A Case Study: Implications of Energy Density on Weight Loss

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INTRODUCTION

Obesity increases risk of chronic diseases, including cardiovascular disease, type 2 diabetes, and musculoskeletal disorders. Weight loss for obese/overweight individuals is a difficult process with which many Americans struggle. Diet and weight loss plans may fail because of low satiety levels related to current methods used for weight loss (1). One strategy to improve satiety has been to alter the energy density (ED) of foods. ED is the energy content in a given weight of food (kcal/g) (2). Choosing foods lower in energy content while maintaining or increasing the volume of the food aids in satiety. Research has shown that foods with low ED, typically high in non-energy containing components (water and/or fiber), increase satiety more than a similar volume or weight (g) of higher ED foods (3). By altering diet behaviors to incorporate more low ED foods (fruits, vegetables, cooked whole grains), satiety is maintained while overall energy intake is reduced, resulting in weight loss. It has been proposed that people regulate daily dietary intake based on volume rather than energy content (4). Thus, a diet that focuses on more low ED foods could prove to be useful for sustained weight loss or maintenance. Our case study focused on the application of this theory by identifying the changes in intake of low ED foods in relation to changes in weight of 4 sedentary, abdominally obese, premenopausal women during a 16 week energy-reduced diet and high intensity exercise intervention.

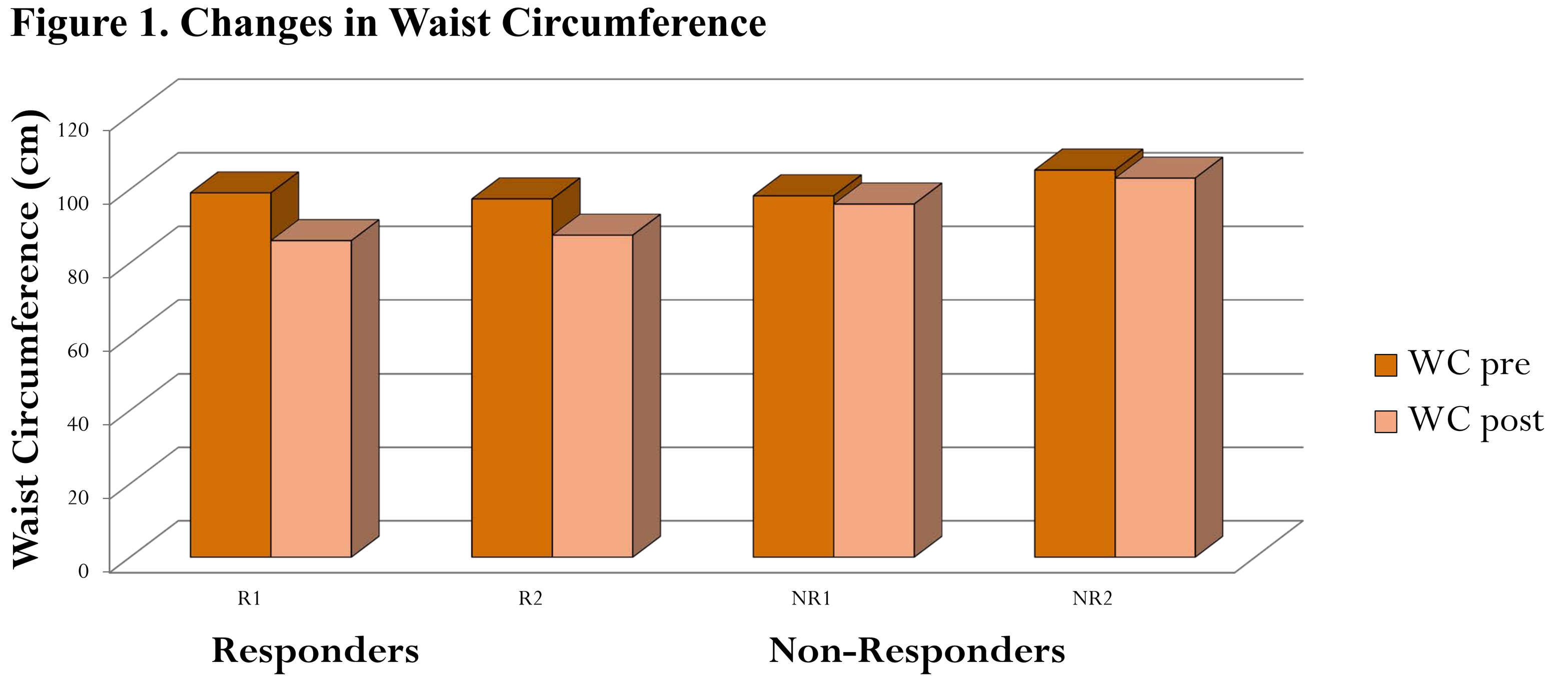
Table 1. Baseline Demographics

Participants	Age (yrs)	Height (in)	Weight (kg)	BMI (kg/m2)	WC (cm)	ED (kcal/g) w/Bev.	ED (kcal/g) w/o Bev.
R1	41	65.7	81.2	29.1	99.0	1.32	1.74
R2	36	63.0	71.2	27.8	97.3	1.12	1.67
NR1	26	68.0	86.0	28.8	98.2	1.22	1.70
NR2	46	66.0	89.8	32.0	105.2	0.80	1.57

METHODS and PROCEDURES

For the purpose of this case study, 4 participants were selected from a larger study focusing on the effects of a diet and physical activity (PA) intervention on the reduction of risk factors for metabolic syndrome in sedentary, premenopausal (21-48y), overweight (BMI 26-32kg/m^2), abdominally obese (waist circumference [WC >80cm; 31.50in]), apparently healthy women . The intervention from the larger study occurred in two phases. Phase I consisted of weekly nutrition education classes and a PA conditioning program. Phase II required participants to attend Zumba exercise classes 3d/wk (30-60min) for 12 weeks. Both phases included ~300kcal/d dietary energy decrease and were expected to produce a 1lb/wk (0.5kg/wk) weight loss. Two responders (R1, R2) and two non-responders (NR1, NR2) were chosen for evaluation of dietary ED. Participants who lost ≥1lb/wk were considered to be responders and those who lost ≤0.5lb/wk were considered to be non-responders.

Figure 1. Changes in Waist Circumference



Body composition was measured using Dual Energy X-Ray Absorptiometry (DXA) at baseline and post intervention. Participants matched on relative $VO_{2\ Max}$ changes. Participants kept 4-d dietary and PA records including at least one weekend day. Participants were provided with a calibrated scale and given verbal and written instructions for the completion of records. From the pre and post 4-d dietary records we calculated the daily ED (kcal/g) both including and excluding beverages (water excluded for both analyses). This approach was used to determine if beverage calories have an influence on dietary ED. Food Processor 10.4.0 (ESHA Research, Salem, Oregon) was used to calculate total energy (kcal) per weight (g) of food. The values for the 4-d records were averaged to find a value for mean dietary ED. We also compared pre and post consumption of whole fruits (cups/d), whole vegetables (cups/d), whole grains (ser/d), and fiber (g/1000kcals) to further examine the ED of their diets. Using this information we compared the participants mean dietary ED and standard deviations (SD) to find the correlations, if any, between ED and weight loss.

RESULTS

The average weight lost by responders was 10.3kg and 0.9kg by non-responders. BMI decreased in 3 of 4 participants. The responders lost an average of 3.6kg/m^2 while non-responders lost 0.2kg/m^2. WC in responders decreased by an average of 11.4cm (4.3in) from baseline, 9.2cm (3.6in) more than non-responders (Figure 1). On average, responders decreased dietary ED by 0.40kcal/g (SD=0.07) including beverages and 0.53kcal/g (SD=0.28) excluding beverages, while non-responders increased ED by 0.02kcal/g including beverages and decreased ED by 0.18kcal/g (SD=0.29) excluding beverages. Responders decreased ED by 0.38kcal/g more than non-responders. See figures 2 & 3 for comparisons in dietary ED change.
Consumption of whole servings of fruits, vegetables, and fiber/1000 kcals all increased in the diets of the responders while they decreased for non-responders (see Figure 4). Responders consumed an average of 2.09 more servings of vegetables than non-responders and 1.57 more servings of fruits, and 8.81g/1000kcals more fiber. See figure 4 for the changes participants made in consumption of whole foods, fiber, and percent composition of fat in their diets.

Figure 2. Average Dietary Energy Density Pre and Post-Intervention Including Beverages

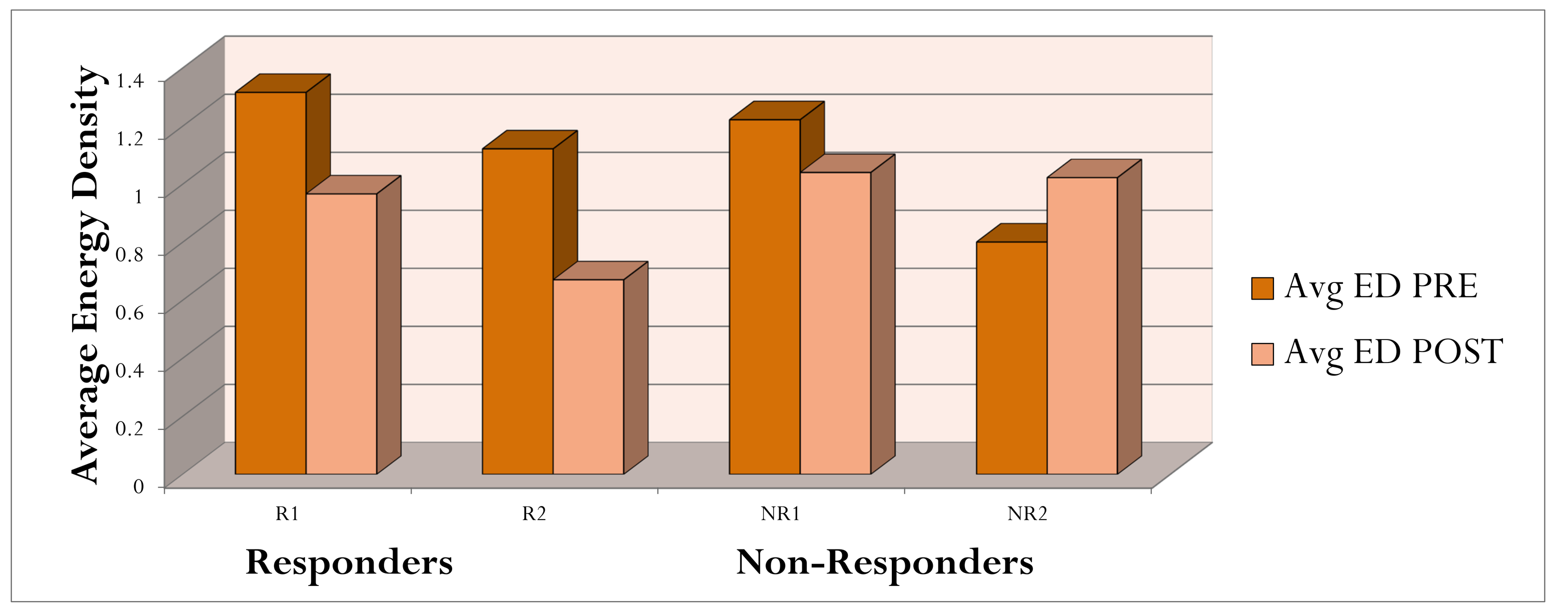


Figure 3. Average Dietary Energy Density Pre and Post-Intervention Excluding Beverages

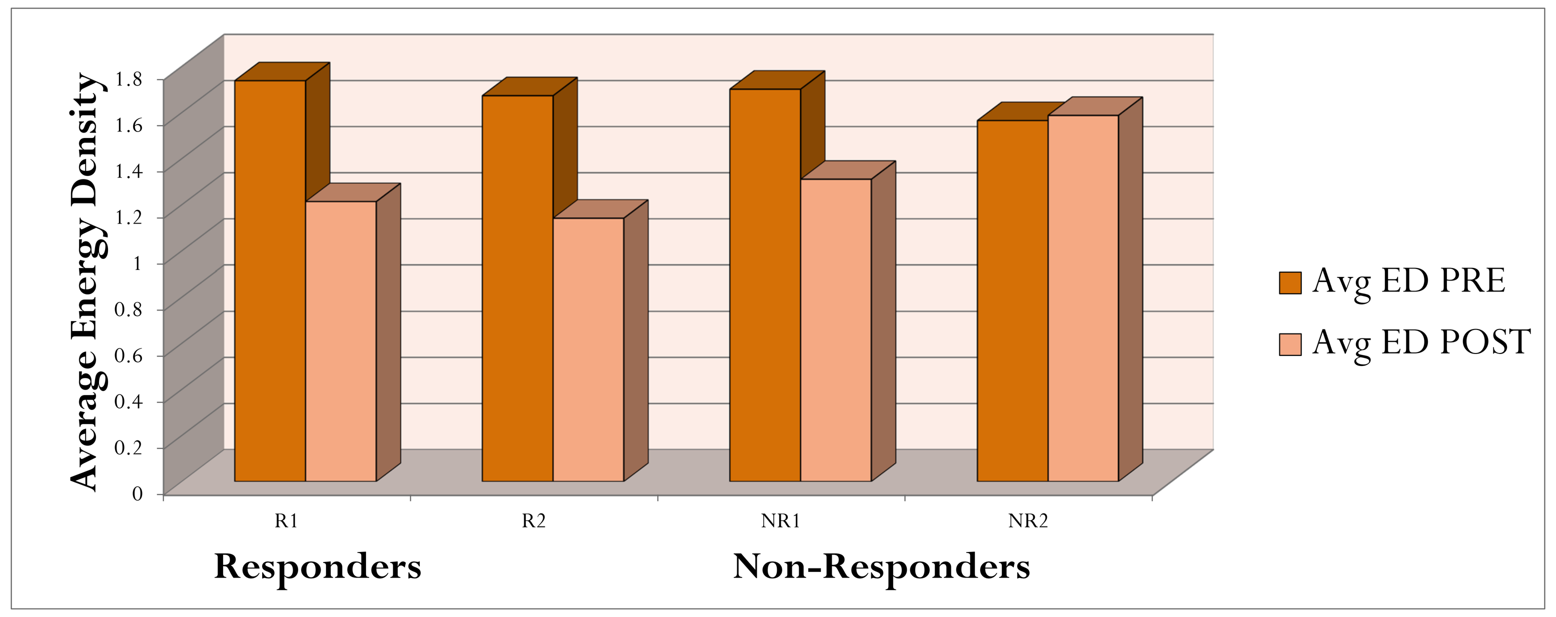


Figure 4. Changes in Consumption of Whole Foods and Percentage of Fat

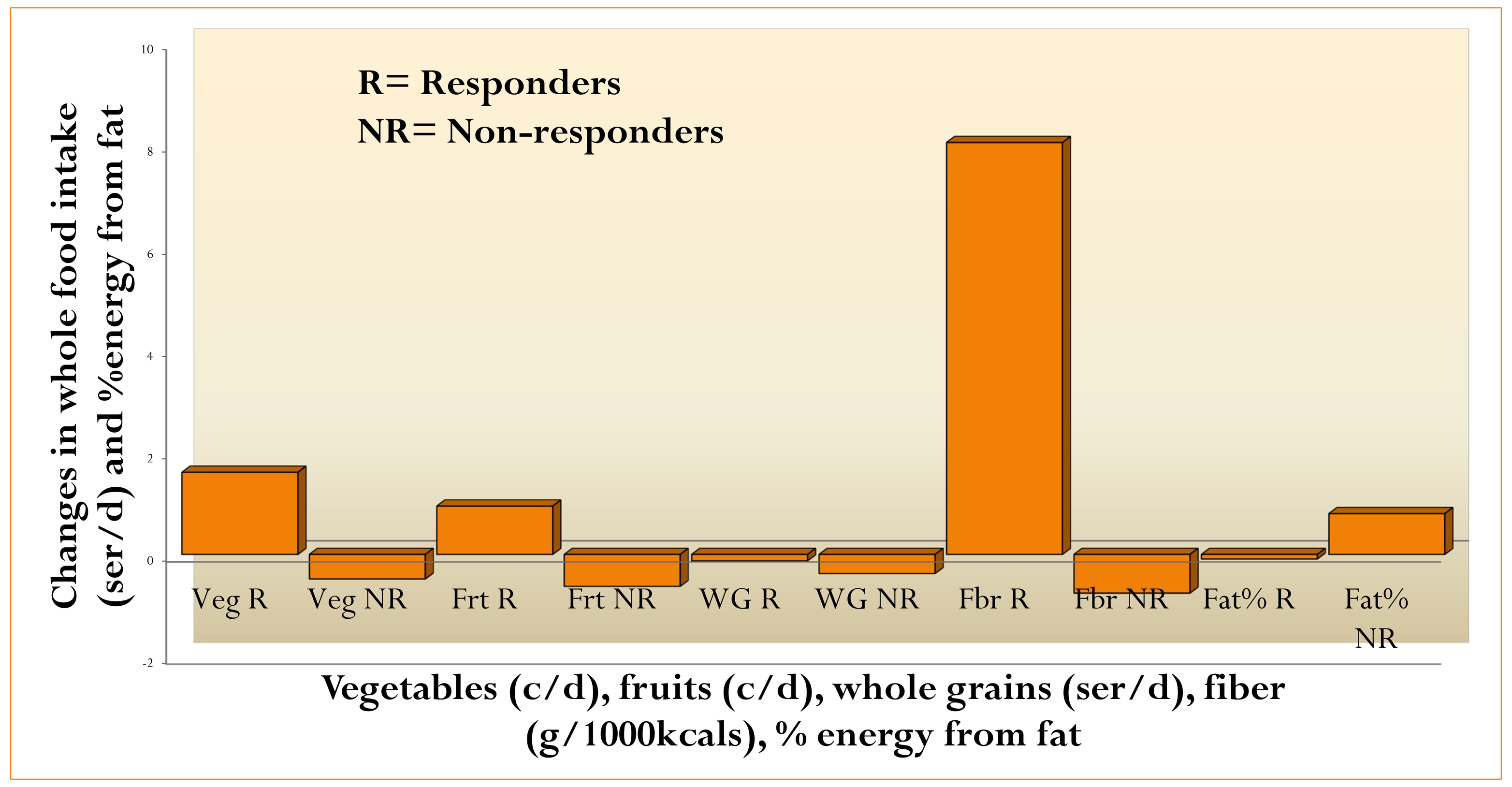
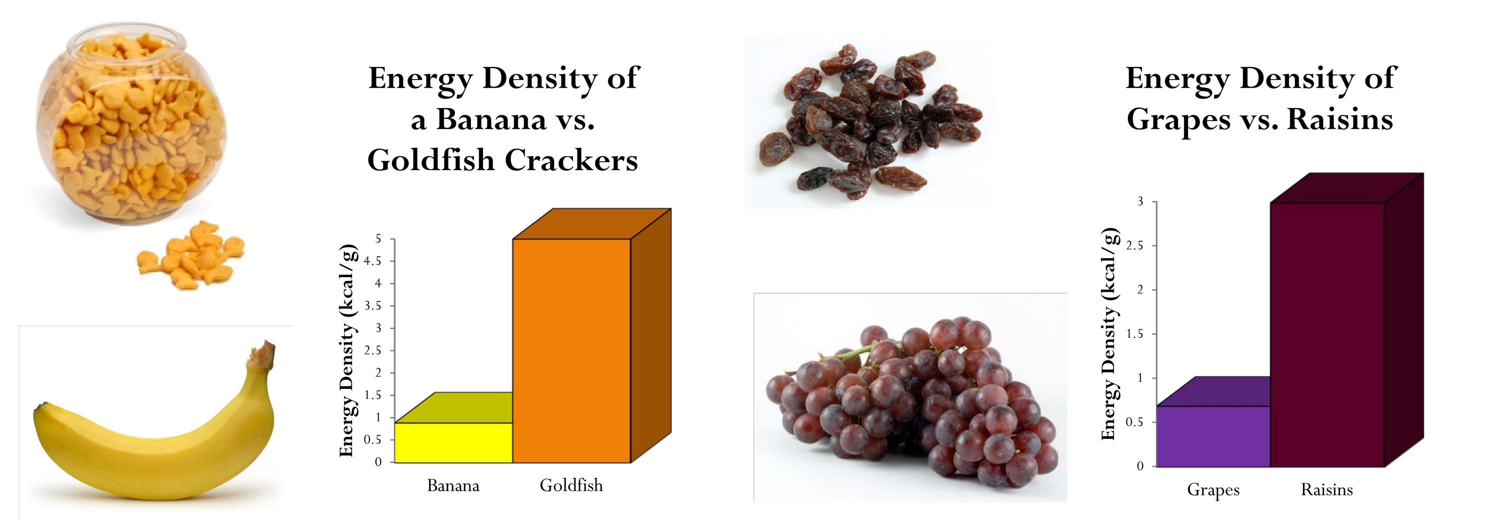


Figure 5. Energy Density of Some Common Snacks



CONCLUSIONS

Our results showed that the average ED change was lower for responders both with and without beverages. Without beverages, NR1's average ED difference was similar to the responders' values, however, with beverages the value increased. This could be explained by an intake of high ED liquids such as flavored lattes, cocktails, and eggnog. This would increase energy consumption but would not provide satisfactory levels of satiety (2). Our case study showed that a decrease of 0.35kcal/g in ED, while including beverages and a decrease of 0.52kcal/g in ED, without including beverages, were accompanied by weight loss. An analysis of the dietary records showed that weight loss occurred with an increase in intake of whole fruits, whole vegetables, and grams of fiber/1000kcals. Thus an increase in the consumption of whole foods and fiber accompany weight loss. With beverages included in the analysis, the responders' ED decreased more than when beverages were excluded. In comparison, the non-responders post intervention diets increased in ED when including beverages as opposed to excluding beverages (Figures 2 & 3). At post-intervention, non-responders consumed more calories through beverages than did responders. Energy intake from beverages impact overall ED of diet, indicating the importance of decreasing energy intake from beverages for weight loss.

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