Published in final edited form as:
Obes Surg. 2014 November ; 24(11): 1926–1932. doi:10.1007/s11695-014-1259-1.

Changes in nutrients and food groups intakes following laparoscopic Roux-en-Y gastric bypass (RYGB)

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Abstract

Introduction/Purpose—Serial changes in dietary intake, including specific food groups and nutrients during the first year following RYGB is of interest due to surgically-induced alterations in meal size, food intolerances present after surgery, and potential nutrient deficiencies. To help improve the nutritional health of surgical patients, this study's purpose was to examine changes in macro- and micronutrients, food groups, and selected foods during 12-months of follow-up in post RYGB individuals.

Materials and Methods—RYGB patients (n=17) completed four-day food records at baseline (prior to surgery) and then at 3-wks, 3-mos, 6-mos, and 12-mos after surgery. Mean daily intake was determined at each time for energy intake, macro- and micronutrients, food groups, and selected foods in targeted food groups.

Results—A dramatic decrease in mean (±SEM) daily energy intake occurred: 2,150±165 kcals at baseline vs. 649±40 kcals at 3-wks; energy intake continually increased to a high of 1307±129 kcals by 12-mos. More than 50% of patients had low intake of vitamins D, E, C, folate, and calcium, magnesium, and potassium at 12-months. Servings from vegetables, grains, fats, and sweetened beverages were lower, whereas, meats, dairy, fruits, and sweets showed only small, transient changes following surgery.

Conclusions—The reduction in energy intake following RYGB is from selected food groups and not solely a reduction in portion sizes across the diet. The lower intake of micronutrients indicates potential risk for deficiencies unless supplements are used. These findings can help in the clinical management of surgical patients to improve nutritional health.

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Conflicts of Interest Statement Dr. Miller has nothing to disclose.
Ms. Norris has nothing to disclose.
Dr. Fernandez has nothing to disclose

Keywords

dietary intake; bariatric surgery; food groups; macronutrients; micronutrients

Introduction

For individuals with obesity Roux-en-Y gastric bypass (RYGB) has been shown to be successful for weight-loss and amelioration of obesity comorbidities.(1) This restrictive and malabsorptive procedure causes surgery-induced anatomical and physiological changes to the gastrointestinal tract that can permanently alter food habits and eating patterns.(2–4) Avoidance of soda and sweet desserts were the most common foods/food groups to restrict post-surgery along with milk, red meats, and breads and cereals.(5) Dietary counseling aimed at modifying eating behavior is crucial for obtaining successful results in weight loss and overall health as well as reducing complications in post bariatric surgery patients.(5)

Severe dietary restriction occurs post-surgery and this is associated with adverse effects, such as unbalanced diet, protein malnutrition, and specific nutrient deficiencies.(6, 7) Thus, providing nutritional guidance to facilitate adequate nutrient and food group intake is required for good nutritional health. With dietary changes accompanying bariatric surgery, it is critical to understand potential trouble areas that may lead to compromised health in post-surgical patients. Additionally, comprehending serial changes in diet that may be associated with relapse or ineffective weight management is valuable for counseling patients following bariatric surgery. Thus, this current analysis focused on studying changes in nutrient intake, as well as food groups and selected types of foods in food groups were assessed in RYGB patients prior to surgery (baseline) and at 4 time points post-surgery (3-weeks, 3-months, 6-months, and 12-months). Comparisons were made between nutrient intakes with recommended values from the Dietary Reference Intakes (DRIs).

Methods and Methods

Study Population

Patients scheduled for laparoscopic RYGB surgery at Wake Forest University Baptist Medical Center were recruited. To be eligible for the research study, patients must have had a minimum BMI of 40.0 kg/m^2 or 35.0 kg/m^2 with an obesity-related comorbidity; willing to report to the medical center to undergo testing procedures at the scheduled times; and plans to remain in the area for the duration of the study. The procedures for the ethical use of human volunteers were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Approval for the study was obtained by the Institutional Review Board of Wake Forest University Health Sciences (#BG05-087). Staff from the general surgery clinic obtained consent for study participation.

All study participants maintained their normal post-surgery visits and received the standard treatment associated with the clinic. This included nutrition counseling by a registered dietitian (A. Norris) with the encouragement for taking a multivitamin and mineral supplement formulated for bariatric surgery patients.

Outcome Variables

Data were collected at baseline (pre-surgery), and 3-weeks, 3-months, 6-months, and 12-months post-surgery. At each of these time points, participants reported to the General Clinical Research Center (GCRC) of Wake Forest University Baptist Medical Center after a 12-hour overnight fast for the following measures.

Body Weight and Height—Using standard techniques body weight and height were determined with shoes, jackets and outer garments removed.

Dietary Intake—Participants were instructed on the completion of a 4-day food record with subsequent nutrient analysis using the Minnesota Nutrition Data System for Research (NDS-R), by a research nutritionist at the GCRC. Four-day averages of total energy, and macro- and micronutrients, as well as for food groups as categorized by NDS-R, were determined for each time point.

The age and gender specific Estimated Average Requirement (EAR) of the Dietary Reference Intake (DRI), when available, was used as a guide to assess the prevalence of nutrient inadequacy in a group. For a number of vitamins and minerals, the EAR has not yet been determined, therefore the Adequate Intake (AI) of these micronutrients was used.

Data Analyses

Repeated measures analysis of covariance was used to assess the dietary intake variables across time, as well as body weight and weight loss. Estimated marginal means ± standard error of the mean are presented from the analysis. Covariates in the model were age, gender, and race. Statistical significance was set at $p \leq 0.05$. All analyses were performed on PASW® version 21.0 (Chicago, IL).

Results

A total of 27 individuals had baseline testing had surgery. Seventeen (16 women and 1 man; 15 white; age = 47.3±2.2 years (mean±SEM)) were included in the analysis as 6 withdrew from the study and 4 others did not have dietary data for at least one of the follow-up periods. There were no differences in demographics and baseline data from the 17 included in the dietary analysis and those that dropped or had incomplete data.

At baseline, body weight was 144.5±5.5 kg, ranging from 98.3 to 193.9 kg with a mean BMI of 53.6±1.7 kg/m^2. Weight loss was 7.9±0.4% at 3-weeks, 17.3±0.6% at 3-months, 25.5±1.2% at 6-months, and 33.2±1.6% at 12-months. Excess weight loss was 14.3±0.9%, 31.4±1.9%, 46.4±2.8%, and 58.3±3.2% at 3-weeks, 3-months, 6-months and 12-months, respectively. Weight loss was significantly greater at each subsequent time point.

Daily mean intake of total energy and macro- and micronutrients at each time point is shown in Table 1. As expected, energy intake was lower at each post-surgery time compared to baseline. Furthermore, total energy consumption was lowest at 3-weeks and was significantly higher at each proceeding period. Consistent with this, the absolute intake of the individual macronutrients (g/day) were highest at baseline and remained lower than baseline during each follow-up point. Expressed per kg of ideal body weight, protein intake was lowest at 3-weeks with no differences between baseline and 3-, 6-, and 12-months. Relative fat and carbohydrate intake showed transient reductions from baseline, but by 12-months there were no differences with baseline values. Notable, dietary fiber, sugar and cholesterol intakes were lower at follow-up time points compared to baseline. Mean alcohol intake was negligible at each period. Micronutrients showed similar patterns of intake (Table 1). Values at baseline were highest, while intake at 3-weeks were lowest, for the vitamins and minerals. The intakes of each of these nutrients tended to increase from 3-weeks to 12-months, with some returning to baseline values by 12-months.

The intake of micronutrients, as well as protein (g protein/kg body weight) and dietary fiber, for each individual was compared to the EAR and AI of the DRI. Table 2 shows the percentage of participants *not* meeting the EAR or AI within a specific time period. Of the 18 nutrients monitored, at least 80% of the participants at baseline were meeting the EAR for 10 of the nutrients. Dietary fiber, vitamin D, and potassium had the highest number of participants (94–100%) not meeting the requirement. During follow-up, as total dietary intake decreased, the percent of participants not meeting the nutrient's requirement generally increased. No nutrients at 3-weeks and 3-months had 80% of the participants meeting the EAR and AI, and only 4 nutrients had at least 80% of the participants meeting the EAR and AI at 6- and 12-months.

To complement the analysis of nutrient intake, comparisons were also performed on food groups and selected types of foods within these groups (Table 3). Total number of servings from vegetables, grains, fats, and sweetened beverages all remained lower through 12-months compared to baseline. Fruits, meats, sweets, and beverages showed transient reductions in number of servings during follow-up post-surgery, but returned to baseline by 12-months. Number of servings from dairy products was not different from baseline at any time during follow-up. Although the total number of servings from grains decreased from more than 6 to 1 between baseline and 3-weeks, there was a gradual increase to nearly 4 servings at 12-months. This 2 serving decrease was attributed to less refined grains. Although meat servings decreased between baseline and 3-weeks, there was a gradual increase up to 12-months, which did not differ from baseline. For dairy, there were no changes across time for products classified as fat free, reduced fat, whole fat, and nondairy. Within the beverage category, intake of sweetened beverages was 0.84 servings at baseline and this decreased to nearly zero throughout follow-up. Servings from the fat category decreased from 4.48 to 0.86 from baseline to 3-weeks, and this remained below baseline at 1.89 servings at 12-months. Although, servings from the sweets category initially decreased from 2.17 at baseline to 0.58 at 3-weeks, by 12-months the number of servings surpassed baseline intake at 4.60 servings.

Discussion

While the success of bariatric surgery for the treatment of individuals with obesity has been well documented, few reports describe serial changes during the first-year post-surgery in dietary behaviors beyond energy and macronutrient intake. This time frame is where radical dietary alterations occur to accommodate physiological and anatomical changes from the surgery. This analysis demonstrates the shifts in dietary intake, leading to fluctuations in nutrient and food group consumption that potentially increases deficiency risks as well as lead to poor health outcomes, and can be applied in the clinical setting for improving nutritional health and weight loss success by being proactive and targeting potential areas of concern.

RYGB appears to have good long-term success with reducing energy intake; by 2 and 4 years of follow-up energy intake did not return to baseline values in patients.(8, 9) A range of 1000 to 1800 kcals have been reported at 1-year follow-up.(8, 10–15) Even up to 4-years post-surgery, patients consumed only 1733 kcals (range 624–3486 kcals).(9) Our results showing a gradual increase in post-surgery energy intake over time is consistent with others.(10) Inherent with this low energy intake is a reduction in foods supplying essential dietary nutrients, as is described below.

The absolute and relative intake of macronutrients at baseline and throughout the follow-up period indicates the imbalance of these nutrients, namely low levels of protein and percent of total energy from carbohydrates, and excessive intake of total fats and specific fatty acids, with regards to the recent Dietary Guidelines for Americans and the DRI. It has been suggested that protein intake be increased during periods of weight loss to help glycemic control and ameliorate the reduction of lean body mass loss and basal metabolism.(16) By all standards, protein intake following surgery was below these marks, or marginal, at best.(5, 14, 17, 18) Achieving the higher protein diet can be troublesome for those following RYGB due to food intolerances and reduced energy intake.

Micronutrient deficiencies following bariatric surgeries are a concern, especially with RYGB as it is a restrictive and malabsorptive procedure, and as shown, patients have extremely low overall energy intake. Whereas vitamin and mineral supplements are commonly taken by post-surgery patients, over 85% take at least one form of supplement by 12–24 months after the procedure, there still remain reports for clinical deficiencies depending on the surgery type. The most frequently reported are vitamin B12, folic acid, vitamin D, vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B6, zinc, calcium, and iron.(11, 19–27) Other reports indicate the importance for addressing mineral deficiencies, such as copper, zinc, iron, and calcium.(28) Our data confirm the need for supplements as well as proper patient education as a high proportion of our participants were not meeting adequate levels of dietary intake for a number of micronutrients over the first year post-surgery. This underscores the importance of clinically monitoring vitamin and mineral deficiencies as dietary intake is unlikely to provide the required level of the nutrient.

At baseline, the number of servings from the various food groups indicates vegetables, total grains, and meats were consumed in adequate amounts based on the United States

Department of Agriculture Dietary Guidelines. However, fruits, milk/milk products, and whole grains were below these recommendations. Throughout the initial 6-months of follow-up, the over 50% reduction in energy intake compared to baseline likely led to the low number of servings in these food groups. Even at 12-months when intake was 1300 kcals, most of the suggested numbers of servings for these food groups were not being met. For fruits, nearly 60% were consuming <1.0 servings per day. About one-in-four were eating <1.0 serving per day of vegetables. Whereas recommendations are that at least 50% of grains come from whole grains, we found that this was about 25% at baseline, 6-months, and 12-months, and 40–50% at 3-weeks and 3-months. Refined grains constituted a much larger proportion of grain intake. Interestingly, the consumption of lean meats, as a proportion of total meat intake was worse at 12-months. In a similar trend, use of fat free dairy products, as a proportion of total dairy, was lowest at 12-months and consuming whole fat daily products was highest at this time. Thus, these findings indicate consumption of more fats from animal sources at 12-months relative to total intake. Unfortunately, data were not available to determine if the increase in sweets was accompanied by intolerances.

These findings and their interpretations are limited by a few methodological issues. The small sample, use of an extensive food record instrument for recording dietary intake, and the lack of an appropriate population specific nutrient recommendations limit the extrapolation to clinicians. It is recognized that several nutrients require higher intakes for post-bariatric surgery patients, but references are not provided by the DRI for these. Thus, it is likely that the potential dietary nutrient deficiencies are being underestimated in the current analysis, which may unjustly dampen the clinical concern for this issue. Dietary assessment techniques have inherent biases that typically lead to a gross underestimation of true intake, which is greater in obese individuals.(29, 30) The low observed intakes of calories and nutrients, especially at baseline may be attributed to this error. Additionally, records for supplement intakes (vitamins, minerals, and protein) were not available for incorporation into the analysis. All participants were recommended and reminded to take multivitamin and mineral supplements specifically formulated for bariatric surgery patients, but adherence to this for all individuals was not available.

These results demonstrate changes in nutrients and food groups during the first year after RYGB. This information can help clinicians working with bariatric patients at bariatric surgery clinics understand the potential pitfalls of dietary intakes in their patients. Inadequate protein intake, as well as high consumption of dietary fats are a concern. A number of vitamins and minerals are of potential concern, and clinical assessment of their deficiencies should be emphasized. Specific food groups, such as fruits, vegetables, and whole grains, which provide dietary fiber, and many phytochemicals, and are low in fat, should be targeted, especially during the time when whole foods are being introduced and tested for tolerance. Dietary counseling remains to be an emphasis in post-surgery patient care. Targeting problem nutrients and food groups may provide better patient care in post-surgery patients.

Acknowledgments

Acknowledgment of Grant Support: Supported by the Wake Forest University Claude D. Pepper Older American Independence Center (National Institutes of Health grant P30 AG21332), the Wake Forest University General Clinical Research Center (National Institutes of Health grant MOI-RR(7122), and the Wake Forest University Cross-Campus Collaboration Grant.

The research was performed by G.D. Miller and A. Fernandez; The research design was by G.D. Miller and A. Fernandez; The data was analyzed by G.D. Miller; The paper was written by G.D. Miller, A. Norris, and A. Fernandez.

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Table 1

Daily intake of total energy, macro and micronutnents, dietary fiber, alcohol, and cholesterol at baseline, 3-weeks, 3-months, 6-months, and 12-months (mean (SEM)). Comparisons were made between each time point using repeated measures of covariance. Values with different letters are statistically significantly different from each other (p<0.05).

Nutrient	Baseline	3-weeks	3-months	6-months	12-months
Energy (kcals)	2150 (165)a	649 (40)e	877 (60)d	1076 (63)c	1307 (129)b
Fat(g)	94.1 (8.2)a	22.7 (2.1)b	36.4 (2.8)c	45.4 (3.7)d	56.1 (6.8)e*
CHO(g)	242.5 (25.2)a	65.2 (4.9)b	80.1 (6.6)c	101.7 (9.1)d	135.9 (15.1)e
Protein (g)	89.3 (5.5)a	49.4 (3.9)b	60.3 (6.1)bc	69.1 (4.1)c	70.6 (6.3)c
Pro/kg Ideal Body Wt (g)	1.4 (0.1)a	0.8 (0.1)b	1.0 (0.1)bc	1.1 (0.1)c	1.1 (0.1)c
Sat Fat (g)	30.9 (2.8)a	8.7 (0.9)b	11.6 (1.0)c	14.8 (1.3)d	18.5 (2.2)e
Mono Fat (g)	36.2 (3.3)a	7.8 (0.8)b	13.8 (1.3)c	17.4 (1.4)d	21.2 (2.8)d
Poly Fat (g)	18.5 (2.0)a	4.2 (0.5)b	7.5 (0.7)c	9.1 (1.2)cd	11.1 (2.1)d
Omega 3 Fat (g)	1.8 (0.2)a	0.5 (0.1)b	0.9 (0.1)c	1.0 (0.2)c	1.2 (0.3)c
Trans Fat (g)	8.3 (1.0)a	1.1 (0.2)b	2.0 (0.4)c	2.9 (0.5)cd	3.6 (0.7)cd
% Energy from Fat	39.2 (1.9)a	30.7 (2.0)b	36.5 (1.9)a	37.9 (2.2)a	37.1 (2.0)a
% Energy from CHO	44.7 (2.1)a	40.2 (1.7)a	36.3 (1.3)b	37.1 (2.1)b	42.0 (2.0)a
% Energy from Protein	17.4 (1.0)a	31.0 (1.9)b	28.4 (1.7)b	26.5 (1.5)b	22.6 (1.2)c
% Energy from Sat Fat	12.8 (0.5)a	11.7 (1.1)a	11.9 (0.9)a	12.4 (0.9)a	12.6 (1.0)a
% Energy from Mono Fat	15.0 (0.8)a	10.6 (0.8)b	13.8 (0.9)a	14.8 (0.9)a	13.8 (0.8)a
% Energy from Poly Fat	7.9 (0.8)a	5.7 (0.6)b	7.5 (0.7)a	7.5 (0.8)a	7.0 (0.7)ab
Alcohol (g)	0.4 (0.3)	0.0 (0.0)	0.1 (0.1)	0.2 (0.2)	0.0 (0.0)
Sugar (g)	100.0 (13.7)a	31.8 (3.8)bc	28.1 (3.1)b	43.1 (5.6)c	51.1 (8.5)c#
Cholesterol (g)	348.3 (31.9)a	104.3 (15.6)b	140.9 (16.0)bc	177.3 (26.7)c	196.4 (29.1)c@
Diet Fiber (g)	16.0 (1.9)a	5.6 (0.6)b	7.7 (0.6)c	9.0 (0.7)d^	11.8 (1.5)e
Sol Fiber (g)	5.1 (0.7)a	1.9 (0.2)b	2.1 (0.2)b	2.2 (0.2)b	3.1 (0.3)c
Insoluble Fiber (g)	10.7 (1.3)a	3.6 (0.4)b	5.5 (0.5)c	6.6 (0.5)d	8.6 (1.2)a
Calcium (mg)	888.9 (100.0)a	658.1 (65.8)ab	607.8 (94.5)b	704.9 (90.4)ab	782.9 (123.3)ab
Iron (mg)	17.6 (2.3)a	6.2 (0.7)d	7.6 (0.7)c	8.3 (0.7)c	10.0 (0.9)b
Mg (mg)	256.7 (22.5)a	125.9 (8.8)d	142.8 (10.4)d	177.5 (18.0)c	202.9 (22.7)b
Zinc (mg)	12.5 (1.5)a	4.9 (0.4)cd	5.9 (0.5)c	7.9 (0.7)b	8.3 (0.7)b
Copper (mg)	1.2 (0.1)a	0.5 (0.1)b	0.8 (0.1)c	0.8 (0.1)c	0.9 (0.1)c
Sodium (g)	3.8 (0.3)a	1.4 (0.1)b	1.9 (0.2)c	2.3 (0.1)d	2.6 (0.3)d
Potassium (g)	2.5 (0.2)a	1.1 (0.1)b	1.3 (0.1)c	1.6 (0.1)d	1.9 (0.2)e
Vit A (RE)	9112 (1476)a	2168 (377)c	3025 (490)b	3714 (740)bcd	4340 (373)d
Vit E (mg)	13.1 (2.2)a	6.8 (1.8)b	6.3 (1.1)b	6.8 (1.1)b	9.7 (2.6)ab
Vit D (mcg)	4.3 (0.6)a	2.9 (0.4)b	3.0 (0.5)ab	3.3 (0.5)ab	5.0 (1.4)ab
Vit K (mcg)	184.4 (30.2)a	33.2 (11.0)b	68.6 (15.9)c	65.6 (16.9)bc	72.3 (8.1)c

Nutrient	Baseline	3-weeks	3-months	6-months	12-months
Vit C (mg)	69.4 (7.0)a	36.5 (6.2)b	39.1 (8.1)bc	39.0 (5.7)bc	50.2 (7.5)ac
Thiamin (mg)	1.8 (0.2)a	0.6 (0.1)b	0.7 (0.4)c	0.8 (0.1)c	1.3 (0.2)d
Riboflavin (mg)	2.1 (0.2)a	1.0 (0.1)bc	0.9 (0.1)c	1.2 (0.1)b	1.7 (0.2)a
Niacin (NE)	24.6 (1.7)a	8.2 (0.8)b	10.0 (0.9)c	15.0 (0.9)d	18.1 (2.0)d
B-6 (mg)	2.0 (0.2)a	0.8 (0.1)b	0.8 (0.1)b	1.8 (0.8)ab	1.5 (0.2)a
Vit B12 (mcg)	5.9 (0.8)a	2.8 (0.3)b	2.8 (0.4)b	4.0 (1.1)ab	4.8 (0.7)a
Folate (mcg)	458.5 (77.2)a	135.9 (14.1)d	181.5 (16.7)c	221.4 (24.6)bc	339.0 (46.8)a

Sat: Saturated; Mono: Monounsaturated; Poly: Polyunsaturated; RE: Retinol Equivalents; NE: Niacin Equivalents

[*] p=0.052 for comparison between 6-mos and 12-mos;

[#] p=0.055 for comparison between 3-wks and 12-mos;

[@] p=0.073 for comparison between 3-mos and 12-mos;

[^] p=0.053 for comparison between 3-mos and 6-mos

Table 2

Percentage of participants withm a time period below the Estimated Average Requirement or Adequate Intake.

Nutrient	Baseline	3-weeks	3-months	6-months	12-months
Protein	29.4%	88.2%	76.5%	58.8%	29.4%
Dietary Fiber	94.1%	100.0%	100.0%	100.0%	94.1%
Vitamin A	5.9%	41.2%	23.5%	17.6%	11.8%
Vitamin D	100.0%	100.0%	100.0%	100.0%	88.2%
Vitamin E	52.9%	88.2%	88.2%	94.1%	88.2%
Vitamin C	41.2%	82.4%	88.2%	82.4%	76.5%
Vitamin B1	5.9%	88.2%	70.6%	76.5%	41.2%
Vitamin B2	0.0%	35.3%	47.1%	17.6%	11.8%
Vitamin B3	0.0%	82.4%	64.7%	11.8%	29.4%
Vitamin B6	0.0%	82.4%	76.5%	47.1%	47.1%
Folate	47.1%	100.0%	88.2%	88.2%	58.8%
Vitamin B12	0.0%	23.5%	35.3%	11.8%	11.8%
Calcium	52.9%	76.5%	82.4%	64.7%	64.7%
Magnesium	58.8%	100.0%	100.0%	88.2%	76.5%
Iron	0.0%	70.6%	70.6%	64.7%	35.3%
Zinc	5.9%	82.4%	70.6%	47.1%	29.4%
Copper	5.9%	64.7%	52.9%	58.8%	29.4%
Sodium	5.9%	70.6%	29.4%	5.9%	5.9%
Potassium	94.1%	100.0%	100.0%	100.0%	100.0%

Table 3

Number of servings (mean (SEM)) from food groups and selected foods within the groups. Only selected foods with at least 0.1 servings at any time period were included in the table. Comparisons were made between each time point using repeated measures of covariance. Values with different letters are statistically significantly different from each other ($p<0.05$).

Food Group	Baseline	3-weeks	3-months	6-months	12-months
Fruits- Citrus Juice	0.17 (0.08)a	0.11 (0.09)ab	0.22 (0.14)ab	0.03 (0.03)b	0.10 (0.05)ab
Fruits- Juice noncitrus	0.06 (0.04)	0.18 (0.11)	0.02 (0.02)	0.00 (0.00)	0.03 (0.03)
Fruits- noncitrus	0.41 (0.15)ab	0.33 (0.12)ab	0.17 (0.06)b	0.72 (0.16)a	0.78 (0.19)a
Fruits- Total	0.65 (0.15)ab	0.62 (0.17)ab	0.46 (0.15)b	0.88 (0.13)a	0.91 (0.21)a
Vegs- Dark Green	0.34 (0.10)a	0.03 (0.02)b	0.25 (0.12)ab	0.25 (0.16)ab	0.19 (0.05)a
Vegs- Yellow	0.26 (0.08)a	0.01 (0.00)b	0.05 (0.01)c	0.09 (0.05)abc	0.10 (0.03)a
Vegs- Tomato	0.28 (0.09)	0.10 (0.04)	0.19 (0.05)	0.15 (0.04)	0.24 (0.08)
Vegs- White Potatoes	0.54 (0.13)a	0.21 (0.05)b	0.15 (0.03)b	0.21 (0.07)b	0.25 (0.05)b*
Vegs- Fried Potatoes	0.43 (0.08)a	0.00 (0.00)b	0.01 (0.00)c	0.02 (0.02)bc	0.03 (0.01)bc*
Vegs- Legumes	0.14 (0.08)	0.17 (0.06)	0.23 (0.06)	0.19 (0.05)	0.19 (0.08)
Vegs- other	0.98 (0.14)a	0.10 (0.02)b	0.52 (0.11)c	0.56 (0.12)c	0.63 (0.16)c*
Vegs- Total	3.27 (0.44)a	0.65 (0.11)b	1.48 (0.25)c	1.61 (0.29)c	1.78 (0.27)c
Grain- Whole Total	1.00 (0.35)a	0.41 (0.12)b*	0.43 (0.11)b*	0.31 (0.10)b	0.63 (0.19)a
Grain- Some Whole total	0.42 (0.11)a	0.08 (0.06)b	0.22 (0.12)b	0.33 (0.09)a	0.35 (0.10)a
Grain- Refined	4.76 (0.62)a	0.51 (0.10)b	1.38 (0.34)c	1.35 (0.24)c	2.69 (0.41)d
Grain- Total	6.23 (0.65)a	1.00 (0.22)b	2.13 (0.41)c	2.16 (0.33)c	3.76 (0.56)d
Meat- Lean Total	2.79 (0.50)a	0.87 (0.17)b	1.62 (0.37)c*	2.07 (0.34)ac	1.52 (0.30)c*
Meat-Fish total	0.41 (0.19)	0.41 (0.19)	0.62 (0.30)	0.30 (0.14)	0.55 (0.18)
Meat- Regular total	2.41 (0.49)a	0.82 (0.23)b	0.97 (0.27)b	1.71 (0.32)a*	2.19 (0.43)a
Meat- Total	6.33 (0.53)a	2.31 (0.32)b	3.33 (0.40)c	4.57 (0.52)d	5.10 (0.63)ad*
Dairy- Nondairy Total	0.45 (0.27)	0.43 (0.35)	0.45 (0.23)	0.19 (0.06)	0.17 (0.08)
Dairy- Fat Free total	0.54 (0.16)	0.49 (0.14)	0.34 (0.11)	0.54 (0.18)	0.48 (0.23)
Dairy- Reduced Fat Total	0.33 (0.07)	0.32 (0.09)	0.17 (0.06)	0.42 (0.15)	0.39 (0.13)
Dairy- Whole Total	0.48 (0.10)	0.34 (0.10)	0.48 (0.10)	0.44 (0.11)	0.58 (0.15)
Dairy- Total	2.39 (0.33)a	2.20 (0.37)a	1.76 (0.25)b*	1.82 (0.23)a	1.87 (0.22)b
Beverage- Alcohol	0.03 (0.02)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)
Beverages- Sweetened	0.84 (0.16)a	0.02 (0.02)b	0.05 (0.03)b	0.02 (0.02)b	0.04 (0.04)b
Beverages- Artificial Sweetened	1.12 (0.33)ab	0.52 (0.25)ab	0.58 (0.19)b	0.82 (0.36)ab	1.17 (0.38)a*
Beverages- Total	2.90 (0.37)a	0.78 (0.31)b	1.00 (0.20)bc	1.79 (0.44)c	3.29 (0.45)a
Fats- Total	4.48 (0.59)a	0.86 (0.13)b	1.84 (0.36)c	1.68 (0.22)c	1.89 (0.36)c
Sweets- Total	2.17 (0.45)a	0.58 (0.25)b	0.94 (0.28)b	1.67 (0.45)a	4.60 (2.00)a

Vegs: Vegetables;

*0.068 for baseline vs. 12-mos for white potatoes;

*0.074 for 3-mos vs. 12-mos for fried potatoes;

*0.082 for baseline vs. 12-mos for other vegs;

*0.056 for baseline vs. 3-wks for grains-whole total;

*0.092 for baseline vs. 3-mos for grains-whole total;

*0.084 for baseline vs. 3-mos for meat lean total;

*0.075 for 3-wks vs. 12-mos for meat lean total;

*0.063 for 3-mos vs. 12-mos for meat total;

*0.063 for 3-mos vs. 6-mos for meat regular total;

*0.091 for baseline vs. 3-mos for dairy total;

*0.059 for 3-mos vs. 12-mos for beverages artificial sweetened