et al** aimed to promote the weight loss of overweight or obese postpartum women, using not only individual motivational counseling but also diet and exercise classes [26]. At 6 weeks postpartum, the enrolled women were randomly divided into the intervention (n=225) or control group (n=225). Two dietary intakes were collected at baseline from all participants using the 24-hour recall method. For the intervention group, eight diet classes and ten exercise classes were offered during the study period. In addition, every 6 weeks the participants in the intervention group received an individual counseling session from a motivational counselor to encourage behavior change and address barriers they encountered preventing them from reaching their dietary and exercise goals. The intervention ended at 11 months postpartum. Dietary intakes for all participants were collected again one month after the end of the intervention. The dietary recall results indicated that the intervention group had a greater reduction in overall calorie consumption compared to the control group, although it was not statistically significant. Study results also indicated that both groups increased their amount of physical activity and lost some body weight, although there was no significant difference between the groups on either measure. Similar to the other intervention studies for postpartum women, there was a 30% drop-out rate for the women in this study. Overall, the intervention designed for postpartum weight loss between 6 weeks and 12 months postpartum did not produce significant results compared to the control group. A lack of significant results may be attributed to low participation rates in the intervention group. Of the women in the intervention group that remained in the study, just over one-third of them did not attend any classes.

Another study also used group sessions to encourage postpartum weight loss in overweight women. There were a total of forty women who participated in the study conducted by **O'Toole et al** [27]. The participants were recruited between 6 weeks and 6 months postpartum, and were randomly assigned to the intervention (n=21) or control (n=19) group. The intervention consisted of regular group educational sessions on nutrition and exercise, in which the participants were encouraged to attend until 1 year postpartum. They each received personalized diet and exercise plans to guide them in addition to the classes. The participants in the control group met once with a dietitian and exercise physiologist individually to devise a diet and exercise plan for them, but did not receive follow-up care. Anthropometric measurements and information from 3-day food records were recorded for each participant at baseline, 12 weeks after baseline, and 1 year postpartum.

The results showed that the women in the intervention had a significant decrease in both body weight and percent body fat 12 weeks after baseline and at 1 year postpartum ($p<0.001$ for both). There were no changes in either of these measurements for the women in the control group. Both groups showed a significant decrease in calorie consumption at 1 year postpartum compared to baseline. Calories burned from exercise and amount of vigorous physical activity significantly increased in the intervention group at 12 weeks after baseline and 1 year postpartum, but no changes were seen at either time point with the participants in the control group. This indicates that diet and exercise in combination may be more beneficial than changing diet alone, because the control group reduced their calorie intake but they did not increase their amount of exercise, and as a result did not lose weight. This type of intervention may be an effective way to promote postpartum weight loss in overweight women. However because of the study's small sample size, a bigger trial should be conducted to confirm these results. A limitation of the study was that there was only a 57% retention rate at 1 year postpartum, suggesting that it is difficult to keep women during the postpartum period engaged in structured intervention programs.

Summary of literature review

Of all the studies presented, compliance rates were low for most of them. This indicates that this may be a difficult population to keep engaged with an intervention program over a period of time, perhaps because of the additional demands their baby has placed on their time. Since women report being more dissatisfied with their bodies during the postpartum period than during their pregnancy, this is a time period when a lot of women are more motivated to lose weight [4]. However, keeping their commitment may prove challenging when they run into unforeseeable obstacles, such as lack of childcare. Therefore, it is possible that providing childcare for the interventions that utilize group educational or exercise sessions would help to increase continued participation.

Overall, smaller intervention studies have been successful. Results show that changes in diet and exercise can help reduce weight retention among postpartum women. Intervention studies have made comparisons about single components of the diet or total numbers of calories consumed, but none have compared differences in the overall quality of the mother's diets. Measuring the quality of one's diet before and after an intervention will provide more insight into what, if any, changes the individuals are making to improve their diet.

CHAPTER III

DIET QUALITY AND WEIGHT CHANGE AMONG OVERWEIGHT AND OBESE POSTPARTUM WOMEN ENROLLED IN A BEHAVIORAL INTERVENTION PROGRAM

INTRODUCTION

In the United States, 34% of the population is considered obese (body mass index [BMI] ≥30), while another 34% of the population is overweight (BMI=25-29.9 [1]**.** Within the last 20 years, the occurrence of obesity in this country has risen more than 50% [28, 29]. Being overweight or obese can have detrimental health consequences, including increased risk for cardiovascular disease, type 2 diabetes, hypertension, and cancer [30]. In an attempt to curtail the increasing trend of weight gain leading to obesity, countless weight loss interventions and strategies have been introduced. However, the prevalence of overweight and obese persons continue to rise. Creating and implementing interventions that address specific groups of people who are most susceptible to weight gain is one strategy being used to help address the growing problem of obesity in this country.

One group that has a particularly high risk for becoming overweight or obese is women of childbearing age. For women, pregnancy is one contributing factor leading to overweight and obesity. In the US, approximately 4 million women give birth each year [31], and in 2004 an estimated 46% of them gained more weight than is recommended by the Institute of Medicine (IOM) [3]. The IOM recommends weight gain between 5-18 kg (11-40 lbs) during pregnancy, depending on one's pre-pregnancy BMI. Evidence shows that excessive weight gain during pregnancy can lead to higher postpartum weight retention. Although the average weight retention during the postpartum period tends to be between 0.5-3 kg [4], studies have reported that 14%-25% of postpartum women retain >4.5 kg [5, 6]. This indicates that the amount of weight actually retained can be highly variable and some women may be more at risk for retaining the weight gained during pregnancy than others. Several risk factors have been identified for significant postpartum weight retention, including higher pre-pregnancy weight, excessive weight gain during pregnancy, smoking cessation during pregnancy, and not breastfeeding [4]. Nuss et al suggest that nutritional knowledge also predicts those women at risk for excessive postpartum weight retention [32]. The results of their study indicated that the women who had less nutritional knowledge retained more postpartum weight compared to those with greater nutritional knowledge.

Looking beyond the postpartum period, a significant predictor for long-term weight gain is the failure to lose the excess weight that was gained during pregnancy by 6 months postpartum [2]. Rooney and Schauberger showed that women who lost the weight that they gained during pregnancy by 6 months postpartum were only 2.4 kg heavier ten years later compared to 8.3 kg heavier for those who still had weight retention 6 months after giving birth [2]. Not losing the excess weight will cause a woman to enter her next pregnancy weighing more, which increases the likelihood of gaining even more during that pregnancy and retaining more during the postpartum period that follows. This issue of retaining postpartum weight can lead to a compounding problem with multiple pregnancies. Intervening during the postpartum period to help women lose the weight gained during pregnancy may have a positive impact on long-term weight maintenance.

One way to help postpartum women lose weight is through restricting energy intake in their diet. The early postpartum period may be an excellent time to promote the consumption of a healthy diet as a way to help lose weight that was gained during pregnancy. Although some women eat healthier during pregnancy to ensure ample nutrients are available for their fetus, they may not continue their healthy eating habits after giving birth [10]. Collectively, studies show that diet quality for women is suboptimal during the postpartum period [8, 9, 11, 12]. Intervening during the early postpartum period to encourage women to continue healthy dietary habits that they practiced during pregnancy could be beneficial as a way to promote weight loss during the postpartum period.

Therefore, the purpose of this study was to determine predictors of diet quality during the early postpartum period. A second aim was to determine whether mothers in a behavioral intervention program significantly improved the quality of their diet, reduced energy intake, and lost more weight from baseline to endpoint compared to participants in the control group. The final aim was to determine if baseline diet quality, baseline energy intake, and lactation status predicted weight change from 6 to 16 months postpartum.

METHODS

Participants

Overweight and obese postpartum women were enrolled in a randomized controlled trial called KAN-DO (Kids and Adults Now- Defeat Obesity). The rationale and detailed design of the study was previously reported [33]. Participants were recruited from a total of 14 counties within the Triangle and Triad regions in North Carolina between September 2007 and November 2009. Recruitment consisted of identifying potentially eligible women based on publicly available state birth certificate records. A postcard was sent to the women identified from the birth records, which described the study and listed a toll-free telephone number for them to call if interested in the study. In addition to the mailed postcards, telephone numbers were obtained through a public search for approximately 50% of these women. The women were contacted by phone as a follow-up to the postcard. To supplement the recruitment process, flyers containing information about the study were posted in pediatric and obstetric offices, day care centers, and other community centers with the toll-free telephone number for potential participants to call.

Women who called the toll-free number and those for which their telephone number was obtained through the public search were screened for eligibility. To be eligible for the study, the mother had to meet the following criteria: pre-pregnancy BMI $\geq$ 25 kg/m^2, gave birth within the last 6 months, have another child aged 2-5 years, English-speaking, $\geq$ 18 years old, and have access to a telephone and mailing address. Interested women who met the criteria guidelines were asked to visit the nearest study site to complete a baseline assessment. The two sites were located at The University of North Carolina at Greensboro (UNCG) and Duke University, Durham, NC. Verbal informed consent was obtained from all participants prior to participation at the baseline visit.

Prior to the baseline visit, a packet was mailed to participants with an informed consent letter, a self-administered questionnaire, and directions to the site. Women were asked to complete and return the questionnaire at the time of the visit. The questionnaire addressed demographics and topics regarding the woman's dietary habits, physical activity, parenting behaviors, and motivational readiness for change. Depression status of the women was categorized based on the validated 10-question Edinburgh Postnatal Depression Scale (EPDS), which was included in the baseline questionnaire to screen for postpartum depression [34, 35]. Following EPDS protocol, scores of 13 or greater were considered a positive screen for depression.

At the baseline visit, all women reviewed and signed the written consent from (Appendix A). Anthropometric measurements for the woman were collected, including height, weight, and waist and hip measurements. Calculations were completed to ensure the woman's measured BMI was ≥ 25 kg/m^2 in order for her to remain eligible for the study. Following the baseline visit, two 24-hour dietary recalls were completed with the woman via telephone within two weeks of one another.

There were a total of 40,379 women who were reached during recruitment and received information regarding the KAN-DO study. Of those women, 4444 (11%) were screened for eligibility. Since 2179 (49%) were ineligible and 1617 (36%) refused, 648 (15%) remained that were eligible and interested in participating. Within this group of women, 152 did not attend their scheduled baseline visit, 80 refused or were considered ineligible during their baseline visit, and 16 did not complete all of the required baseline assessments. The remaining 400 women were enrolled to participate in the study.

Upon completion of the baseline visit (with anthropometric data), questionnaire, and dietary recalls, the women were equally randomized into the control or intervention arm of the study based on a 16-block randomization with 4 strata (preschooler's age (2-3 vs. 4-5), mother's race (black vs. non-black), study site (Durham vs. Greensboro), and mother's days postpartum (<122 days vs. >122 days). At the point of randomization, the women had to be between 2-7 months postpartum. All study procedures were approved by the Institutional Review Boards of University of North Carolina at Greensboro and Duke University Medical Center.

Anthropometric measures

Anthropometric measurements were collected for all participants at baseline, which was between 2-6 months postpartum. Measurements were collected again 10 months later, after the completion of the intervention. All measurements were collected in person with research staff at one of the two study locations.

Body weight was measured using the Tanita BWB-800S digital scale (Tokyo, Japan) and height was measured with the SECA 214 portable stadiometer (Hamburg, Germany). Height was measured at baseline only, whereas the body weight was collected at both time points. Participants were measured without shoes and wearing minimal clothing for all measurements.

Dietary assessment and analysis

Dietary interviews were conducted with all participants at baseline and at the end of the intervention period. The interviews were conducted via telephone by trained research staff using the Nutrition Data System for Research (NDSR), which follows the multiple pass, 24-hour dietary recall method. The multiple pass method is a technique used to increase accuracy of dietary recalls, in which the interviewer first collects a brief list of foods consumed, then inquires for more details about the food items, and lastly reviews the collected information with the participant. The multiple pass method is described in detail elsewhere [36]. Two recalls were collected at each of the time points. They were completed on unannounced days and generally within 2 weeks of one another.

At the baseline and endpoint visits, the participants were given a Food Amounts Booklet containing two-dimensional pictures of food amounts, in order to assist them in estimating portion sizes during the interviews. All participants were asked to verify that their food intake was typical for the day being recalled in order to help ensure accuracy of the data collected. Previous research has indicated that multiple pass, 24-hour dietary recalls are an accurate way to capture dietary intakes [36]. Research also indicates that interviews completed via telephone are as accurate as in-person interviews, which was validated using the doubly labeled water technique [37]. Dietary intake data were collected using NDSR software versions 2007, 2008, and 2009, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. Final calculations were completed using the NDSR version 2009.

The Healthy Eating Index-2005 (HEI-2005) tool was utilized to determine the quality of each participant's diets both before and after the intervention period (baseline and endpoint). HEI-2005 is a tool used to assess the quality of an individual's diet based on established national guidelines. It was originally created in 1995 by the United States Department of Agriculture (USDA). The original HEI was based on the Dietary Guidelines set forth by the 1990 Dietary Guidelines for Americans [13]. Because the Dietary Guidelines are generally updated every five years, the HEI has since been revised to better reflect the latest Dietary Guidelines, set forth in 2005. The new HEI-2005 has shown to be a valid and reliable method to measure diet quality [14].

The HEI-2005 is comprised of 12 components, each of which assesses an important aspect of diet quality. Nine of the components measure nutrient adequacy in the diet and the other three measure items that should be consumed in moderation within the diet [38]. See Table 1 for the complete list of components [39]. A score is assigned to each component, and then summed for a total score. There is a minimum and maximum score that can be earned for each component, with an overall total score of 0-100 that can be earned. According to the HEI-2005 technical report, an overall score of 81-100 is considered 'good', whereas scores of 51-80 'need improvement' and scores of 50 or below are 'poor' [40]. Using HEI-2005 to analyze diet quality for postpartum women before and after completing the intervention will provide some evidence as to what areas of the diet showed significant improvement after the intervention, as well as other areas that still need attention. The total HEI-2005 score can indicate whether the overall diet improved compared to baseline.

Table 1 indicates the minimum and maximum points that can be allotted for each component, and lists the food/nutrient amounts required to obtain the minimum or maximum scores. The scoring is prorated based on the amount of food/nutrient consumed; therefore any score between the minimum and maximum can be assigned. A difference between the original HEI and HEI-2005 is that the scoring for HEI-2005 is based on food/nutrient density (e.g. nutrient intake per 1,000 kcal consumed) rather than absolute amounts of food or nutrients consumed, since dietary recommendations vary according to how many calories are consumed. This change helps account for the differences in the amount of total calories people consume. Using the density approach helps to standardize the recommended amounts of food or nutrients, regardless of total calorie consumption.

The HEI-2005 approach to measuring diet quality differs from other methods in that it has several unique components, which are the Whole Fruit, Oils, and discretionary calories counted in the Solid Fat, Alcohol, and Added Sugar (SoFAAS) component. Also unique to the HEI-2005 tool is the use of the density approach to control for diet quality. The HEI-2005 emphasizes whole fruit, dark green vegetables, orange vegetables, legumes, whole grains, sodium, and discretionary calories because they are the dietary components consumed in amounts furthest from the recommendations [40].

Since two days of dietary information were collected at baseline and endpoint for this study, an overall diet quality score was assigned to the average of the two days at each time point for all the participants. To calculate the HEI-2005 scores, three output files from the NDSR software were utilized. Output file 1, titled Component/Ingredient

File, contained the nutrient totals per food item. Output file 4, titled Intake Properties Totals, contained the daily totals for individual nutrients. Output file 9, titled Servings Count Totals, contained the daily totals for food group serving counts based on servings defined by the Dietary Guidelines for Americans 2005.

The serving count information from output file 9 was utilized to compute the scores for the following components: total fruits, whole fruits, total vegetables, dark-green and orange vegetables and legumes, total grains, whole grains, dairy, and meats and beans. In order to compare the number of servings to the HEI-2005 scoring standards, the serving counts were converted to cups for total fruits, whole fruits, total vegetables, dark green and orange vegetables and legumes, and milk. The serving counts were converted to ounces for total grains, whole grains, and meat and beans.

Total fruit was defined by the HEI-2005 as all fruit listed in the MyPyramid Equivalents Database. From NDSR, all the corresponding fruit groups were collapsed to generate a fruit total. HEI-2005 defined the Whole Fruit component to exclude 100% juice of the fruits from the Total Fruits category, so the fruit juice groups were excluded from the NDSR output when generating the Whole Fruit total. HEI-2005 defined the Total Vegetables as all vegetables listed in the MyPyramid Equivalents database. Therefore, all vegetable groups were collapsed to generate a Total Vegetable score from the NDSR output. As defined by HEI-2005, Dark Green and Orange Vegetables and Legumes include all dark green vegetables such as broccoli, kale, parsley, and spinach; and all orange vegetables such as carrots, pumpkin, and sweet potatoes; and legumes such as black beans, chick peas, lima beans, and pinto beans.

HEI-2005 defined Total Grains as all grains listed in the MyPyramid Equivalents database, including rice, popcorn, and baked goods prepared with grain flour such as cakes, croissants, and pie crust. All grain groups were collapsed from the NDSR output to generate a total for all grains consumed. As a subset of the Total Grains component, HEI-2005 defined Whole Grains as grains that contain the entire kernel such as whole-wheat flour, oatmeal, and brown rice. Since the NDSR output separates grains into three categories: whole grains (WG), some whole grains (SWG), and refined grains, it was decided that each serving of SWG was considered half of a serving of WG when computing the whole grains score, in order to account for the whole grains consumed from food items in this category.

HEI-2005 defined Milk as all products produced from cow's and goat's milk, and soy beverages. However, products made primarily of fat were to be excluded such as butter, cream, and sour cream. From the NDSR output all the dairy groups were collapsed except for the high-fat ones HEI-2005 requested to be excluded. The HEI-2005 defined Meat and Beans to include all meats, as well as legumes, eggs, nuts, and soy-based products such as tofu and soy burgers. The corresponding food groups from the NDSR output were used to calculate this component. Following HEI-2005 protocol, legumes were added to the Dark Green and Orange Vegetables and Legumes category only after the Meat and Beans standard was met.

Nutrient daily totals from output file 4 were utilized to calculate the scores for the following components: Oils, Saturated Fats, Sodium, and Solid Fats, Alcohol, and Added Sugars (SoFAAS). Gram amounts were provided for saturated fats, sodium, and for two subcomponents of SoFAAS (added sugars and ethanol from alcoholic beverages). The HEI-2005 defined Oils as fats that are liquid at room temperature. Therefore, the monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) gram amounts from the NDSR output were used as the surrogate for the Oils component. In order to compare saturated fat to the HEI-2005 standard, saturated fat grams were converted to calories by multiplying by 9 kcal/gram. Since the HEI-2005 standard for the SoFAAS component is also expressed as a percentage of total calories, the grams of added sugars and solid fats were converted to calories by multiplying the amounts by 4 kcal/gram and 9 kcal/gram, respectively.

HEI-2005 defined the solid fat component as all excess fat consumed from food items in the Milk and Meat and Beans components beyond what would be consumed with the version lowest in fat, including cream, butter, lard, and meat drippings. There is no "solid fat" information in the NDSR output, therefore grams of saturated fat and trans fat were used as the surrogates for solid fat.

For the two SoFAAS calculations, alcohol beverages were defined as beer, wine, and distilled spirits by the HEI-2005, and the ethanol from these beverages listed in the NDS output was included in the ethanol calculation. As defined by HEI-2005, added sugar includes sugar used in prepared and processed foods, such as breads, soft drinks, jams, ice cream, and sugar added separately to foods/beverages. NDSR output includes total added sugar computed this way.

Output file 1 was used to determine the amount of carbohydrates (in grams) consumed from the alcoholic beverages, which is the final subcomponent for the

SoFAAS component. The carbohydrate grams were converted to calories by multiplying by 4 kcal/gram. This calorie total was added to the calorie totals calculated for the other three subcomponents for the SoFAAS component (solid fat, added sugar, and ethanol from alcoholic beverages) in order to generate the total number of calories consumed from SoFAAS.

Per HEI-2005 protocol, the following example shows how the points were generated in a prorated fashion [40]. The equations shown below were used to determine point values for the Total Fruit category [40].

$$\frac{\textit{2 day average for Total Fruit consumed (cups)}}{\textit{2 day average for Total Energy}} \times \textit{1000} = \textit{Participant Fruit Standard}$$

Then

$$\frac{\textit{Participant Fruit Standard}}{\textit{0.8 (HEI Total Fruit Standard)}} \times \textit{5 (maximum points possible)} = \textit{Total Fruit Score}$$

Similar equations were used to determine scores for the other eleven components. If someone consumed excess of the recommendation and earned above the maximum score for the given component, it was replaced by the maximum score.

Lactation status

At baseline, lactation status was assessed in the questionnaire by asking the mother how she was currently feeding her infant: breastfeeding only, formula feeding only, or a combination of the two methods. The questionnaire that was administered at endpoint was used to determine breastfeeding duration and intensity of the mothers during the postpartum period. The method of infant feeding was assessed for each month during the first twelve months of the infant's life to calculate a lactation score. Two points were awarded for each month that the woman exclusively breastfed, one point was awarded for each month that the mother partially breastfed, and no points were awarded for the months that the mother did not breastfeed, for a total lactation score of 0-24.

Intervention and control groups

The participants randomized to the intervention group received an interactive, educational kit each month in the mail for a total of eight months during the intervention period. The eight kits were family-friendly, containing useful information for both the mother and her preschooler. The kits focused on making positive changes in the home and encouraged healthy behaviors. The kits also focused on stress management and parenting skills and styles. Each kit had a different theme and consisted of printed information for the mother relating to the theme and a corresponding activity for the preschooler. See Table 2 for the title of each kit. The main theme for kits 2-4 was about making healthy diet-related changes for themselves and within the family, and being a role model for healthy dietary habits in the home. Each kit also contained a postcard, which asked three questions about the information found in the kit. The mother was asked to answer the questions and return it in the mail. There was a monetary incentive for the mother to return each postcard.

Following the receipt of each kit, the participant received a telephone call from a motivational counselor to review the topic of the current month's kit and address their level of motivation and any barriers that they may have encountered. The telephone calls were typically made one week after the participants received the kits and they lasted between 20-30 minutes. The telephone counseling sessions followed the counseling approach known as motivational interviewing. This technique is described in greater detail elsewhere [41, 42].

In addition to the above, participants were invited to attend one group educational session during the intervention period. The sessions, which lasted approximately 120 minutes, were taught by a Registered Dietitian and a motivational counselor. The session reinforced the topics found in the kits and also stressed the importance of a healthy family, including healthy eating and healthy behaviors. Group discussions were encouraged throughout the session. The participants were given a packet of child-friendly recipes and an individual cooler filled with snack ideas. A free meal and child care were provided to encourage participation. Sessions were offered twice a month, once on a weeknight and once on a Saturday.

The participants in the control group received monthly informational guides in the mail for a duration of 8 months. The information focused on reading skills for the preschooler, and reading time between the mother and her preschooler. The guides were assembled based on information provided by the Reading is Fundamental (RIF) program [43].

Statistical analysis

JMP statistical software (version 8, 2008, SAS Institute Inc, Cary, NC) was used for all statistical analyses. The first aim of the study was to determine predictors of the mother's diet quality during the early postpartum period (at baseline). Bivariate analyses were conducted with the sample of 392 women to determine whether any relationships existed between dietary quality (using the baseline HEI-2005 scores) and baseline characteristics. Analyses were conducted with the following ten baseline characteristics: BMI, race, household income, education, lactation status, marital status, parity, work status, smoking status, and depression screen. Then a general linear model was used to determine factors that predict the quality of the mother's diet. The ten variables listed above as well as age were entered into the model. BMI and age were entered as continuous variables, whereas the rest were entered as categorical. HEI score was the dependent variable, and entered as a continuous variable.

The second aim of the study was to determine whether mothers in the intervention group significantly improved their diet quality, reduced energy intake, and lost more weight from baseline to endpoint compared to the mothers in the control group. Because the analysis for this aim was conducted with a subset of the original sample size, chi-square tests were used to test for any differences between the two groups for the following categorical variables: BMI, race, education level, household income, lactation status, parity, depression screen, marital status, smoking status, and work status. A Student's t-test was conducted to test for differences in age at baseline between the control and intervention groups. The HEI-2005 scores generated from baseline and endpoint dietary intake were used to determine if the participants made any changes to the quality of their diets. Using a Student's t-test, the total HEI-2005 scores were compared between participants in the intervention group and the control group. For the statistical analyses, the independent variable was the participant's group assignment (control or intervention) and the dependent variable was the women's endpoint total HEI-2005 scores. A Student's t-test was conducted to test for differences in percent change in energy consumption [(endpoint energy (kJ)- baseline energy (kJ)/baseline energy) x 100] using group assignment as the independent variable and percent change in energy consumption as the dependent variable. To compare change in weight, a Student's t-test was run using group assignment as the independent variable and percent weight change as the dependent variable.

The third aim was to determine if baseline diet quality, baseline energy intake, and lactation status predicted weight change from 6 to 16 months postpartum for the women in the study. Bivariate analyses were conducted to determine if any relationship existed between weight change from baseline to endpoint and the following three variables: diet quality at baseline, energy intake at baseline, and lactation status. Then a multivariate analysis was conducted to determine if diet quality, energy intake, and lactation status predicted weight change, when controlling for other variables. Baseline HEI-2005 score, baseline kilocalories, and lactation score [0 to 11 (short duration and/or low intensity) vs. 12 to 24 (long duration and/or high intensity)], were the independent variables and absolute weight change was the dependent variable. The following variables were also entered into the model because of their potential influence on weight change or their relation to the baseline HEI-2005 score: group assignment (control or intervention), baseline body weight, household income, work status, race, parity, education level, age, smoking status, marital status, and depression screen. Results were found to be significant at $p<0.05$ and are reported as mean (standard deviation).

RESULTS

Participants

Of the 400 participants that were enrolled in the KAN-DO study, 392 completed two dietary recalls at baseline and 8 completed one dietary recall. To account for day-to-day variability in the participant's diets, only those who completed two dietary recalls were considered for analysis. Characteristics of the 392 participants included in the analyses are listed in Table 3. Thirty nine percent were considered overweight (BMI= 25-29.9 kg/m^2), and the remaining were considered obese (BMI $\geq$ 30 kg/m^2). Twenty two percent of the participants were black, 75% were white, and 3% were other races. Over half of the women (56%) had a household income greater than $60,000, and 69% of the women had a college degree. There were similar numbers of women fully breastfeeding (41%) and not breastfeeding (38%) (feeding their infant with formula only); the remaining 22% were feeding their infant with a combination of breast milk and formula. On average, women were 177 days postpartum at the time of randomization.

Dietary quality based on HEI-2005 scores

For the total sample of women, the average total HEI-2005 score and average HEI-2005 component scores were generated for each of the 12 components. The data is shown in Table 4. The average total HEI-2005 score for the sample was 64.4. The average scores for the Total Grains, Meat and Beans, and Oils components were the highest, while the average scores for the Total Fruit and Sodium components were the lowest. The distributions of the HEI-2005 scores for each of the 12 components were bimodal or skewed, as reflected in the standard deviations that are noted in Table 4. Only the total HEI-2005 score was normally distributed.

The average component and total HEI-2005 score data were also analyzed to determine what percentage of the women met the maximum score for each of the components. If any of the women scored the maximum number of points for a given component, that meant they met the recommendation per 1,000 kilocalories (kcal). These results are also shown in Table 4. While 97% of the women met the recommendation to consume at least 12 gm of oil per 1,000 kcal, only 1% of the women met the recommendation for consuming less than 700 mg of sodium per 1,000 kcal. The percentage of women meeting the total fruit and total vegetable recommendations were very low, 13% and 21% respectively. And only 9% of the women met the recommendation of having a good diet quality, which is earning a total HEI-2005 score above 80.

Relationship between baseline characteristics and dietary quality

Results of the average HEI-2005 score for each baseline characteristic variable is shown in Table 5. There were significant bivariate relationships between all of the baseline characteristics and HEI-2005 scores except for work status and depression screen. For example, as the mother's BMI category increased the average HEI-2005 score decreased ($p<0.01$). Regarding race, the participants in the white/other category had a significantly higher HEI-2005 score compared to the blacks ($p<0.001$). Participants who breastfed (either fully or partially), had a higher education and higher income, were married, and did not smoke had significantly higher HEI-2005 scores. However, as parity increased, HEI-2005 scores decreased for the participants.

Predictors of diet quality during the postpartum period

Next, multivariate analysis was conducted to predict factors that contribute to a healthy diet for this sample of women during the postpartum period. Eleven variables were entered into the model: the same ten tested in the bivariate analysis as well as age. The results revealed that three variables significantly predicted dietary quality: BMI, lactation status, and household income (Table 6). For every whole number increase in BMI, the diet quality decreased by a score of 0.25 ($p<0.05$). Compared to the women who were fully breastfeeding, the women who were not breastfeeding had a total HEI-2005 score that was 3.01 points lower ($p<0.05$). And compared to the women with a household income that was ≤ $15,000, all other income categories had significantly higher dietary quality scores ($p<0.01$).

Characteristics of intervention and control groups

Three hundred and eight women (156 in the intervention group and 152 in the control group) completed endpoint measurements, for an attrition rate of 23%. Dietary information was collected for 293 of the possible 308 participants at endpoint. Two days of dietary recall information was collected for 277 of them, and one day was collected for the other 16. Consistent with baseline, the women completing only one dietary recall were eliminated from analyses. Of the 277 women, one woman was not in the baseline analysis (n=392) because she did not complete two dietary recalls at baseline. Therefore, the final number of women included for the longitudinal analyses was 276. See Figure 1. Each of these women completed two dietary recalls at both baseline and endpoint. Within the sample of 276 women, there were 131 in the intervention group and 145 in the control group. None of the baseline characteristics were significantly different between groups. See Table 7. Additionally, there were 18 women who were pregnant at endpoint (10 in the intervention and 8 in the control). These women were included in the diet quality analyses because the results did not change when they were removed from the total sample. However, they were not included in the weight change analyses.

There were no significant differences in baseline characteristics between the 276 participants remaining at endpoint and the 116 participants that either dropped out or provided an insufficient number of dietary recalls. Although not significant, the 116 women that no longer remained in the analysis at endpoint were more likely to be black, have no college degree, and have a household income of ≤ $30,000.

Changes in dietary quality

Table 8 shows the average HEI-2005 scores for baseline and endpoint for both groups. At baseline, there were no significant differences between groups in terms of dietary quality, as reflected in the average total and composite HEI-2005 scores. When comparing the average HEI-2005 scores at endpoint for each group to their baseline averages, no significant changes were seen over time. Interestingly, the average score for the Milk HEI-2005 component increased from 6.4 to 7.0 for the control group over time, but decreased from 6.7 to 6.4 for the intervention group. None of the other components showed any notable changes in their average scores when comparing them between groups. Again, all of the component score distributions were bimodal or skewed. Only the total HEI-2005 scores for the two groups were normally distributed at baseline and endpoint.

The percentage of women who were meeting the government recommendations for the each of the HEI-2005 components and the total HEI-2005 score are listed in Table 9. The women were considered to have met the recommendation if they received the maximum score for the respective component. At baseline and endpoint, nearly all the women in both the intervention and control groups were meeting the recommendation for the Oils component, however virtually no one was meeting the recommendation for sodium at either time point. In general, the percentages of women meeting the government recommendations were low. Only for the Total Grains, Meat & Legumes, and Oils components did at least half of the women meet the recommendation.

The percentage of women in the control group meeting the recommendation for Meat & Legumes increased from 50% to 66%, while the percentage of women in the intervention group meeting the recommendation decreased from 62% to 59% ($p<0.01$). This was the only significant difference between groups for meeting recommendations. Because of issues with multiple testing, this significant statistic must be interpreted with caution. Although not significant, the percentage of women in the intervention group meeting the recommendation for Total Grains increased from 72% to 78%, and the percentage of women in the intervention group meeting the government recommendations increased for the SoFAAS component from 9% to 17%. The percentage of women in the control group meeting recommendations for those two components did not change over time. Lastly, the percentage of women in the intervention group that met the recommended Total HEI-2005 score of greater than 80 doubled from 8% to 16%. Although this is percentage is still low, the increase over time is greater than that found in the control group (12% to 15%). However, this was not significant ($p=0.09$).

Changes in energy intake and body weight

Both groups reduced their average energy intake from baseline to endpoint. However, no significant changes were reported. The average energy intake decreased for the intervention group from 2013 (607) kcal to 1760 (516) kcal, for a reduction of 12.6%. The average energy intake for the control group also decreased, from 2076 (547) kcal to 1840 (520) kcal, for an 11.4% reduction.

An average weight loss was reported for both the intervention and control group. However, it was not significant for either group over time, nor was there a significant difference between the groups. The intervention lost an average of 1.9 (5.5) kg and the control lost an average of 1.0 (5.3) kg. Even after excluding the women who were pregnant at endpoint, there were still no significant differences over time or between groups for weight loss. Without considering the pregnant women, the average weight loss for the intervention group was 2.3 (5.4) kg and 1.5 (4.7) kg for the control group.

Intervention participation rates

The average participation for the 131 women in the intervention group that were included in the analysis was quite variable. For these women, the average number of counseling calls completed was 5.2 out of 8 possible. To illustrate the participation variability, there were 18 women who completed all 8 calls but 2 women who did not complete any calls. The average number of postcards returned from the mailed kits were 4.5 out of 8 possible. Again the participation varied greatly; 37 women returned all 8 of them, but 29 women did not return any postcards. There were a total of 9 women who completed all of the calls as well as returned all of the postcards, and 1 woman who did not complete any counseling calls or return any postcards. For the group educational class, the attendance rate was 60%.

Because of the highly variable participation rates and lack of significant results for changes in diet quality, a secondary analysis was conducted to determine whether a relationship existed between higher participation and greater improvement in diet quality.

The women were categorized as having a low or high participation rate for completing the counseling calls and returning the postcards. Low counseling call participation was considered if the women completed 0-3 calls; high participation was considered if women completed 4-8 calls. The same ranges were used to determine low and high participation for returning the postcards. Therefore, for the analysis, there were four categories of participation: low calls/low cards, low calls/high cards, high calls/low cards, and high calls/high cards. For the ANOVA, the independent variable was participation rate (using the four participation categories explained above) and the dependent variable was the change in HEI-2005 score from baseline to endpoint (endpoint HEI-2005 score – baseline HEI-2005 score). The analysis showed no differences in participation rate and changes in diet quality.

Another secondary analysis was conducted to determine whether a relationship existed between participation rates in the intervention group and change in BMI. The results indicated that a significant relationship existed between participation rates and change in BMI score ($p=0.04$). For the women that had high participation (completed ≥ 4 counseling calls and ≥ 4 postcards), the average change in BMI was -0.85, whereas the women with low participation (completed < 4 counseling calls and < 4 postcards) had an average BMI change of -0.07.

Predictors of weight change

For the women in this analysis (n=256, due to the 18 pregnant women who were excluded), weight change was highly variable, ranging from a loss of 16.4 kg to a gain of

22.4 kg. A bivariate analysis showed a significant, but weak, relationship (r^2=0.04) between baseline total HEI-2005 score and percent weight change. The results showed that higher diet quality during early postpartum (at baseline) correlated with highest percent weight loss 10 months later (endpoint) ($p<0.01$). There was also a significant relationship between baseline energy intake (kcal) and percent weight change ($p<0.01$, r^2=0.03), indicating that the less energy consumed at baseline, the more weight that was lost 10 months later. A bivariate analysis was also conducted between lactation score and percent weight change. The distribution of the lactation scores was bimodal, therefore they were condensed into two categories for the bivariate analysis. The lactation score was entered as a categorical variable, <12 and ≥ 12. Forty three percent of the women earned a lactation score < 12, and the remaining 57% earned a score ≥ 12. Information to calculate the lactation scores were missing for 6 participants. No significant relationship was found between lactation score and percent weight change.

Then, a multivariate analysis was conducted to control for other factors that may also affect weight change. The results of the analysis indicated that baseline diet quality no longer remained significant as a predictor of weight change (Table 10). However, baseline energy intake (kcal) remained a significant predictor weight change ($p<0.03$); and mother's work status ($p<0.01$) and lactation score ($p<0.02$) also significantly predicted weight change. Baseline energy intake was negatively associated with weight loss, so the women who consumed less energy lost more weight. The women who worked part-time lost more weight compared to the women who worked full-time and those who did not work for pay. The women who breastfed for a high intensity/long duration lost less weight [1.5 (5.2) kg] than those who breastfed for a low intensity/short duration [2.2 (5.0) kg]. However, in a bivariate analysis this was not significant. In addition, women who breastfed for a high intensity/long duration ate significantly more energy at baseline [2142 (557) kcal] compared to those who did not breastfeed or who breastfed for a low intensity/short duration [1915 (564) kcal] ($p<0.002$). The women who breastfed for a high intensity/long duration also ate more energy at endpoint compared to those who did not breastfeed or who breastfed for a low intensity/short duration [1840 (528) kcal] vs. 1770 (490) kcal, respectively). However, this was not significant.

DISCUSSION

To our knowledge, this is the first paper investigating diet quality, as determined by HEI-2005 scores, of overweight and obese postpartum women and examining its relationship to weight change while controlling for other factors. The mean total HEI-2005 score at baseline for the sample was 64.4, below the definition of a good quality diet set forth by the government, which is an HEI-2005 score >80 [40]. According to the 2001-02 National Health and Nutrition Examination Survey (NHANES) data, the national average HEI-2005 score was 58.2 for individuals aged 2 and up [44] . Specifically for US adults, the average HEI-2005 score was 53.3 for non-smokers, and even less for smokers, at 44.7 [40]. Comparatively speaking, participants in this current study had a better average diet quality than the typical American. Furthermore, their diet quality was also higher than another US cohort of overweight and obese postpartum women, which had a mean HEI-2005 score of 51.4 [15]. However, that cohort was different in that only low-income women were included. Tsigga et al reported a mean HEI-2005 of 66.6 and 66.7 for overweight and obese women, respectively, who were pregnant living in Greece [17]. Although slightly lower, the overall diet quality of the participants in the KAN-DO study most closely reflected women who were pregnant and consuming a Greek diet.

The average HEI-2005 component scores for the women in the KAN-DO study were similar to the average non-smoking American adult for the total and whole fruit, total vegetables, total grains, meat and legumes, and saturated fat components [40]. The KAN-DO participants scored slightly higher in the dark green and orange vegetables and legumes, whole grains, and milk components and lower in the sodium component. The KAN-DO participants also scored markedly higher in the SOFAAS component and oils component compared to the average non-smoking American adult [13.6 (4.7) vs. 9.7 (0.2) and 10.0 (0.3) vs. 5.6 (0.1), respectively]. The average HEI-2005 component scores for the KAN-DO participants were fairly similar to the low-income overweight and obese postpartum women scores reported by Shah et al [15], except for the Oils and SoFAAS components. These women had an Oils score of 2.3±0.1 and SoFAAS score of 7.5±0.5, which were both much lower than the KAN-DO participant averages.

A limitation of the current study is that the diet quality scores for the women may be inflated due to underreporting. It is a common problem for overweight and obese populations to underreport actual food consumption, especially with foods high in fat and sugar that may be perceived as unhealthy choices [45-47]. If the women reported less discretionary calories, then they may have scored better in the HEI-2005 SoFAAS category, leading to a higher overall score.

Although the bivariate analyses showed significant relationships between HEI-2005 scores and all baseline characteristics (except work status and depression screen), only BMI, lactation status and household income remained significant predictors of diet quality during the early postpartum period for overweight and obese women after adjusting for the other variables. Using the prediction equation, a fully breastfeeding, high-income, overweight (BMI = 27) postpartum mom would have an HEI-2005 score of 77.2, compared to a score of 62.2 for a fully formula feeding, low-income, class II obese (BMI = 40) postpartum mom. This suggests that women who choose to breastfeed their infant may also choose to eat a healthier diet. Therefore, encouraging new mothers to breastfeed their infant may be one way to improve diet quality and augment the effects of breastfeeding on reducing weight retention during the postpartum period, especially in women who are already overweight or obese. However, it is not clear whether the decision to breastfeed leads to the consumption of a healthier diet, or whether women who already lead a healthier lifestyle also choose to breastfeed. More research still needs to be conducted in this area.

The intervention for the KAN-DO study aimed to promote postpartum weight loss through attainment of a healthy diet in overweight and obese women. However, no significant differences in diet quality or weight loss were reported between the intervention and control groups. Both groups reported a decrease in energy intake, but again no differences were found between the groups.

Similar to previous intervention studies with postpartum women, the attrition rate was high in this study. Within the intervention group, participation was highly variable. The average rates of participation were lower than expected for both the postcards and counseling calls. The postcards were intended to measure the participant's engagement with the content in the kits. Therefore, it is possible more participants did read and implement the information from the kits into their daily lives without sending the postcard back in the mail. However, this is unlikely because of the low participation also seen with the counseling calls and group session attendance, and the lack of significant results. Group educational sessions were offered twice a month for the duration of the intervention period, allowing the participant ample opportunity to attend one session. Childcare and a free meal were offered during the session to encourage attendance, yet just over half of the participants attended a group session.

A secondary analysis found a significant relationship between participation rates in the intervention group and change in BMI. The women that had high participation (completed ≥ 4 counseling calls and ≥ 4 postcards) decreased their average BMI score more than the women with low participation (completed < 4 counseling calls and < 4 postcards). This indicates that the participants who had the time to commit to the intervention program gained the most benefits, as seen by greater weight loss during the postpartum period. The women who had low participation in the intervention group may have weakened the outcomes (diet quality, energy intake, and weight change), leading to the lack of significant results between the intervention and control groups.

Based on previous research conducted by our research group [26], we hypothesized that a home-based intervention may prove more successful than a group-based intervention for this population of women because it would be less demanding on their time. Home-based interventions deliver the main intervention material to participants in their homes, whereas intervention material is delivered to participants during group sessions held in the community with group-based interventions. However, the home-based method in the KAN-DO study did not result in significant findings and the attrition rate was still high at 23%. An earlier study did report successful results with postpartum weight loss using a home-based correspondence intervention [22], but also reported a high attrition rate of 27%. Unlike the current study, the study by Leermakers et al enrolled normal weight women in addition to overweight and obese postpartum women [22]. They found that the women who were heaviest at baseline and retained more of their pregnancy weight were more likely to drop-out, which illustrates the challenges of working with an overweight and obese population.

The home-based intervention that was successful with Leermakers et al focused on energy restriction rather than diet quality [22]. The participants were asked to follow a 1000-1500 kilocalorie diet and restrict fat intake to 20% of total energy consumed, and record their intake on a daily basis. Therefore, it seems that focusing on overall calories rather than just diet quality is a better way to encourage weight loss during the postpartum period. The participants in the KAN-DO study were not asked to keep track of their daily food intake, but Leermakers et al asked their participants to record their intake on a daily basis and they found that there was a significant correlation between weight loss and completion of self-monitoring records. This may be another way to make postpartum women more conscious of what they are eating as a way to make better diet-related choices to help them reduce postpartum weight retention.

This study also aimed to determine predictors of weight change from early postpartum to ten months later. Although diet quality did negatively influence weight change (higher HEI-2005 score associated with increased weight loss), it was not a significant predictor ($p=0.07$). However, what did come out significant was the amount of baseline kilocalories consumed. This again illustrates that energy intake is more important for weight loss than diet quality. This also showed that women that had part-time jobs lost more weight than those who stayed at home or worked full-time. It may be that mothers with a part-time job have more time to exercise and cook healthy meals at home for the family than moms who work full-time, but do not snack as much as stay at home moms who have free access to food in the home environment (spend less time sitting at home eating snacks from the kitchen cupboards).

Other studies have reported women who breastfeed lose more weight in the postpartum period than those who do not breastfeed [48-50]. However, women in the current study who breastfed for a higher intensity/longer duration (lactation score ≥ 12) reported less of a weight decrease, not more like one may expect. Energy intakes were compared between the women with lactation scores <12 and ≥ 12 and, on average, the women with higher lactation scores consumed more kilocalories at baseline and endpoint which may explain the observed results. Baker et al found that breastfeeding intensity and duration was related to weight loss in the postpartum period, but only for women with a BMI of <35 kg/m^2 [49]. It had no effect on weight loss in women who were classified as class II (BMI=35-39.9 kg/m^2) or class III (BMI ≥40 kg/m^2) obese. With twenty eight percent of our study participants in the longitudinal study classified as class II or class III obese, our results are similar to what Baker et al found [49].

This home-based intervention focused on improving diet quality to reduce postpartum weight retention, but did not prove successful for overweight and obese women to significantly improve their diet quality or help lose more weight. The postpartum period is a time of great change for many women with added home and childcare responsibilities. With an overall attrition rate of 23% and low participation rates in the intervention group, many of the postpartum women had a hard time staying committed to the intervention program. This is similar to what other studies have found [22, 26, 27].

In summary, women that have a lower BMI, a higher income, and choose to breastfeed have a healthier diet quality during the early postpartum period. However, the women who breastfed for a high intensity/long duration did not lose more weight than those moms who breastfed for a low intensity/short duration or did not breastfeed. For the KAN-DO intervention, it did not result in significant changes in diet quality or weight change. To better assist women in losing weight during the postpartum period, the focus should be on reducing total energy intake in addition to the quality of the diet. Diet quality is important for overall health, but what seems to be more important for weight loss is total energy consumed.

Although overweight and obese postpartum women who breastfeed may eat a healthier diet, our study showed that those who breastfed for a higher intensity/longer duration ate more energy both at baseline and endpoint. This led to less weight loss for these women compared to the women who did not breastfeed or who breastfed for a lower intensity/shorter duration. Therefore, if women are encouraged to breastfeed they should also be given accurate information on how many extra daily calories, if any, that they need. The data from this study's results collectively show that what matters is total energy intake for weight loss during the postpartum period, and this should be the focus of future interventions.

Table 1.* List of Healthy Eating Index-2005 components and the standards used for scoring.

Component	**Score Range**	**Standard for maximum score**	**Standard for minimum score of zero**
Total Fruit (includes 100% juice)	0 – 5	≥ 0.8 cup/1000 kcal	No fruit
Whole Fruit	0 – 5	≥ 0.4 cup/1000 kcal	No whole fruit
Total Vegetables	0 – 5	≥ 1.1 cup/1000 kcal	No vegetables
Dark green and orange vegetables and legumes	0 – 5	≥ 0.4 cup/1000 kcal	No dark green and orange vegetables or legumes
Total Grains	0 – 5	≥ 3.0 cup/1000 kcal	No grains
Whole Grains	0 – 5	≥ 1.5 oz/1000 kcal	No whole grains
Milk	0 – 10	≥ 1.3 cup/1000 kcal	No milk
Meat and Legumes	0 – 10	≥ 2.5 oz/1000 kcal	No meat or legumes
Oils	0 – 10	≥ 12 g/1000 kcal	No oil
Saturated Fats	0 – 10	≤ 7% of energy	≥ 15% of energy
Sodium	0 – 10	≤ 0.7 g/1000 kcal	≥ 2.0 g/1000 kcal
Energy from solid fat, alcohol, and added sugars (SoFAAS)	0 – 20	≤ 20% of energy	≥ 50% of energy
* Table modified from reference [39]			

Table 2. Titles of the intervention kits.

Kit Number	**Title**
1	*Building a healthy home*
2	*Family Mealtimes*
3	*Feeding the Family*
4	*Planning Meals*
5	*Active Family*
6	*Get Moving*
7	*Overcoming roadblocks*
8	*Staying KAN-DO (Kids and Adults Now Defeat Obesity)*

Table 3: Baseline characteristics of mothers in the KAN-DO study.

Variable	Baseline (n=392) % (n)
Age, years (mean, SD)	32.6 (4.9)
Race	
White/other	78 (307)
Black	22 (85)
Body Mass Index (kg/m^2)	
Overweight (25 – 29.9)	39 (153)
Obese class I (30 – 34.9)	32 (126)
Obese class II (35 – 39.9)	17 (68)
Obese class III (≥40)	12 (45)
Lactation Status	
Fully breastfeeding	41 (159)
Mixed feeding	21 (83)
Fully formula feeding	38 (150)
Education	
≤ 12th grade	11 (45)
Some college or vocational	20 (77)
College graduate	42 (166)
Graduate school	27 (104)
Household Income *	
Up to $15,000	10 (38)
$15,001 -- $30,000	9 (35)
$30,001 -- $60,000	24 (93)
$60,001 +	56 (220)
Marital Status	
Single	13 (51)
Married	87 (341)
Parity	
Second	68 (267)
Third	21 (82)
Fourth or more	11 (43)
Mother's Work Status	
Full time	30 (116)
Part time	19 (75)
Not paid for work	51 (201)
Mother's Smoking Status **	
Current smoker	5 (20)
Non-smoker	95 (371)

Depression Screen †	
Positive screen	83 (327)
Negative screen	17 (65)

* = missing information for 6 participants
** = missing information for 1 participant
† According to the Edinburgh Postnatal Depression Scale [35]

Table 4: Average HEI-2005 component scores and total score and the percent meeting recommendations for the HEI-2005 scores at baseline (n=392).

HEI-2005 Category	Score Range	Average Score Avg (SD)	Recommendations per 1,000 kcal	% Meeting Recommendation
Total Fruit	0 – 5	1.9 (1.8)	≥ 0.8 c	13%
Whole Fruit	0 – 5	2.1 (2.0)	≥ 0.4 c	20
Total Vegetables	0 – 5	3.2 (1.4)	≥ 1.1 c	21
Dark Green and Orange Vegetables and Legumes	0 – 5	2.2 (1.9)	≥ 0.4 c	20
Total Grains	0 – 5	4.7 (0.6)	≥ 3.0 oz	72
Whole Grains	0 – 5	2.7 (1.9)	≥ 1.5 oz	25
Milk	0 – 10	6.3 (3.1)	≥ 1.3 c	24
Meat and Legumes	0 – 10	8.7 (2.2)	≥ 2.5 oz	57
Oils	0 – 10	10.0 (0.3)	≥ 12 gm	97
Sodium	0 – 10	3.4 (2.6)	≤ 700 mg	1
Saturated Fat	0 – 10	5.7 (3.4)	≤ 7% of total kcal	9
SoFAAS †	0 – 20	13.6 (4.7)	≤ 20% of total kcal	13
Total HEI-2005 Score	0 – 100	64.4 (11.4)	> 80	9

† Energy from solid fat, alcohol, and added sugar

Table 5: Average HEI-2005 scores from bivariate analyses with baseline characteristics of participants (n=392).

Variable	HEI-2005 Score	p-value
Lactation Status		**<0.001**
Fully breastfeeding	66.6	
Mixed feeding	66.5	
Fully formula feeding	60.9	
Race		**<0.001**
White/other	65.4	
Black	60.6	
Body Mass Index (kg/m^2)		**<0.002**
Overweight (25 – 29.9)	66.2	
Obese class I (30 – 34.9)	64.9	
Obese class II (35 – 39.9)	63.2	
Obese class III (≥ 40)	58.9	
Education		**<0.0001**
≤ 12^{th} grade	57.4	
Some college of vocational	61.4	
College graduate	65.4	
Graduate school	68.1	
Household Income *		**<0.0001**
Up to $15,000	53.1	
$15,000 - $30,000	60.9	
$30,001 - $60,000	66.0	
$60,000 +	66.4	
Marital Status		**<0.001**
Single	56.2	
Married	65.6	
Parity		**0.03**
Second	65.3	
Third	63.3	
Fourth or more	60.7	
Mother's Work Status		0.25
Full time	64.6	
Part time	66.2	
Not paid for work	63.6	
Mother's Smoking Status **		**<0.001**
Current smoker	53.9	
Non-smoker	65.0	

Depression Screen †		0.19
Negative screen	64.7	
Positive screen	62.7	
*= missing information for 6 participants **= missing information for 1 participant † According to the Edinburgh Postnatal Depression Scale [35]		

Table 6: Predictors of diet quality for overweight and obese women during the early postpartum period.

Variable	Effect Size	p-value
Intercept	67.2	<0.0001
Mother's Age		
Avg: 32.6 years	0.09	0.49
BMI		
Avg: 32.8	-0.25	**0.02**
Lactation Status		
Fully breastfeeding	reference	
Mixed feeding	1.20	0.42
Fully formula feeding	-3.01	**0.02**
Race		
White/other	reference	
Black	-1.12	0.46
Marital Status		
Single	reference	
Married	-0.06	0.98
Household Income		
Up to $15,000	reference	
$15,001 – $30,000	8.40	**0.002**
$30,001 - $60,000	10.07	**<0.001**
$60,001 +	8.76	**0.002**
Education		
≤ 12th grade	reference	
Some college or vocational	0.77	0.72
College graduate	1.45	0.53
Graduate school	3.99	0.10
Parity		
Second	reference	
Third	-0.31	0.82
Fourth or more	-2.50	0.18
Mother's Work Status		
Not paid for work	reference	
Part-time	0.96	0.50
Full-time	-0.47	0.73
Mother's Smoking Status		
Current smoker	reference	
Non-smoker	1.81	0.52
Depression Screen		
Positive screen	reference	
Negative screen	1.23	0.39

Table 7: Baseline characteristics of KAN-DO participants by group.

Variable	Control (n=145) % (n)	Intervention (n=131) % (n)	p-value ***
Age, years (mean, SD)	33.7 (4.3)	33.3 (4.6)	0.52
Race			0.79
White/other	83 (120)	84 (110)	
Black	17 (25)	16 (21)	
Body Mass Index (kg/m^2)			0.30
Overweight (25 – 29.9)	39 (56)	44 (57)	
Obese class I (30 – 34.9)	30 (44)	32 (42)	
Obese class II (35 – 39.9)	21 (30)	12 (16)	
Obese class III (≥ 40)	10 (15)	12 (16)	
Lactation Status			0.36
Fully breastfeeding	50 (73)	44 (58)	
Mixed feeding	14 (20)	(26)	
Fully formula feeding	36 (52)	(47)	
Education			0.77
≤ 12th grade	9 (13)	7 (9)	
Some college or vocational	17 (25)	16 (21)	
College graduate	46 (67)	44 (58)	
Graduate school	28 (40)	33 (43)	
Household Income *			0.43
Up to $15,000	6 (8)	6 (8)	
$15,001 -- $30,000	8 (11)	4 (5)	
$30,001 -- $60,000	22 (32)	28 (36)	
$60,001 +	64 (93)	60 (79)	
Marital Status			0.97
Single	8 (12)	8 (11)	
Married	92 (133)	92 (120)	
Parity			0.20
Second	67 (97)	76 (99)	
Third	23 (33)	15 (19)	
Fourth or more	10 (15)	10 (13)	
Mother's Work Status			0.81
Full time	30 (44)	29 (38)	
Part time	21 (30)	18 (24)	
Not paid for work	49 (71)	53 (69)	
Mother's Smoking Status **			0.44
Current smoker	3 (5)	5 (7)	
Non-smoker	97 (140)	95 (124)	

Depression Screen †			0.73
Negative screen	86 (125)	85 (111)	
Positive screen	14 (20)	15 (20)	
* = missing information for 6 participants ** = missing information for 1 participant *** = Independent t-tests for differences in means; chi-square test for differences in proportions † According to the Edinburgh Postnatal Depression Scale [35]			

Table 8: Average HEI-2005 composite scores and total score at baseline and endpoint for the participants in the intervention and control groups.

	Control (n = 145)		Intervention (n = 131)	
	Baseline (SD)	Endpoint (SD)	Baseline (SD)	Endpoint (SD)
Total Energy	2076 (547) kcal	1840 (520) kcal	2013 (607) kcal	1760 (516) Kcal
Total Fruit	1.9 (1.8)	1.9 (1.8)	1.9 (1.7)	2.0 (1.7)
Whole Fruit	2.1 (2.0)	2.2 (2.0)	2.3 (2.1)	2.5 (2.0)
Total Vegetables	3.1 (1.4)	3.1 (1.5)	3.3 (1.4)	3.2 (1.5)
Dark Green and Orange Vegetables and Legumes	2.2 (1.9)	2.2 (2.0)	2.4 (1.9)	2.1 (2.0)
Total Grains	4.8 (0.5)	4.7 (0.7)	4.7 (0.7)	4.7 (0.7)
Whole Grains	3.0 (1.9)	2.9 (1.8)	2.9 (1.9)	2.9 (1.8)
Milk	6.4 (3.1)	7.0 (2.8)	6.7 (3.0)	6.4 (3.0)
Meat and Legumes	8.4 (2.2)	8.7 (2.2)	8.9 (2.0)	8.7 (2.1)
Oils	10.0 (0.1)	10.0 (0.4)	10.0 (0.3)	10.0 (0.3)
Sodium	3.7 (2.7)	3.4 (2.7)	3.3 (2.6)	2.9 (2.7)
Saturated Fat	5.7 (3.4)	5.6 (3.4)	5.5 (3.5)	5.3 (3.5)
SoFAAS †	13.8 (4.9)	14.3 (4.8)	13.9 (4.5)	14.5 (4.4)
Total Score	65.0 (11.8)	66.0 (11.9)	65.9 (11.2)	65.4 (11.1)

† Energy from solid fat, alcohol, and added sugar

Table 9: Percent of participants meeting recommendations for the HEI-2005 components and total HEI-2005 score at baseline and endpoint.

	Control (n=145)		Intervention (n=131)	
	Baseline	Endpoint	Baseline	Endpoint
Total Fruit	15%	13%	11%	12%
Whole Fruit	19	22	25	25
Total Vegetables	19	21	23	26
Dark Green and Orange Vegetables and Legumes	19	22	23	23
Total Grains	75	74	71	77
Whole Grains	30	26	27	29
Milk	28	26	26	24
Meat and Legumes*	50	66	62	59
Oils	99	99	98	99
Sodium	1	0	0	0
Saturated Fat	9	8	8	8
SoFAAS †	15	15	9	17
Total Score	12	15	8	16

* $p < 0.01$
† Energy from solid fat, alcohol, and added sugar

Table 10: Predictors of weight change for overweight and obese women from 6 months to 16 months postpartum (n=258).

Variable	Effect size	p-value
Intercept	0.73	0.86
Baseline weight		
Avg: 87.1 kg	0.03	0.22
Baseline HEI-2005 score		
Avg: 65.7	-0.05	0.07
Baseline energy intake		
Avg: 2060 kcal	0.0013	**<0.03**
Mother's Age		
Avg: 33.6 years	-0.08	0.31
Group		
Control	reference	
Intervention	-0.52	0.40
Lactation Score		
Score 0-11	reference	
Score 12-24	1.65	**<0.02**
Race		
White/other	reference	
Black	0.21	0.82
Household Income		
Up to $15,000	reference	
$15,001 – $30,000	-1.36	0.55
$30,001 - $60,000	-2.39	0.25
$60,001 +	-1.79	0.39
Education		
≤ 12th grade	reference	
Some college or vocational	1.19	0.44
College graduate	0.12	0.94
Graduate school	-0.25	0.88
Marital Status		
Single	reference	
Married	-0.17	0.92
Parity		
Second	reference	
Third	-0.55	0.51
Fourth or more	-0.86	0.44
Mother's Work Status		
Not paid for work	reference	
Part-time	-0.33	0.68
Full-time	2.25	**<0.005**

Mother's Smoking Status		
Current smoker	reference	
Non-smoker	-1.60	0.39
Depression Screen		
Positive screen	reference	
Negative screen	-1.53	0.11

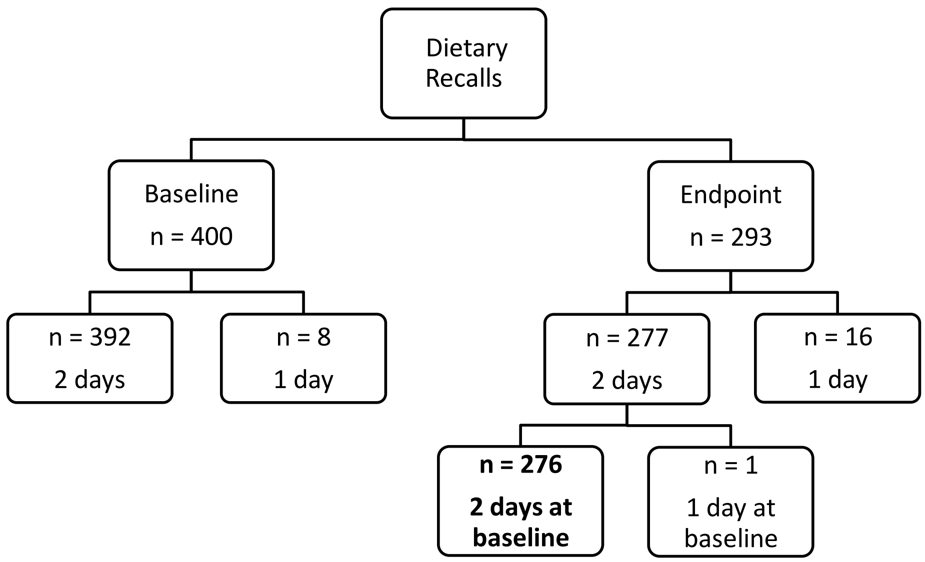

Figure 1. Number of participants that completed dietary recalls at baseline and endpoint. A total of 276 women completed two dietary recalls at both time points.

CHAPTER IV

EPILOGUE

This study addressed diet quality and weight loss for overweight and obese women during the postpartum period. Results showed that women who breastfeed their infant, have a lower BMI (are overweight rather than obese), and have a household income over $15,000 are more likely to have a healthier diet quality during the early postpartum period. Although weak, a negative relationship was shown between the women's baseline dietary quality and weight change over time (r^2=0.04). However, after controlling for other variables that could also affect weight change over time, diet quality no longer significantly influenced weight change (p=0.07). The results showed that baseline energy intake was more important than diet quality on influencing weight change among these women.

This point addresses the need to not just focus on eating healthier during the postpartum period. Although diet quality is important to ensure adequate intake of vitamins/minerals and other important nutrients, it does not have a significant effect on weight loss. To better address weight loss during the postpartum period, energy intake should be the primary focus. However, our study did not specifically address recommended energy intake for weight loss or self-monitoring methods to record daily intakes. If women begin to lose weight by following energy restrictions, then they may also be driven to begin switching some of their unhealthier food items for healthier ones, which will then lead to improvement of their overall diet quality as well. Many people eat healthier food items when they are trying to lost weight, but it ultimately comes down to the total amount of energy consumed that will lead to significant weight loss.

To measure diet quality for this study, we used the Healthy Eating Index-2005 tool, which was created in 2007 to reflect the 2005 Dietary Guidelines for Americans. Although the HEI-2005 is a validated method to measure diet quality [14], there are still some limitations of using this method. They include that total energy intake is not directly considered, and that the discretionary calories from the SoFAAS component and saturated fat are heavily weighted. The SoFAAS component is worth more than any other component, at 20 points (or 20% of the total score). Saturated fat has its own component worth 10 points and is also part of the solid fats in the SoFAAS component. According to the HEI-2005 technical report, the SoFAAS category is weighed more heavily because discretionary calories are consumed far in excess of the 2005 Dietary Guidelines recommendations [40]. Also, this method of measuring diet quality does not account for excess intake for the adequacy components.

The average HEI-2005 score at baseline for the women in this study was already higher than the average American. And no other research that has reported HEI-2005 scores for populations in the United States has reported an average higher than the women from this study. Therefore, women in this study may have already been a healthier group making it harder for us to be able to see significant improvements in their diets.   The other issue is that they could have underreported unhealthier foods and/or over reported healthier foods which would have falsely inflated their HEI-2005 scores.

Future interventions with this population should begin while the women are pregnant and continue during the postpartum period. Many women gain above what is recommended by the Institute of Medicine (IOM) for healthy gain weight during pregnancy, which is especially problematic for women who are already overweight or obese. Since it has been reported that excessive weight gain during pregnancy is one of the primary risk factors for significant postpartum weight retention [2], intervening during the pregnancy period for women who are overweight or obese may be beneficial to help prevent women from gaining excess weight.

To conclude, multiple factors contribute to the quality of women's diets during the early postpartum period. And although one would expect higher diet quality to correlate with increased weight loss over time, energy intake is even more important in determining amount of weight change from 6 to16 months postpartum. Interestingly, women who breastfed for a longer duration or higher intensity ate more energy at baseline and endpoint, leading to less weight loss among this group compared to the women who did not breastfeed or who breastfed for a shorter time or lower intensity. This reveals a possible misconception about how many extra calories women think they need to maintain a healthy milk production. Although the intervention conducted with this study did not result in significant improvements for diet quality, energy intake or weight loss, the women who had the highest participation (completed ≥4 phone calls and returned ≥4 postcards) showed the greatest reductions in their BMI scores. This suggests that that material within the intervention and the phone calls were helpful for the women who put the time and effort into implementing the information from the intervention into their daily lives.

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