HHS Public Access
Author manuscript
J Acad Nutr Diet. Author manuscript; available in PMC 2017 September 01.

Published in final edited form as:
J Acad Nutr Diet. 2016 September ; 116(9): 1387–1394. doi:10.1016/j.jand.2016.03.019.

Adult intake of minimally processed fruits and vegetables: Associations with cardiometabolic disease risk factors

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Abstract

Background—The U.S. Department of Agriculture launchedChooseMyPlate.gov nutrition recommendations designed to encourage increased fruit and vegetable intake in part as a strategy for improving weight control through the consumption of high satiation foods.

Objective—The purpose of this cross-sectional study was to assess the relationship between adults' reported daily intake of fruits and non-starchy vegetables (i.e., those thought to have the lowest energy density) expressed as a proportion of their total daily food intake and objectively measured cardiovascular and metabolic disease risk factors using data from the 2009–2010 National Health and Examination Survey (NHANES). Physical activity was included as a moderator variable.

Design—This study employed a cross-sectional examination of 2009–2010 NHANES data to assess how daily fruit and non-starchy vegetable intake were associated with anthropometric measures and cardiometabolic blood chemistry markers.

Participants/setting—Adults free of cardiac or metabolic disease (N=1,197) participated in 24-hour dietary recalls; a variety of cardiometabolic biomarkers and anthropometric measures were also collected from participants.

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No authors report a conflict of interest related to this manuscript

Main outcome measures—Among participants with complete data on all variables, the ratio of the combined cup equivalents of fruit and non-starchy vegetable intake to the total gram weight of all foods consumed daily (FV ratio) served as the primary independent variable. Main dependent measures included: fasting glucose, insulin, glycosylated hemoglobin, HDL cholesterol, LDL cholesterol, triglycerides, total cholesterol, waist circumference, and body mass index.

Statistical analyses performed—Demographic and behavioral predictors of the FV ratio and the association between the FV ratio and cardiometabolic disease risk factors were examined using multivariate regression.

Results—BMI ($\beta = -2.58$, 95% CI [−3.88, −1.28]), waist circumference ($\beta = -6.33$, 95% CI [−9.81, −2.84]), and insulin ($\beta = -0.21$, 95% CI [−0.37, −0.05]) were inversely associated with the FV ratio. These associations were weakened for the subset who adhered to federal physical activity recommendations. No other statistically significant associations were found between FV ratio and main dependent measures.

Conclusions—In this nationally representative sample, predicted inverse associations between the proportion of daily fruit and non-starchy vegetable intake relative to total intake and measures reflective of body fat composition and fasting insulin were confirmed. Future research should examine whether a similar association is observed for other sources of resistant starch, such as whole grains, which are arguably more strongly linked with satiety and host insulin levels.

Keywords

cardiovascular disease; fruit and vegetable intake; physical activity; dietary guidelines; health disparities

Introduction

In June 2011, the United States Department of Agriculture (USDA) announced the replacement of the MyPyramid icon with MyPlate[1] as the iconic distillation of the 2010 Dietary Guidelines for Americans (DGA).[2] Prompted by the 2010 White House Taskforce on Child Obesity,[3] the USDA Center for Nutrition Policy & Promotion developed the MyPlate concept,[4] and related consumer messages[5] in part to encourage Americans to greatly increase their consumption of minimally processed fruits, vegetables (F&V) and whole grains. One of three reasons originally given by the DGA for this advice was to promote better weight control.[5] The specific MyPlate consumer message, "Make half your plate fruits and vegetables," is consistent with the DGA's calorie-adjusted cup-equivalent daily servings of F&V but more actionable because most consumers can more readily implement the ½ plate recommendation than measure out the prescribed calorie-adjusted cup-equivalent servings.[5]

One rationale for why adherence to this MyPlate message might result in better weight control is that foods vary in their capacity to satiate appetite. Water and fiber, both found abundantly in minimally processed fruits and vegetables,[6] contribute the most to satiation.[7,8] Another constituent, namely protein, has also been found to be exceptionally satiating,[8,9] but healthy, non-elderly Americans already consume enough protein, so urging Americans to over-consume protein in order to better control their weight is less attractive than urging them to eat more F&V, which they currently under-consume.[10] Satiation represents the inhibitory processes that bring an on-going eating episode to an end.[11] Satiety is concerned with the continued inhibition of eating following the end of an eating episode until hunger or other signals induce a new episode of eating.[11] Minimally processed F&V are those with almost all of their original nutrients preserved and with little added sugar, fat or sodium. One hypothesized mechanism for an effect of F&V intake on weight is that consumption of F&V produces more satiation-inducing stomach distention than consumption of isocaloric energy dense foods.[6,12] Recent research suggests the possibility of an additional long-term satiety benefit mediated by short chain fatty acid products of plant fiber fermentation in the gut.[13] By accelerating the transit of fiber through the small intestine, exercise may augment the amount of undigested fiber available as fuel for the commensal microbes in the large bowel, thereby contributing to increased satiety signaling.[14,15] This satiation/satiety benefit of minimally processed plant food intake augmented by physical activity could make loss of excess weight or healthy weight maintenance more sustainable when eating disproportionately more F&V.[16]

The satiety-signaling benefit of consuming minimally processed F&V is probably mediated in part by the impact of undigested carbohydrate on metabolic processes involving the large bowel. Recent studies of the human gut microbiota suggest that regular consumption of the “western” dietary pattern contributes to excess waist circumference, abnormally high levels of serum glucose and insulin and other negative cardiometabolic outcomes.[17] The "western" dietary pattern is rich in refined carbohydrate and deficient in dietary fiber, especially resistant starch. Resistant starch-rich foods include legumes, raw bananas, avocados and oatmeal that feature oligosaccharides that "resist" digestion in the small intestine unless they are highly processed.[18] Several studies have shown that continual consumption of a western dietary pattern deprives colonic microbes of needed fuel and yields over time a dearth of commensal bacteria specialized in the generation of short chain fatty acids, notably butyrate and propionate. Deficits in butyrate and propionate result in impaired gut barrier integrity, systemic inflammation, centralized adiposity, various features of the metabolic syndrome, reduced satiety, and increased conversion of dietary intake into energy for the host.[19–22]

Increasing fruit and vegetable intake as a weight loss strategy in behavioral interventions has produced conflicting results. Kaiser et al.[23] analyzed weight loss studies that prescribed increased fruit and vegetable intake and concluded that there is no consistent relationship between fruit and vegetable intake and weight-related outcomes. By contrast, a second meta-analysis conducted by Mytton et al.[24] found that interventions to increase fruit and vegetable intake resulted in weight loss or better weight maintenance in intervention participants than in controls. A major difference between these studies was the latter's exclusion of studies that included 100% fruit juice, raising the possibility that these divergent findings may be the result of the lower satiation experienced when consuming F&V as juice versus in their whole, unprocessed form.[11,25] The metabolic fate of the energy value of a food is now recognized to be contingent, in part, on whether the food is consumed in solid or liquid form.[25,26] Both meta-analyses also used studies of relatively short duration, raising the possibility that this approach is more effective over the long-term given that it focuses on maximizing satiation/satiety (diminished hunger)[16] versus restricting energy intake (despite residual hunger). Observational[27] and experimental evidence[16] suggests that increasing intake of minimally processed fruits and vegetables (e.g., no juices) is associated with more successful long-term weight control and improved metabolic function. Randomized controlled trials of the Mediterranean dietary pattern, which typically features twice the volume of fruit and vegetable consumption compared to the standard U.S. dietary pattern, provide further support for a weight control benefit of increased intake of minimally processed fruits and vegetables.[28–30]

The purpose of the current study was to assess the relationship between respondents' reported daily intake of fruits and vegetables, excluding fruit juices and starchy vegetables, expressed as a proportion of their total daily food intake and objectively measured cardiovascular and metabolic disease risk factors using interview and physical examination data from the 2009–2010 National Health and Examination Survey (NHANES).

Materials and Methods

Study Design and Population

The NHANES is a nationally representative cross-sectional survey conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention with the purpose of assessing the health and nutritional status of the non-institutionalized U.S. population through interviews and a physical examination.[31] This analysis used 2009–2010 NHANES data and was restricted to respondents 21 years of age and older at the time of the survey who were included in the NHANES laboratory subsample for fasting plasma and glucose. Laboratory subsamples were created from predetermined combinations of groups consisting of randomly assigned participants to reduce participant burden and facilitate scheduling and completion of examinations. Of 2,878 meeting these criteria (46.3% of original sample), 1,109 who reported using medications classified by NHANES as cardiovascular agents or metabolic agents (exclusive of miscellaneous metabolic agents and bone resorption inhibitors) and an additional 572 with missing data on outcome or control variables were excluded, resulting in a final analytical sample size of 1,197.

Data collection and measurement

Prior to data collection by trained interviewers, NHANES participants provided written informed consent. The NHANES protocol included a general questionnaire, a 24-hour dietary intake interview, complete medical examination, anthropometric measures, and collection of blood and urine.[32] NHANES data collection procedures and specific questionnaires are available at the NHANES section of the Centers for Disease Control and Prevention website.[33] The following variables from interview data were used: age, sex, education, race/ethnicity, ratio of household income to poverty, smoking status (“Have you smoked at least 100 cigarettes in your entire life”), recreational physical activity (defined as sports, fitness, or recreational activities that cause a small but noticeable increase in heart rate such as brisk walking), and dietary intake. A measure of weekly minutes of total physical activity was calculated by summing reported weekly minutes of moderate activity and double-weighted number of reported weekly vigorous activity minutes in accordance with national guidelines.[34] This study was deemed exempt by the University of California, Los Angeles Institutional Review Board under federal regulation 45 46.101 (b) CFR.

Fruit and vegetable ratio (FV ratio) and outcome measures—Dietary intake was assessed in NHANES using a 24-hour diet recall interview, first in person and then a second time 3–10 days later via phone. In the current study, the mean of these two assessments was used to minimize individual-level variability. From these data, a variable was derived representing the proportion of dietary intake coming from fruit and non-starchy vegetables by dividing the sum of the total number of non-starchy vegetable cup equivalents and fruit cup equivalents (fruit juices excluded) by the total gram weight of food consumed. This ratio was called the "FV ratio." Because satiation is more greatly influenced by gastric volume than by nutrient content, total food gram weight consumed daily rather than the total energy consumed daily was used as the denominator.[35,36] Cup equivalent amounts were obtained from the 2009–2010 USDA Food Patterns Equivalents Database (FPED), which converts NHANES dietary intake data into the respective number of cup equivalents of fruits and vegetables consumed by each respondent.[37] Fruit and vegetable cup equivalents were calculated using FPED defined subcategories by subtracting total starchy vegetable cup equivalents from the total dark green, red and orange, starchy, and other vegetables cup equivalents and summing these values with the total intact fruits (whole or cut) cup equivalents. Legumes and starchy vegetables were excluded from vegetable cup equivalents. Starchy vegetables (mostly potatoes) were excluded because three different cohorts of health professionals each were observed to increase obesity risk when consuming more potatoes but to decrease obesity risk when consuming whole fruits and non-starchy vegetables.[27] It was impractical to try to separate vegetable juices from the vegetable category, but the mean quantity of vegetable juices consumed relative to other juices is sufficiently small that researchers have excluded them in epidemiological studies of U.S. beverage intake because their exclusion introduced negligible error.[38] Outcome measures were those commonly used to gauge risk of metabolic and cardiovascular disease (fasting glucose, insulin, glycosylated hemoglobin, HDL cholesterol, LDL cholesterol, triglycerides, total cholesterol, waist circumference, and body mass index).[39]

Statistical Analysis

All analyses were performed using Stata/IC for Mac (version 13.1, 2014, Stata Corp.). To adjust for the multistage stratified probability sampling method used by NHANES, survey weights per NHANES analytical recommendations were used.[40] Due to the number of statistical tests conducted in the analysis, the significance level for all multiple regression tests was adjusted using the false discovery rate (FDR) method developed by Benjamini and Hochberg.[41] Based on an FDR of .05, the nominal significance level for all tests was set at $p < 0.015$. All variables were screened for normality and the following variables were log-transformed to correct for excessive skewness and/or kurtosis: fasting glucose, insulin, glycosylated hemoglobin, minutes of recreational physical activity, FV ratio, and total kilocalories. In order to make parameter estimates more interpretable, the FV ratio was expressed as fruit and vegetable cup equivalents per 1000 grams of food and beverages consumed. Descriptive statistics were calculated for all variables. Survey respondents excluded due to medication use and missing data were compared to those included in the analysis by using linear regression with exclusion status as the independent variable for the continuous outcome measures listed above. Pearson chi squared tests were used for comparing these two groups on categorical measures. Demographic and behavioral predictors of the FV ratio and the association between the FV ratio and cardiovascular disease risk factors were examined using multivariate regression. For the examination of cardiovascular disease risk the following covariates were used: sex, age, education, socioeconomic status, race/ethnicity, tobacco use, and physical activity. The analysis was performed for the entire analytical sample and then separately for respondents reporting ≥ 150 weekly minutes of physical activity. To assess differences in cardiovascular disease risk between respondents meeting MyPlate recommendations versus those who did not, an FV ratio was calculated that represented meeting the recommendations (FV ratio = 1.9). Because MyPlate is based on the 2010 *Dietary Guidelines for Americans*, recommended amounts of fruit and vegetable intake in the 2010 *Dietary Guidelines for Americans* based on a 2000-calorie diet (the daily intake amount found on food labels) were used to calculate the recommended FV ratio. The recommended ratio was calculated by summing the federally recommended fruit and vegetable cup equivalents and dividing that sum by the total number of grams (estimated from an average of USDA published gram weights for common foods by category) for a 2000-calorie diet. Categories of participants meeting the recommendations (FV ratio ≥ 1.9), approaching the recommendations (FV ratio 1.0–1.9), and not meeting the recommendations (FV ratio < 1.0) were then created. Various metabolic and cardiovascular disease risk factors were regressed onto a dummy variable representing adherence to federal fruit and vegetable consumption recommendations.

Results

Participant characteristics are detailed in Table 1. The sample (N=1,197) was predominately non-Hispanic White (67%) with more than a high school education (64%) and a mean age of 41 years. Mean weighted values for lipids, fasting glucose, insulin, and glycohemoglobin were within normal ranges. Thirty percent of participants were obese (BMI >29.9), 34% were overweight (BMI 25.0 – 29.9), 34% were of normal weight (BMI 18.5 – 24.9) and 2% were underweight (BMI < 18.5) (data not shown). Participants reported a mean of 228.0 minutes of physical activity per week. Few participants reported an FV ratio value ≥ 1.9 (1.1%) with most participants reporting an FV ratio <1 (84%). Over one-third of the total cup equivalents came from fruit (38.7%). Results of the linear trends analysis based on these categories are not reported because of the small number of respondents reporting an FV ratio meeting federal recommendations.

Significant differences were observed in the means of several variables between respondents excluded due to medication use and missing data and those included in the analysis (Table 1), with excluded respondents being older and less educated than retained respondents. Significant predictors of increased FV ratio included increasing age, female sex, being a non-smoker, and some college education (Table 2). Compared to non-Hispanic Whites, Mexican Americans and other Hispanics had a higher FV Ratio (Table 2).

CVD risk factors that were significantly negatively associated with FV ratio among our entire subsample included BMI ($\beta = -2.58$, 95% CI [−3.88, −1.28]), waist circumference ($\beta = -6.33$, 95% CI [−9.81, −2.84]), and insulin ($\beta = -0.21$, 95% CI [−0.37, −0.05]) (Table 3). When these same regressions were replicated for the subset of respondents reporting greater than 150 minutes of physical activity per week the observed effects were attenuated to statistical insignificance (Table 3). No other statistically significant associations were found between FV ratio and main dependent measures (Table 3).

Discussion

Examination of the intake of fruit and non-starchy vegetables excluding 100% fruit juices as a proportion of overall intake (FV ratio) in a nationally representative survey of the US population revealed modest but significant associations between the FV ratio and several important anthropometric cardiovascular disease risk factors. Body composition, whether measured as BMI or as waist circumference, was inversely related to fruit and vegetable intake. Despite this finding, the relationship between fruit and vegetable intake and most common blood chemistry correlates of obesity were not statistically significant. Consistent with our finding that F&V ratio is associated with fasting serum insulin but not fasting serum glucose, the emerging literature examining dietary influences on gut microbiota function supports a positive association of fiber-rich, calorie-poor fruit and vegetable intake with satiety signals emanating from the colon that covaried with insulin level but not with blood glucose levels.[42]

Previous studies have found that few (~10%) US adults consume adequate amounts of fruits and vegetables, even when 100% fruit juice is included.[43–47] Because we excluded fruit juices and starchy vegetables from our measure of fruit and vegetable intake in our analysis, an even smaller percentage (~2%) of respondents met our criterion for meeting the 2010 *Dietary Guidelines for Americans*-derived recommended proportions.

The findings related to predictors of the FV ratio are also congruent with previous studies. There is evidence that Hispanics eat greater amounts of fruits and non-starchy vegetables than non-Hispanic Whites, although still less than recommended amounts.[48] This may be a result of immigrant populations retaining non-Western dietary habits that encourage greater daily intake of whole fruits, beans, starches and non-starchy vegetables.[49,50] Females and older adults also consumed greater amounts. Consistent with other studies, the increasing consumption of fruits and non-starchy vegetables with increasing age was particularly striking. One possible explanation is that the neophobic response to new plant tastes, which represents a consistent challenge to getting children to eat more fruits and vegetables, may be overcome by a lifetime of multiple exposures.[51] Greater adherence could also be attributed to the changes in the distribution and reduced density of taste buds found in older age groups[52,53] or a cohort effect related to historical changes in dietary patterns,[54] or other reasons.

The strongest associations in the current study related to cardiovascular disease risk were inverse associations between the FV ratio and the anthropometric measures of waist circumference and BMI. The evidence of an association between fruit and vegetable intake and weight in the scientific literature is unclear, with mixed results from cross sectional studies.[55] Although overall increases in whole fruit and non-starchy vegetable consumption could theoretically lead to weight gain, in practice people tend to eat the same quantity of food each day, so the increased quantity of whole fruit and non-starchy vegetables consumed tends to be offset by a reduction in the quantity of higher energy-dense foods consumed, leading to net reduction in energy intake and greater weight loss.[6] Because 100% fruit juices were excluded from the calculation of the FV ratio in the current study, the association between whole fruit and vegetable intake and satiation/satiety may have been enhanced when compared to the association between fruit and vegetable intake and satiation/satiety observed in studies that included fruit juices.

In the 757 respondents reporting adherence to federal physical activity guidelines, the magnitude of the associations between fruit and vegetable consumption and chronic disease risk factors was reduced. This may be in part the result of the metabolic benefit of physical activity[56] overwhelming the association between fruit and vegetable consumption and chronic disease risk.[57]

This study has several limitations. The results of this study were based on a subpopulation that excluded all cases that were missing any data on predictor or outcome variables and excluded those taking medications related to the study outcomes, thereby limiting its generalizability. It was not possible to compare those meeting federal recommendations vs. those not meeting recommendations due to the small number of respondents meeting recommendations. By focusing exclusively on fruits and non-starchy vegetables this study ignored other rich sources of resistant starch (e.g., legumes, whole grains). Resistant starch is arguably the type of fiber most strongly associated with enhanced satiety, reduced systemic inflammation and reduced risk of metabolic disease.[58] While the first 24-hour dietary recall took place on the same day as the blood sampling, the second 24-hour dietary recall occurred between three to ten days later. Including both recalls increased confidence that the recall data reflected usual respondent food choices but including the second recall necessarily reduced the associations with biomarkers taken on the day of the first dietary recall (data not shown). Finally, although this study attempted to control for important confounding variables, the clustering of different health habits among individuals raises the possibility that the significant associations that were found were affected by influences not captured in the modeling described herein.

Conclusions

In this nationally representative sample of U.S. adults, the proportion of minimally processed fruits and non-starchy vegetables relative to total daily food intake was shown to be inversely associated with measures reflective of body fat composition and fasting insulin but not other metabolic indicators of obesity. The mechanisms by which consuming proportionally more minimally processed fruits and vegetables may be beneficially associated with reduction of cardiometabolic risk factors remain to be elucidated. However, some of these associations may be mediated by the potential weight control benefit of eating more minimally processed fruits and non-starchy vegetables. Future research is needed to explore the health impact of including other food sources rich in resistant starch and to focus greater research attention on how food preparation and preservation may influence the magnitude of associations between amount of fruits and vegetables consumed daily and the cardiometabolic outcomes reported in this study.

Acknowledgments

This manuscript was supported by the Cancer Education and Career Development Program, Postdoctoral Fellowship, UCLA Center for Cancer Prevention and Control Research (NCI R25 CA87949) and the UCLA-USC Center for Population Health and Health Disparities (NHLBI 1P50HL105188 # 6904).

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Table 1

Characteristics of participants included in the analytic sample and of those excluded due to medication use and missing data

Characteristic	Mean (Standard Error) or %		
	Included (n=1,197)	Excluded (n=1,380 – 1,681)[a]	*P* value[b]
Age (years)	**41.3 (0.5)**	**53.6 (0.7)**	**<0.001**
Ratio of Household Income to Poverty	2.9 (0.1)	2.9 (0.1)	0.99
Sex (%)			0.05
Male	44	49	
Female	56	51	
Race/Ethnicity[c] (%)			0.02
Non-Hispanic White	67	67	
Non-Hispanic Black	10	13	
Mexican American/Other Hispanic	17	13	
Other Race – Including Multi-racial	7	7	
Education Level (%)			**<0.001**
High school graduate or less	36	47	
More than high school graduate	64	53	
Smoked at Least 100 Cigarettes (%)			0.12
Yes	42	46	
No	58	54	
Blood chemistry values (fasting):			
Glucose (mg/dL)[d]	**97.7 (0.8)**	**110.3 (1.2)**	**<0.001**
Insulin (uU/mL)[e]	**12.1 (0.3)**	**16.1 (0.4)**	**<0.001**
Glycohemoglobin (%)	**5.4 (0.0)**	**5.9 (0.0)**	**<0.001**
Direct HDL-Cholesterol (mg/dL)[f]	**55.7 (0.6)**	**53.1 (0.7)**	**<0.01**
LDL-cholesterol (mg/dL)[f]	**120.4 (1.4)**	**112.5 (1.0)**	**<0.001**
Total Cholesterol (mg/dL)[f]	198.6 (1.7)	193.6 (1.3)	0.02
Triglyceride (mg/dL)[g]	**112.6 (2.0)**	**142.5 (4.0)**	**<0.001**
Waist Circumference (cm)	**95.1 (0.6)**	**101.9 (0.6)**	**<0.001**
Body Mass Index (kg/m^2)	**27.7 (0.3)**	**29.8 (0.2)**	**<0.001**
Physical Activity (minutes/week)	**228.0 (15.6)**	**159.8 (8.8)**	**<0.001**
Ratio of Daily Fruit & Veg. Cup Equiv per Total Grams × 1000	0.60 (0.02)	0.65 (0.01)	0.06

[a]Excluded cases varied in how many of their covariate or outcome measures were missing, with the result that the per-measure sample sizes varied from 1,380 to 1,681, depending on the measure.

[b]For continuous measures, the p-value represents the significance of the beta coefficient for exclusion as a predictor variable in a linear regression model, for categorical variables, the pvalue represents the significance of a Pearson's χ^2 test. To correct for multiple comparisons only p-values < .015 are considered to be statistically significant and are indicated by bold type.

[c]Percentages sum to greater than 100 due to rounding

[d]To convert mg/dL glucose to mmol/L, multiply mg/dL by 0.0555

[e]To convert uU/mL insulin to pmol/L, multiply uU/mL by 6.95

[f]To convert mg/dL cholesterol to mmol/L, multiply mg/dL by 0.026

[g]To convert mg/dL triglyceride to mmol/L, multiply mg/dL by 0.0113

Table 2

Predictors of fruit and vegetable cup equivalents per 1000 grams of daily food intake (n=1,197)

Sample characteristic (unweighted n)	Regression Coefficient	95% CI	SE	*P* value[a]	*P* trend[a]
Age (years)					<0.001
21–34 (443)	-	-	-	-	
35–44 (290)	0.01	[−0.04, 0.07]	0.02	0.59	
45–54 (222)	**0.14**	**[0.05, 0.22]**	**0.04**	**< 0.01**	
55–64 (154)	**0.16**	**[0.08, 0.25]**	**0.04**	**<0.01**	
65–74 (62)	**0.32**	**[0.23, 0.41]**	**0.04**	**< 0.001**	
75+ (26)	**0.40**	**[0.30, 0.50]**	**0.05**	**< 0.001**	
Sex (female) (666)	**0.10**	**[0.04, 0.16]**	**0.03**	**< 0.01**	
Ratio of Household Income to Poverty					0.16
0-.92 (248)	-	-	-	-	
.92.–1.39 (238)	0.03	[−0.06, 0.12]	0.04	0.51	
1.39 – 2.71 (241)	0.06	[−0.06, 0.18]	0.06	0.29	
2.71 – 4.43 (232)	0.06	[−0.05, 0.17]	0.05	0.26	
4.43 and above (238)	0.10	[0.02, 0.19]	0.04	0.02	
Smoked Less than 100 Cigarettes in Lifetime (692)	**0.09**	**[0.02, 0.16]**	**0.03**	**0.012**	
Some College Education (653)	**0.10**	**[0.02, 0.18]**	**0.04**	**0.015**	
Race/Ethnicity					<0.01
Non-Hispanic White (549)	-	-	-	-	
Non-Hispanic Black (178)	−0.03	[−0.09, 0.03]	0.03	0.34	
Other Hispanic/Mexican American (409)	**0.12**	**[0.06, 0.19]**	**0.03**	**< 0.01**	
Other Race – Including Multi-race (61)	0.03	[−0.09, 0.14]	0.05	0.61	
Physical Activity[b]	0.01	[0.00, 0.02]	0.00	0.03	

[a]To correct for multiple comparisons only p-values < .015 were considered to be statistically significant and are indicated by bold type.

[b]Log-transformed variables (to normalize distributions) include fruit and vegetable cups/gram × 1000 and physical activity

Table 3

Associations between fruit and vegetable cup equivalents per 1000 grams of daily food intake and selected chronic disease risk factors

	Included Respondents (n=1,197)[a]				Included Respondents Reporting > 150 minutes of physical activity per week (n=757)[b]			
Risk factor	**Coefficient**	**95% CI**	**SE[c]**	***P* value[d]**	**Coefficient**	**95% CI**	**SE[c]**	***P*value[d]**
BMI (kg/m^2)	**−2.58**	**[−3.88, −1.28]**	**0.61**	**< 0.01**	−1.92	[−4.10, 0.26]	1.03	0.08
Waist Circumference (cm)	**−6.33**	**[−9.81, −2.84]**	**1.64**	**< 0.01**	−5.29	[−10.38, −0.19]	2.40	0.04
Blood values (fasting):								
Triglycerides (mg/dL)	−9.12	[−22.60, 4.36]	6.36	0.17	−7.50	[−28.74, 13.74]	10.02	0.47
Total Cholesterol (mg/dL)	−3.71	[−15.58, 8.16]	5.60	0.52	−4.59	[−17.30, 8.11]	6.00	0.46
LDL Cholesterol (mg/dL)	−4.06	[−13.23, 5.10]	4.33	0.36	−4.82	[−14.50, 4.87]	4.57	0.31
HDL Cholesterol (mg/dL)	2.20	[−0.95, 5.35]	1.49	0.16	1.73	[−2.46, 5.92]	1.98	0.40
Insulin (Uu/mL)[e]	**−0.21**	**[−0.37, −0.05]**	**0.08**	**0.015**	−0.09	[−0.32, 0.14]	0.11	0.41
Hemoglobin A1C (%)[e]	−0.01	[−0.03, 0.00]	0.01	0.14	−0.01	[−0.03, −0.00]	0.01	0.04
Glucose (mg/dL)[e]	−0.03	[−0.06, 0.00]	0.01	0.04	−0.02	[−0.05, 0.01]	0.01	0.22
Total Kcals/day[e]	0.01	[−0.06, 0.08]	0.03	0.75	0.01	[−0.07,0.09]	0.04	0.83

[a]Model includes sex, age, education, socioeconomic status, race/ethnicity, tobacco use, and physical activity as covariates

[b]Model includes sex, age, education, socioeconomic status, race/ethnicity, and tobacco use as covariates

[c]SE = standard error

[d]To correct for multiple comparisons only p-values < .015 were considered to be statistically significant and are indicated in bold.

[e]Log-transformed variables (to normalize distributions) include fasting glucose, insulin, A1C, total calories & fruit and vegetable cups/gram × 1000