HHS Public Access

Author manuscript

Int J Health Nutr. Author manuscript; available in PMC 2015 November 18.

Published in final edited form as:

Int J Health Nutr. 2013 ; 4(1): 33–45.

Dietary Intake among American Indians with Metabolic Syndrome – Comparison to Dietary Recommendations: the Balance Study

Rohaid ALI[1], **Elisa T. LEE**[1], **Allen W. KNEHANS**[2], **Ying ZHANG**[1], **Jeunliang YEH**[1], **Everett R. RHOADES**[1], **Jared B. JOBE**[3], **Tauqeer ALI**[1,*], and **Melanie R. JOHNSON**[1]

[1]Center for American Indian Health Research, University of Oklahoma Health Sciences Center, United States

[2]Department of Nutritional Sciences, University of Oklahoma Health Sciences Center, United States

[3]Division of Cancer Control and Population Sciences, National Cancer Institute, United States

Abstract

Background—American Indians have a very high prevalence of metabolic syndrome that increases their risk of developing cardiovascular disease and type 2 diabetes. Dietary habits are of central importance in the prevention and treatment of metabolic syndrome.

Objective—The main objective of this article was to describe dietary intake among American Indians with metabolic syndrome and compare it to several dietary recommendations. A secondary objective was to identify certain barriers to dietary adherence experienced by this population.

Methods—A total of 213 participants with metabolic syndrome were enrolled in the Balance Study, a randomized controlled trial with two intervention groups: Guided Group and Self-Managed Group. Dietary intake was assessed using the Block Food Frequency questionnaire. Dietary intakes were evaluated against the Dietary Guidelines for Americans.

Results—Intakes of saturated fats, cholesterol, and sodium were higher and intakes of dietary fiber, calcium, magnesium, potassium, vitamin A, vitamin D, and vitamin E were lower than recommended. Additionally, intake of many food groups was noticeably low. Economic factors seem to be related to low adherence to dietary recommendations.

Conclusion—Results showed low adherence by the participants to dietary recommendations for key nutrients and food groups related to risk factors for metabolic syndrome, type 2 diabetes, and cardiovascular disease. Economic factors are related to this low adherence. These findings illustrate a need to develop innovative, focused, and perhaps individualized health promotion strategies that can improve dietary habits of American Indians with metabolic syndrome.

Keywords

American Indians; Balance Study; Dietary Intake; Metabolic Syndrome

*Corresponding Author: T. ALI, tauqeer-ali@ouhsc.edu, Phone: +14052713090, Fax:+14052714390.

INTRODUCTION

Metabolic syndrome (MetSyn) is a constellation of cardiometabolic risk factors. The components of MetSyn include abdominal obesity, hypertension, dyslipidaemia, and glucose intolerance (Grundy et al. 2004). MetSyn is associated with increased risk of type 2 diabetes (T2DM) (Sattar et al. 2003), cardiovascular disease (CVD) (McNeill et al. 2005), and all-cause mortality (Lakka et al. 2002). American Indians experience the highest rates of T2DM of any population group in the United States (U.S.) (Centers for Disease Control and Prevention, 2011). National Data indicate that heart disease is the leading cause of death among American Indian men and the second leading cause of death among American Indian women (National Heart, Lung, and Blood Institute, 2012). Overall prevalence of MetSyn from the Strong Heart Study, a longitudinal population-based epidemiologic study of CVD in 4549 American Indians, was 55.2% among participants aged 45-74years, 43.6% and 56.7% respectively among men and women aged 45-49 years, which was much higher than the 20% and 23.1% observed among all men and all women, respectively, in National Health and Nutrition Examination Survey (NHANES) III (Resnick 2002).

Previous studies have linked dietary intake to these individual components of MetSyn (Appel et al. 2006; Choi et al. 2005; Malik et al. 2006; Parillo & Riccardi, 2004; Schulze et al. 2004) as well as to the prevalence of MetSyn (Dhingra et al. 2007; Esmaillzadeh et al. 2006, 2007; McKeown et al. 2004; Mennen 2000; Sahyoun et al. 2006). Therefore, as a part of a larger study, we measured the dietary intakes of a group of American Indians with MetSyn and compared them to national nutrient and food recommendations. Although previous studies have examined the diet of American Indians (Eilat-Adar et al. 2012; Zephier et al. 1997), no study, to our knowledge, has applied these dietary recommendations to American Indians with MetSyn.

The Balance Study was a 2-arm randomized controlled trial (RCT) to compare two CVD prevention strategies in American Indians with MetSyn. A total of 213 participants were randomized into the two intervention groups. This article considers all of the 213 participants, regardless of their intervention group assignments. The participants were a population-based sample of American Indians with MetSyn, as defined by the National Heart, Lung, and Blood Institute (NHLBI) (Grundy et al., 2004). Baseline data from the Balance Study included information on the dietary intake of the study participants. The purpose of the current study is to report baseline dietary intake by the participants in the Balance Study and compare it to several national recommendations.

To provide accurate comparisons, we report dietary intake results by gender and have used the same age groups as provided in the sources for comparisons. Data on household income and health practices were also analyzed to identify some barriers to dietary adherence.

MATERIAL AND METHODS

Participant Selection

The study design and methods have been previously described (Lee et al. 2012). Briefly, the 213 participants in the Balance Study came from the Seven Tribes in southwestern

Oklahoma – the Apache, Caddo, Comanche, Delaware, Ft. Sill Apache, Kiowa, and Wichita. All participants live among the general population in the Lawton and Anadarko areas.

Inclusion criteria included: 1) age 30-75 years; 2) Body mass index (BMI) ≥ 25; 3) MetSyn as defined by the NHLBI (Grundy et al. 2004): the presence of three or more of the following five characteristics: waist circumference > 102 cm (> 40 inch) in men or > 88 cm (> 35 inch) in women, triglyceride (TG) level > 150 mg/dL, high-density lipoprotein cholesterol (HDL-C) level < 40 mg/dL in men and < 50 mg/dL in women, systolic blood pressure (SBP) ≥ 130 mm Hg or diastolic blood pressure (DBP) ≥ 85, and fasting plasma glucose (FPG) ≥ 100 mg/dL. At the screening visit, fasting lipids and glucose levels were obtained from capillary blood using Cholestech analyzer (Allain et al. 1974). Cholestech results were used to determine the eligibility of prospective participants. We adjusted the values for triglycerides and HDL-C slightly according to previous reports (Carey 2006; Cummings 1994; Rogers 1993); that is, triglycerides ≥ 170 mg/dL, HDL-C < 35 mg/dL for men and < 45 mg/dL for women. The criterion for FPG by Cholestech remained ≥ 100 mg/dL.

Exclusion criteria included: (1) participation in the Special Diabetes Program for Indians; (2) participation in the study of another person from the same household ; (3) current participation in any weight loss program; (4) currently pregnant, lactating, or planning to become pregnant in the next 12 months; (5) mental incapacity and/or cognitive impairment; (6) incident CVD, cancer, or end stage renal disease; (7) diabetes mellitus or hypertension uncontrolled by medication; (8) weight over 350 pounds; or (9) TG > 400 mg/dL.

Before recruitment of participants, the protocol was approved by the participating Indian tribes, the institutional review boards of the University of Oklahoma Health Sciences Center and the Oklahoma City Area Indian Health Service (IHS), and the Protocol Review Committee appointed by the National Heart Lung and Blood Institute. Various recruitment methods included personal contact, mass mailing, telephone contact, media announcement, contact at community and tribal meetings, contact at community gatherings, posters displayed at various tribal and health facilities and referrals through IHS physicians.

Written informed consent was obtained from the prospective participants. A screening exam was conducted to determine the eligibility of prospective participants before enrollment in the study.

Assessments and Measures

A personal interview and a brief physical examination were conducted at the baseline visit after enrollment. The personal interview collected data on socio-demographics, medical history, health practice (Health Practices Survey), quality of life and self-efficacy; questionnaires for dietary intake and physical activity level (Kriska & Bennett,1992; Kriska et al. 1990) were administered. A pedometer (ACCUSPLIT Model AE120XL) was provided to every participant to record walking data for seven consecutive days. The physical examination included height, weight, waist circumference, and blood pressure. Laboratory evaluation included fasting serum glucose, lipids, and hemoglobin A1c (HbA1c), and urinary sodium, potassium, albumin and creatinine. Because a laboratory was not available on-site, blood and urine specimens were shipped to off-site laboratories and results on some of the measures were received after several days.

Dietary Assessment

Dietary information at baseline examination was collected using the previously validated Block 2005 Food Frequency Questionnaire (FFQ) (Block Questionnaire, 2005; Boucher et al., 2006). This FFQ was used to evaluate food consumption during the previous six months and ascertained consumption of 125 food items, including some traditional foods. In one study, addition of some ethnic-specific foods was shown to result in increased nutrient estimates for some nutrients (G. Block et al. 2004). The FFQ asked two questions about each of 125 food items, how often participants ate those foods, and then how much they ate each time. There were nine pre-defined frequency categories, ranging from "NEVER" to "EVERY DAY", as well as predefined portion size categories. For example, for green beans or green peas, first select how often, on average did you eat the food during the past 6 month from NEVER, A FEW TIMES, ONCE PER MONTH, 2-3 TIMES PER MONTH, ONCE PER WEEK, 2 TIMES PER WEEK, 3-4 TIMES PER WEEK, 5-6 TIMES PER WEEK, EVERY DAY. Then select how much did you usually eat of the food on those days, from A, B, C, D (from portion size picture). The FFQ questionnaire booklet included a portion size picture guide, instructions for participants, and a description of several American Indian Foods. The Block FFQ utilizes the Nutrition Data System for Research Database Version 4.06_34 (Minneapolis, MN) (G. Block et al. 2004). A Balance Study interviewer explained the FFQ to every participant and answered questions. Once the participant completed the FFQ, the interviewer reviewed the form to ensure that the participants completed it correctly. The forms were then sent to NutritionQuest (Berkeley, CA) to be analyzed. The analysis report included detailed nutrient and whole food intake of each participant. This article reports the baseline dietary data of the Balance Study participants.

Sources for Comparisons

For the purpose of comparison to the national dietary recommendations, the source for all nutrient recommendations except for saturated fat, polyunsaturated fat, monounsaturated fat, and cholesterol is the Dietary Reference Intakes (DRI) series (National Research Council 2005) developed by the Institute of Medicine of the National Academy of Sciences. DRI is the general term for a set of reference values used for planning and assessing nutrient intake for healthy people. Four important types of reference values included in the DRIs are: 1) Acceptable Macronutrient Distribution Range (AMDR); 2) Recommended Dietary Allowances (RDA); 3) Adequate Intakes (AI); and 4) Tolerable Upper Intake Levels (UL). We used RDA/AI and UL to create references ranges for calcium, iron, magnesium, sodium, vitamin A, vitamin D, vitamin E, vitamin C, niacin, folate, and vitamin B6. For potassium, no UL is provided in the DRI, and because no adverse effects have been documented of its excessive consumption from food alone (National Research Council 2005), we added ≥ in front of AI. Furthermore, we added ≥ in front of AI for thiamin, riboflavin, vitamin B12, and vitamin K because DRI does not provide UL for these nutrients (National Research Council 2005).

Recommendations for saturated fat, polyunsaturated fat, monounsaturated fat, and cholesterol are from the National Cholesterol Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report 2002.

The U.S. Department of Agriculture (USDA) (U.S. Department of Agriculture, 2012) Food Groups Overview was used for the recommendations for the food groups.

Statistical Analysis

Summary statistics (frequencies, means and 95% confidence intervals (95% CI)) of the daily nutrient intake were stratified by age and gender. Frequencies and percentages of participants whose nutrient intake were either below the recommended values or were above the recommended values were provided. To assess for any differences between the sex groups by baseline characteristics, daily nutrient intake, or by daily food group intake, Fisher's exact test for categorical variables and t-test for continuous variables were performed. Significance level was $p < 0.05$. All statistical analyses were performed with SAS statistical software, version 9.2.

RESULTS

Of the 213 participants of the study, 207 had baseline data available on most study measures. Baseline characteristics of the participants by gender are given in Table 1. Only 20% of the participants were men. The mean ages for men and women were 51 and 52 years respectively. Women had significantly higher mean BMI (37.01 kg/m^2) than men (34.62 kg/m^2) ($p = .011$). More men (56.1%) reported being former smokers than women (35.2%), whereas more women (23.9%) reported being current smokers than men (12.2%) ($p = 0.047$). Although a substantial proportion of both men (51.2%) and women (45.2%) reported being current drinkers, the number of drinks consumed in a typical week by 90% of men and 93% of women in this study were found to be within the recommended guidelines (U.S. Department of Agriculture and U.S. Department of Health and Human Services). Men had significantly higher means than women for systolic blood pressure (SBP), 131.7 mmHg vs. 125.8 mmHg ($p = 0.043$), and for diastolic blood pressure (DBP), 82.27 mmHg vs. 76.66 ($p = 0.001$). The mean number of steps walked per day from the 7-day period after enrollment was significantly lower for women (4011.9) than men (6775.7) ($p = 0.001$). The baseline mean 7-day step count for both men and women are much lower than the 8000 free-living-steps, which are roughly equivalent to the recommend 30 minutes moderate activity per day. None of the other baseline characteristics were significantly different between men and women.

The FFQ was completed by 166 participants. Reasons for incompletion of FFQ by about 20% of participants were mainly related to the time requirement to complete the FFQ. On average, it takes about 40 minutes to complete this form. Some participants did not have sufficient time during their baseline visit to complete this form. Because the FFQ is a self-administered questionnaire, the participants who were unable to complete this form during the baseline visit were given the form to complete at their homes and return to the study at a later time. Efforts to retrieve completed forms from some participants were not successful.

Comparison of the group of participants who completed the FFQs to the group that did not, showed no statistical difference between these two groups for age (p = 0.187), gender (p = 0.586), and years of education completed (p = 0.528). Based on these comparisons, the authors are confident that there is no negative impact on the results that are presented in this article because of the missing FFQs. Comparisons to the recommendations are given in Table 3, which shows the mean daily nutrient intake (along with the 95% CI) of these baseline Balance participants who had completed the FFQ and the proportions of participants below and above the recommended levels. The results were considered significant if the CI did not overlap with the recommended levels.

The mean intake by participants was consistent with dietary recommendations for protein, carbohydrates, and both polyunsaturated and monounsaturated fats. However, intake of total fiber was below the recommended level in 75.4% of women and 93.8% of men. Fiber consumption was significantly lower for both genders and for all age groups. Calcium intake was significantly below the recommended level in men aged above 30 years, and in women above 50. Consumption of potassium, vitamin D, and vitamin E were significantly below the recommended levels in both genders. Intakes of magnesium and vitamin A were also significantly below the recommendations men.

Intakes of total fat, saturated fat, cholesterol, and sodium were significantly above the recommendations for both genders. All men and 99.3% of women over-consumed saturated fats. Men, on average, were consuming nearly double the recommended limit for saturated fat intake, and were consuming it significantly more than women. A large proportion of both men and women over-consumed sodium in the 30-50 (83.3% of men and 83.3% of women) and the 51-70 (66.6% of men and 67.1% of women) age groups.

For a broader perspective on dietary habits, Table 4 displays the average daily food group intake of participants along with the USDA Food Group recommendations. As a whole, participants substantially under-consumed whole grains, vegetables, fruits, and milk. The average daily recommendation for milk intake is 3 cups per day, according to USDA Food Group recommendations, and, on average, men drank less than a cup per day. Additionally, men consumed half or less than half the daily recommended intake of fruit depending on age group. Men and women did adhere adequately to total grain intake, but both genders did not adhere to whole grain intake: men consumed less than a third of daily whole grain recommendations and women consumed less than a half. Women aged 31 to 50 consumed significantly more whole grains than men in the same age range. Significant over-consumption was observed for protein foods by women in > 30 age group.

A question in the Health Practices Survey assessed if the participants ate five servings of fruits or vegetables each day. If the answer was “no” to this question, a follow-up question then assessed the reasons for not eating five servings of fruits or vegetables. A substantial proportion (30.3%) of participants selected the option of “too expensive” and 17.1% of participants selected the option of “Family members don't like them” as the reasons for not eating five servings of fruits or vegetables each day.

DISCUSSION

Our results show that, in general, adherence to national dietary recommendations is poor in this group of American Indians with MetSyn. As a whole, the group substantially diverged from the dietary recommendations of USDA Food Group recommendations for whole grain, vegetable, fruit, and milk intake. The lack of adherence to food group recommendations is subsequently reflected in poor adherence to many nutrient recommendations.

As noted earlier, no previous study has examined the dietary adherence of American Indians with the MetSyn. There have been documented health implications, however, for certain dietary trends. Discussed below are cardiometabolic health implications resulting from low adherence to dietary recommendations, specifically for those nutrients whose level of consumption by the participants in this study was significantly different from the national recommendations.

A majority of the participants did not have enough fiber. High-fiber diets have received considerable attention in recent years due to their association with decreased incidence of several metabolic disorders. High-fiber intake has been found to be associated with significant reduction in blood pressure (BP) (Whelton et al. 2005). Large cohort studies have demonstrated an inverse relationship between fiber intake and CVD rates (Rimm et al. 1996). Fiber intake has been associated with a reduced risk of T2DM (Montonen et al. 2003). A previous study has noted that low fiber and high protein intake is “marginally” associated with poor glycemic control (Xu et al. 2007). It is unclear how this finding applies to this group, as Table 3 shows consumption of protein as a percentage of calories at recommended levels, but Table 4 shows consumption of the food group of high protein foods to exceed recommendations among 31-50 year-old women.

Participants in this study did not consume the recommended amount of calcium (79% of women and 78% of men). Low consumption of calcium has been reported to be associated with increased BMI and body fat (Eilat-Adar et al. 2007).

A large proportion of both men and women (93.8% and 92.5% respectively) under-consumed potassium. The favorable effects of dietary potassium are well documented. Previous studies have detected an inverse relationship between dietary potassium intake and BP (Ascherio et al. 1992; Whelton PK 2003). Results of an intervention study showed positive effect of increased potassium intake on CVD mortality (Chang et al. 2006). Potassium is particularly abundant in fruits and vegetables. A greater fruit and vegetable consumption has been shown to protect against the occurrence of stroke (FJ. He et al. 2006).

Magnesium was under-consumed by 87.5% of men. Magnesium plays a role in a number of chronic conditions. Some investigators have reported inverse association between magnesium intake and the incidence of MetSyn (K. He et al. 2006), and T2DM risk (Lopez-Ridaura et al. 2004). Increased magnesium intake has been observed to improve serum lipid profiles (Vaskonen 2003).

Intake of vitamin A was below the recommended level in men and intake of vitamin E was also low in both men and women. Both vitamins A and E are considered antioxidants.

Researchers have documented that eating a diet rich in antioxidant-containing foods, such as fruits, vegetables, and whole grains, has been linked to reduced risk of CVD (Dauchet et al. 2006; Kelly et al. 2007; Rautiainen et al. 2012; Seal 2006). Reports from a previous study showed an inverse association between plasma vitamin E concentration and MetSyn (Sempertegui et al. 2011).

Consumption of vitamin D was low in all of the study participants. Researchers have observed that vitamin D intakes have been inversely associated with BMI (Kamycheva et al. 2003), CVD risk (Zittermann et al. 2009), and incident MetSyn (Fung et al. 2012).

Data in Table 4 indicate that consumption of vegetables was substantially below the recommended level in all subgroups except for women over the age of 51. Also, in all gender and age subgroups, whole grains, fruits, and milk were substantially under-consumed. These food groups contribute important nutrients that were shown to be substantially under-consumed in Table 3. Whole grains, fruits, and vegetables, for example, are rich in fiber and their insufficient consumption seems to have led to inadequate consumption of this macronutrient in all age and gender categories. This relationship between under-consumed nutrient and under-consumed food group holds true for calcium (contributors: milk, fruit, and vegetables), potassium (contributors: fruits, vegetables, and milk), magnesium (contributors: vegetables and whole grains), vitamin A (contributors: fruits and vegetables, vitamin D (contributor: milk), and vitamin E (contributor: vegetables).

Just as some macronutrients were significantly under-consumed, there were other macronutrients that had unhealthy overconsumption among large proportion of participants. Across both genders saturated and total fats had an intake greater than the recommended levels. A previous longitudinal study of American Indians has shown that increased intake of saturated fats and total fats increases the likelihood of fatal and non-fatal CVD events (Xu et al. 2006).

Additionally, a large proportion of both men and women used too much sodium which is known to be a contributor to hypertension (Hummel et al. 2012), and hypertension is a characteristic of metabolic syndrome (Grundy et al. 2004).

Some other relationships between nutrients and health parameters are more difficult to interpret. Saturated fat and cholesterol were on average over-consumed. However, baseline results in Table 1 indicate that except for less than optimal mean HDL-C level for women, the mean levels of total serum cholesterol, low-density lipoprotein cholesterol (LDL-C), and HDL-C for men are all within normal ranges. Perhaps one explanation for this phenomenon could be relatively younger mean age of the study participants who have not yet developed substantial dyslipidemia. Based on the previous reports on negative changes in lipid profile in American Indians as they grew older (Welty et al. 2002), and from the findings from this study of significant over-consumption of saturated fat and cholesterol, it is likely that without any lifestyle intervention the participants in this study will eventually develop dyslipidemia at an older age. The Strong Heart Study documented unfavorable changes in the lipid profile over four years of follow-up among its participants in which men aged from 55.6 to 59.5 years and women aged from 56.5 to 60.4 years (Welty et al. 2002). The adverse changes in lipid profile in the participants in this study included increases in LDL-C for women and decreases in HDL-C for both men and women. Furthermore, it has been reported that even modestly elevated LDL-C levels as well as low HDL-C levels are risk factors for CVD among American Indians (Howard et al. 1995).

We analyzed the household income data and information from the Health Practices Survey to identify some potential barriers to adherence to dietary guidelines. The data on household annual income showed that 68% of participants had household income of ≤ $35,000 and 85.5% of participants had household income of ≤ $50,000.

Although 97.5% of study participants said that it is not hard to find fruits and vegetables in grocery stores in study communities, a substantial proportion (30.3%) of participants said that the reason that they do not eat at least five servings of fruits or vegetables each day is because it is too expensive to do so. Researchers have suggested that low-income neighborhoods have increased exposure to fast food that contributes to the environmental causes of the obesity epidemic in these populations (JP. Block et al. 2004). Such barriers should be carefully considered while planning nutrition education strategies in these communities.

The dietary intakes of participants of this study were similar to the trends observed in other dietary investigations involving American Indian populations. Less than half of the participants in the Strong Heart Dietary Study (SHDS) (Zephier et al. 1997) met dietary guidelines for reduction of chronic disease. A meta-analysis of dietary investigations among American Indians showed fat intake ranged from 31% to 47% of total caloric intake (Story et al. 2000). The Navajo Health and Nutrition Survey (Ballew et al. 1997) revealed that fruits and vegetables were each consumed less than once per day per person, as were dairy products.

Although similar trends of low adherence to dietary recommendations were observed among American Indians from three geographic areas in the SHDS (Zephier et al. 1997), the SHDS showed difference in the intake of some nutrients by the geographic area. Men in Arizona (American Indians in the SHDS mostly live on reservations in Arizona) consumed more energy from carbohydrates and less energy from total fat than did men in North and South Dakota (American Indians in the SHDS mostly live on reservations in North and South Dakota) and Oklahoma (American Indians in the SHDS live among general public in Oklahoma) ($p \le 0.01$). Men and women in Arizona consumed more cholesterol and fiber than did participants in North and South Dakota and Oklahoma ($p \le 0.01$) and less antioxidant vitamins ($p \le 0.01$).

We compared findings of this study to some of the dietary intake characteristics of the general population in the U.S. Intake of fat and saturated fat in this population of American Indians with MetSyn is far above what has been observed in the general population in the U.S. Based on data from the National Health and Nutrition Examination Survey (NHANES) 2009-10 (What We Eat in America, NHANES 2009-2010), the intake of fat in adults averaged between 31-34% of calories, depending on age and gender, with an overall average intake of 33% of calories. This compares to fat intake of 39-40% of calories seen in the population of American Indians in this study. The intake of saturated fat in the general population averaged between 10-11%, depending on age and gender, with an overall average intake of 11% of calories. This compares to a saturated fat intake of 12-13% of calories seen in the population of American Indians in this study. Comparisons for intake of fruits and vegetables showed that 32.8% of the U.S. adults reported meeting the recommended fruit intake (CDC State Indicator Report on Fruits and Vegetables, 2009), whereas only 7.83% of American Indian participants of this study reported meeting the recommended fruit intake (the recommendation for fruit intake that is used in the CDC State Indicator Report on Fruits and vegetables, 2009, is used for this comparison). Furthermore, 27.4% of the U.S. adults reported meeting recommended vegetable intake (CDC State Indicator Report on Fruits and Vegetables, 2009), whereas only 10.2% of American Indian participants of this study reported meeting the recommended vegetable intake (the recommendation for vegetable intake that is used in the CDC State Indicator Report on Fruits and vegetables, 2009, is used for this comparison). It is obvious from these comparisons that adherence to dietary recommendations by American Indians in this study is worse than the adherence to dietary recommendations by the general population in the U.S.

Although nutrition is a key environmental factor associated with MetSyn risk, a role for genetic susceptibility to MetSyn phenotypes has also been identified. However, recent genetic studies that included American Indians (including some American Indians from our study communities) provide inconclusive evidence of association between genetic variation and MetSyn phenotypes in American Indians and illustrate the need for additional investigations. A study conducted to investigate the joint impact of 61 previously identified single nucleotide polymorphisms (SNPs) in nicotinic acetylcholine receptor genes on insulin resistance and T2DM in 3,665 American Indians showed that, although multiple SNPs displayed marginal individual association with insulin resistance and T2DM, only a few passed adjustment for multiple testing (Yang et al. 2012). The Population Architecture using Genomics and Epidemiology (PAGE) Consortium investigated the association between the 13 SNPs that were identified by the Genome-Wide Association Studies (GWAS) (primarily in populations of European ancestry) and body mass index (BMI) and obesity in 69,775 subjects, including 6,149 American Indians (Fesinmeyer et al. 2012). This study defined “generalizing SNPs” as those associated with an allele frequency-specific increase in BMI. By this definition, this study generalized 5/9 SNP associations in American Indians, suggesting inadequate tagging of causal variants in this group. In another study, researchers with the PAGE Consortium investigated the association between 49 GWAS-identified SNPs and fasting HDL-C, LDL-C, and TG levels in 38,265 subjects, including 6,000 American Indians (Dumitrescu et al. 2011). This study generalized 45%, 64%, and 77% genotype-phenotype associations for HDL-C, LDLC, and TG respectively, again suggesting inadequate tagging of causal variants.

This study had several limitations. The sample size was relatively small and women far out-numbered men. Since American Indians in Oklahoma do not live on reservations; they live among the general population, it may be inappropriate to generalize these findings to American Indians living on reservations. Similarly, because these participants were all located in Southwestern Oklahoma, it may be inappropriate to generalize these findings to

American Indians living in other parts of the country. Because this current investigation is a cross-sectional analysis, cause and effect cannot be established.

The strength of this study is the ability to describe dietary patterns in a population of American Indians who have MetSyn. American Indians already have, as noted previously, the highest rate of type-2 diabetes in the country and increasing rates of cardiovascular disease. These participants are at high risk of developing these two ailments, of which the MetSyn is a major risk factor.

As described by Jobe and colleagues (Jobe et al. 2012), a number of reasons exist for the high rates of obesity, and for type 2 diabetes and MetSyn in American Indians, but one important factor is the adoption of unhealthy Western lifestyles at the expense of more healthy traditional Native lifestyles. Although traditional American Indian diets vary by tribe and region, generally, they are very healthy and include corn, climbing beans (but not pinto beans), and squash (known as The Three Sisters), wild rice, roots, berries, nuts, and lean game meats (bison, deer, turkey, fish). The traditional lifestyle includes hunting, gathering, fishing, sports and games, and traditional dances.

CONCLUSION

Results showed low adherence by our American Indian participants to dietary recommendations for key nutrients and food groups related to risk factors for metabolic syndrome, T2DM, and cardiovascular disease. Economic factors are related to this low adherence. The results of this study can be used to direct the design of specific health promotion and disease prevention programs that are sensitive to the barriers to adherence to national nutrition guidelines that exist in American Indian communities, and that focus on increasing the consumption of fruit, vegetables, whole grains, and low fat dairy products in order to mitigate the risk of developing CVD and diabetes for American Indians with the MetSyn. Intervention efforts should focus on the community level, as well as the individual level, and focus on intake of more traditional American Indian foods. Intervention efforts should be innovative and focused to alleviate the burden of MetSyn, T2DM, and CVD in the American Indian communities.

ACKNOWLEDGEMENTS

The authors thank the American Indian tribes (Apache, Caddo, Comanche, Delaware, Fort Sill Apache, Kiowa, and Wichita) and communities in southwestern Oklahoma and the Indian Health Service Lawton Indian Hospital and its clinics at Anadarko and Carnegie for their support, cooperation and assistance. We are also thankful to the Balance Study staff for their support and diligent work.

REFERENCES

Allain CC, Poon LS, Chan CS, Richmond W, Fu PC. Enzymatic determination of total serum cholesterol. Clin Chem. 1974; 20(4):470–475. [PubMed: 4818200]

Appel LJ, Brands MW, Daniels SR, Karanja N, Elmer P J, Sacks F M. Dietary approaches to prevent and treat hypertension: a scientific statement from the American Heart Association. Hypertension. 2006; 47(2):296–308. doi: 47/2/296 10.1161/01.HYP.0000202568.01167.B6. [PubMed: 16434724]

Ascherio A, Rimm EB, Giovannucci EL, Colditz GA, Rosner B, Willett WC, Stampfer MJ. A prospective study of nutritional factors and hypertension among US men. Circulation. 1992; 86(5): 1475–1484. doi: doi:10.1161/01.CIR.86.5.1475. [PubMed: 1330360]

Ballew C, White LL, Strauss KF, Benson LJ, Mendlein JM, Mokdad AH. Intake of nutrients and food sources of nutrients among the Navajo: findings from the Navajo Health and Nutrition Survey. J Nutr. 1997; 127(10 Suppl):2085S–2093S. [PubMed: 9339174]

Block G, Mandel R, Gold E. On food frequency questionnaires: the contribution of open-ended questions and questions on ethnic foods. Epidemiology. 2004; 15(2):216–221. doi: 00001648-200403000-00015. [PubMed: 15127915]

Block JP, Scribner RA, DeSalvo KB. Fast food, race/ethnicity, and income: a geographic analysis. American Journal of Preventive Medicine. 2004; 27(3):211–217. doi: 10.1016/j.amepre. 2004.06.007S0749-3797(04)00139-4. [PubMed: 15450633]

Block Questionnaire. [18 December 2012] NutritionQuest. 2005. http://www.nutritionquest.com/assessment/list-of-questionnaires-and-screeners/.

Boucher B, Cotterchio M, Kreiger N, Nadalin V, Block T, Block G. Validity and reliability of the Block98 food-frequency questionnaire in a sample of Canadian women. Public Health Nutrition. 2006; 9(1):84–93. doi: S1368980006000139. [PubMed: 16480538]

Carey M, Markham C, Gaffney P, Boran G, Maher V. Validation of a point of care lipid analyzer using a hospital based reference laboratory. Irish Journal of Medical Sciences. 2006; 175(4):30–35.

Centers for Disease Control and Prevention. [18 December 2012] National Diabetes Fact Sheet, 2011. 2011. http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdfnational.

Centers for Disease Control and Prevention. [08 April 2013] State Indicator Report on Fruits and Vegetables, 2009. http://www.cdc.gov/nutrition/downloads/StateIndicatorReport2009.pdf

Chang HY, Hu YW, Yue CS, Wen YW, Yeh WT, Hsu LS, Pan WH. Effect of potassium-enriched salt on cardiovascular mortality and medical expenses of elderly men. American Journal of Clinical Nutrition. 2006; 83(6):1289–1296. doi: 83/6/1289. [PubMed: 16762939]

Choi HK, Willett WC, Stampfer MJ, Rimm E, Hu FB. Dairy consumption and risk of type 2 diabetes mellitus in men: a prospective study. Archives of Internal Medicine. 2005; 165(9):997–1003. doi: 165/9/99710.1001/archinte.165.9.997. [PubMed: 15883237]

Cummings MH, Watts GF, Mazurkiewicz JC, Slavin BM. An evaluation in the diabetic clinic of the Cholestech LDX analyzer. Practical Diabetes. 1994; 11(4):151–153. doi: 10.1002/pdi. 1960110406.

Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. The Journal of Nutrition. 2006; 136(10): 2588–2593. doi: 136/10/2588. [PubMed: 16988131]

Dhingra R, Sullivan L, Jacques PF, Wang TJ, Fox CS, Meigs JB, Vasan RS. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. Circulation. 2007; 116(5):480–488. doi: 10.1161/CIRCULATIONAHA. 107.689935. [PubMed: 17646581]

Dumitrescu L, Carty CL, Taylor K, Schumacher FR, Hindorff LA, Ambite JL, Anderson G, Best LG, Brown-Gentry K, Bůžková P, Carlson CS, Cochran B, Cole SA, Devereux RB, Duggan D, Eaton CB, Fornage M, Franceschini N, Haessler J, Howard BV, Johnson KC, Laston S, Kolonel LN, Lee ET, MacCluer JW, Manolio TA, Pendergrass SA, Quibrera M, Shohet RV, Wilkens LR, Haiman CA, Le Marchand L, Buyske S, Kooperberg C, North KE, Crawford DC. Genetic determinants of lipid traits in diverse populations from the population architecture using genomics and epidemiology (PAGE) study. PLoS Genet. 2011; 7(6):e1002138. doi: 10.1371/journal.pgen. 1002138. Epub 2011 Jun 30. [PubMed: 21738485]

Eilat-Adar S, Mete M, Fretts A, Fabsitz RR, Handeland V, Lee ET, Howard BV. Dietary patterns and their association with cardiovascular risk factors in a population undergoing lifestyle changes: The Strong Heart Study. Nutrition, Metabolism, and Cardiovascular Diseases. 2012 Epub ahead of print 25 April 2012. doi: 10.1016/j.numecd.2011.12.005.

Eilat-Adar S, Xu J, Loria C, Matti C, Goldbourt U, Howard BV, Resnick HE. Dietary calcium is associated with body mass index and body fat in American Indians. Journal of Nutrition. 2007; 137(8):1955–1960. doi: 137/8/1955. [PubMed: 17634270]

Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. The American Journal of Clinical Nutrition. 2006; 84(6):1489–1497. doi: 84/6/1489. [PubMed: 17158434]

Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. The American Journal of Clinical Nutrition. 2007; 85(3):910–918. doi: 85/3/910. [PubMed: 17344515]

Fesinmeyer MD, North KE, Ritchie MD, Lim U, Franceschini N, Wilkens LR, Gross MD, Bůžková P, Glenn K, Quibrera PM, Fernández-Rhodes L, Li Q, Fowke JH, Li R, Carlson CS, Prentice RL, Kuller LH, Manson JE, Matise TC, Cole SA, Chen CT, Howard BV, Kolonel LN, Henderson BE, Monroe KR, Crawford DC, Hindorff LA, Buyske S, Haiman CA, Le Marchand L, Peters U. Genetic Risk Factors for BMI and Obesity in an Ethnically Diverse Population: Results From the Population Architecture Using Genomics and Epidemiology (PAGE) Study. Obesity (Silver Spring). Jun 22.2012 doi: 10.1038/oby.2012.158.

Fung GJ, Steffen LM, Zhou X, Harnack L, Tang W, Lutsey PL, Van Horn LV. Vitamin D intake is inversely related to risk of developing metabolic syndrome in African American and white men and women over 20 y: the Coronary Artery Risk Development in Young Adults study. The American Journal of Clinical Nutrition. 2012; 96(1):24–29. doi: ajcn.112.036863. [PubMed: 22648727]

Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation. 2004; 109(3):433–438. doi: 10.1161/01.CIR. 0000111245.75752.C6. [PubMed: 14744958]

He FJ, Nowson CA, MacGregor GA. Fruit and vegetable consumption and stroke: meta-analysis of cohort studies. Lancet. 2006; 367(9507):320–326. doi: S01406736(06)68069-0. [PubMed: 16443039]

He K, Liu K, Daviglus ML, Morris SJ, Loria CM, Van Horn L, Savage PJ. Magnesium intake and incidence of metabolic syndrome among young adults. Circulation. 2006; 113(13):1675–1682. doi: CIRCULATIONAHA.105.588327 [pii] 10.1161/CIRCULATIONAHA.105.588327. [PubMed: 16567569]

Howard BV, Lee ET, Cowan LD, Fabsitz RR, Howard WJ, Oopik AJ, Welty TK. Coronary heart disease prevalence and its relation to risk factors in American Indians. The Strong Heart Study. American Journal of Epidemiology. 1995; 142(3):254–268. [PubMed: 7631630]

Hummel SL, Seymour EM, Brook RD, Kolias TJ, Sheth SS, Rosenblum HR, Weder AB. Low-Sodium Dietary Approaches to Stop Hypertension Diet Reduces Blood Pressure, Arterial Stiffness, and Oxidative Stress in Hypertensive Heart Failure With Preserved Ejection Fraction. Hypertension. 2012; 60(5):1200–6. doi: HYPERTENSIONAHA.112.202705 [pii] 10.1161/ HYPERTENSIONAHA.112.202705. [PubMed: 23033371]

Jobe JB, Adams AK, Henderson JA, Karanja N, Lee ET, Walter KL. Community-responsive interventions to reduce cardiovascular risk in american indians. The Journal of Primary Prevention. 2012; 33(4):153–159. doi: 10.1007/s10935-012-0277-9. [PubMed: 22983753]

Kamycheva E, Joakimsen RM, Jorde R. Intakes of calcium and vitamin d predict body mass index in the population of Northern Norway. Journal of Nutrition. 2003; 133(1):102–106. [PubMed: 12514276]

Kelly SA, Summerbell CD, Brynes A, Whittaker V, Frost G. Wholegrain cereals for coronary heart disease. Cochrane Database of Systematic Reviews (Online). 2007; 18(2) doi: 10.1002/14651858.CD005051.pub2.

Kriska AM, Bennett PH. An epidemiological perspective of the relationship between physical activity and NIDDM: from activity assessment to intervention. Diabetes Metabolism Reviews. 1992; 8(4): 355–372. doi: DOI: 10.1002/dmr.5610080404. [PubMed: 1307524]

Kriska AM, Knowler WC, LaPorte RE, Drash AL, Wing RR, Blair SN, Kuller LH. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. Diabetes Care. 1990; 13(4):401–411. doi:10.2337/diacare.13.4.401. [PubMed: 2318100]

Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, Salonen JT. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA. 2002; 288(21):2709–2716. doi: joc21220 [pii]. [PubMed: 12460094]

Lee ET, Jobe JB, Yeh J, Ali T, Rhoades ER, Knehans AW, Rogers B. A Cardiovascular Risk Reduction Program for American Indians with Metabolic Syndrome: The Balance Study. The Journal of Primary Prevention. 2012; 33(4):187–96. doi: 10.1007/s10935-012-0273-0. [PubMed: 22941041]

Lopez-Ridaura R, Willet WC, Rimm EB, Liu S, Stampfer MJ, Manson JE, Hu FB. Magnesium intake and risk of type 2 diabetes in men and women. Diabetes Care. 2004; 27(1):134–140. [PubMed: 14693979]

Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. The American Journal of Clinical Nutrition. 2006; 84(2):274–288. doi: 84/2/274 [pii]. [PubMed: 16895873]

McKeown NM, Meig JB, Liu S, Saltzman E, Wilson PW, Jacques PF. Carbohydrate nutrition, insulin resistance, and the prevalence of the metabolic syndrome in the Framingham Offspring Cohort. Diabetes Care. 2004; 27(2):538–546. doi:10.2337/diacare.27.2.538. [PubMed: 14747241]

McNeill AM, Rosamond WD, Girman CJ, Golden SH, Schmidt MI, East HE, Heiss G. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. Diabetes Care. 2005; 28(2):385–390. doi: 28/2/385 [pii]. [PubMed: 15677797]

Mennen LI, Lafay L, Feskens EJM, Novak M, Lepinay P, Balkau B. Possible protective effect of bread and dairy products on the risk of metabolic syndrome. Nutrition Research. 2000; 20(3):335–347.

Montonen J, Knek P, Jarvinen R, Aromaa A, Reunanen A. Whole-grain and fiber intake and the incidence of type 2 diabetes. The American Journal of Clinical Nutrition. 2003; 77(3):622–629. [PubMed: 12600852]

National Cholesterol Education Program. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation. 2002; 106:3143–3342. [PubMed: 12485966]

National Heart, Lung, and Blood Institute. [18 December 2012] Morbidity & Mortality: 2012 Chart Book on Cardiovascular, Lung, and Blood Diseases. 2012. http://www.nhlbi.nih.gov/resources/docs/2012_ChartBook.pdf.

National Research Council. Dietary Reference Intakes. The National Academies Press; Washington, DC: 2005. 2005 http://www.nap.edu. [18 December 2012]

Parillo M, Riccardi G. Diet composition and the risk of type 2 diabetes: epidemiological and clinical evidence. British Journal of Nutrition. 2004; 92(1):7–19. doi: 10.1079/BJN20041117 S0007114504001266 [pii]. [PubMed: 15230984]

Rautiainen S, Levitan EB, Orsini N, Akesson A, Morgenstern R, Mittleman MA, Wolk A. Total antioxidant capacity from diet and risk of myocardial infarction: a prospective cohort of women. The American Journal of Medicine. 2012; 125(10):974–980. doi: S0002-9343(12)00328-2 [pii] 10.1016/j.amjmed.2012.03.008. [PubMed: 22998880]

Resnick HE. Metabolic syndrome in American Indians. Diabetes Care. 2002; 25(7):1246–1247. doi: 10.2337/diacare.25.7.1246. [PubMed: 12087031]

Rimm EB, Ascherio A, Giovannucci E, Spiegelman D. Vegetable, fruit, and cereal fiber intake and risk of coronary heart disease among men. JAMA. 1996; 275:447–451. doi: doi:10.1001/jama.1996.03530300031036. [PubMed: 8627965]

Rogers EJ, Misner L, Ockene IS, Nicolosi RJ. Evaluation of seven Cholestech LDX analyzer for total cholesterol determination. Clinical Chemistry. 1993; 39(5):860–864. [PubMed: 8485877]

Sahyoun NR, Jacques PF, Zhang XL, Juan W, McKeown NM. Whole-grain intake is inversely associated with the metabolic syndrome and mortality in older adults. The American Journal of Clinical Nutrition. 2006; 83(1):124–131. doi: 83/1/124 [pii]. [PubMed: 16400060]

Sattar N, Gaw A, Scherbakova O, Ford I, O'Reilly DS, Haffner SM, Shepherd J. Metabolic syndrome with and without C-reactive protein as a predictor of coronary heart disease and diabetes in the West of Scotland Coronary Prevention Study. Circulation. 2003; 108(4):414–419. doi: 10.1161/01.CIR.0000080897.52664.9401.CIR.0000080897.52664.94 [pii]. [PubMed: 12860911]

Schulze MB, Manson JE, Ludwig DS, Colditz GA, Stampfer M J, Willett WC, Hu FB. Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. JAMA. 2004; 292(8):927–934. doi: 10.1001/jama.292.8.927 292/8/927 [pii]. [PubMed: 15328324]

Seal C J. Whole grains and CVD risk. The Proceedings of the Nutrition Society. 2006; 65(1):24–34. doi: S0029665106000048 [pii]. [PubMed: 16441941]

Sempertegui F, Estrella B, Tucker KL, Hame DH, Narvaez X, Sempertegui M, Meydani SN. Metabolic syndrome in the elderly living in marginal peri-urban communities in Quito, Ecuador. Public Health Nutrition. 2011; 14(5):758–767. doi: S1368980010002636 [pii]10.1017/S1368980010002636. [PubMed: 20955641]

Story, M.; Strauss, K.; Gilbert, T. Nutritional Health and Diet related Concerns.. In: Rhoades, ER., editor. American Indian Health: Innovations in Health Care, Promotion, and Policy. The Johns Hopkins University Press; Baltimore and London: 2000. p. 201-220.

United States Department of Agriculture. [18 December 2012] Food Groups Overview. 2012. http://www.choosemyplate.gov/food-groups/.

United States Department of Agriculture. United States Department of Health and Human Services. Dietary guidelines for Americans. 7th ed.. U.S. Government Printing Office; Washington, DC: 2010. http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/Policy Doc/Chapter3.pdf [08 April 2013]

United States Department of Agriculture. Agricultural Research Service. [05 April 2013] Energy Intakes: Percentages of Energy from Protein, Carbohydrate, Fat, and Alcohol, by Gender and Age, What We Eat in America, NHANES 2009-2010. 2012. http://www.ars.usda.gov/ba/bhnrc/fsrg

Vaskonen T. Dietary minerals and modification of cardiovascular risk factors. The Journal of Nutritional Biochemistry. 2003; 14(9):492–506. doi: S0955286303000743 [pii]. [PubMed: 14505811]

Welty TK, Rhoades DA, Yeh F, Lee ET, Cowan LD, Fabsitz RR, Howard BV. Changes in cardiovascular disease risk factors among American Indians. The Strong Heart Study. Annals of Epidemiology. 2002; 12(2):97–106. doi: S1047279701002708 [pii]. [PubMed: 11880217]

Whelton, PK.; He, J.; Louis, GT. Potassium supplementation.. In: Whelton, PK.; He, J.; Louis, GT., editors. Lifestyle Modification for the Prevention and Treatment of Hypertension. Marcel Dekker Inc; New York: 2003. p. 185-195.

Whelton SP, Hyre AD, Pedersen B, Yi Y, Whelton PK, He J. Effect of dietary fiber intake on blood pressure: a meta-analysis of randomized, controlled clinical trials. Journal of Hypertension. 2005; 23(3):475–481. doi: 00004872-200503000-00002 [pii]. [PubMed: 15716684]

Xu J, Eilat-Adar S, Loria C, Goldbourt U, Howard BV, Fabsitz RR, Lee ET. Dietary fat intake and risk of coronary heart disease: the Strong Heart Study. The American Journal of Clinical Nutrition. 2006; 84(4):894–902. doi: 84/4/894 [pii]. [PubMed: 17023718]

Xu J, Eilat-Adar S, Loria CM, Howard BV, Fabsitz RR, Begum M, Lee ET. Macronutrient intake and glycemic control in a population-ased sample of American Indians with diabetes: the Strong Heart Study. The American Journal of Clinical Nutrition. 2007; 86(2):480–487. doi: 86/2/480 [pii]. [PubMed: 17684222]

Yang J, Zhu Y, Cole SA, Haack K, Zhang Y, Beebe LA, Howard BV, Best LG, Devereux RB, Henderson JA, Henderson P, Lee ET, Zhao J. A gene-family analysis of 61 genetic variants in the nicotinic acetylcholine receptor genes for insulin resistance and type 2 diabetes in American Indians. Diabetes. 2012; 61(7):1888–94. doi: 10.2337/db11-1393. Epub 2012 May 14. [PubMed: 22586585]

Zephier EM, Ballew C, Mokdad A, Mendlein J, Smith C, Yeh JL, Howard BV. Intake of nutrients related to cardiovascular disease risk among three groups of American Indians: the Strong Heart Dietary Study. Preventive Medicine. 1997; 26(4):508–515. doi: S0091-7435(97)90164-X [pii] 10.1006/pmed.1997.0164. [PubMed: 9245673]

Zittermann A, Frisch S, Berthold HK, Gotting C, Kuhn J, Kleesiek K, Koerfer R. Vitamin D supplementation enhances the beneficial effects of weight loss on cardiovascular disease risk markers. The American Journal Clinical Nutrition. 2009; 89(5):1321–1327. doi: ajcn.2008.27004 [pii] 10.3945/ajcn.2008.27004.

Table 1

Baseline Characteristics of Balance Study Participants, Mean (Standard Deviation) or Percent

	Men (n=42)	Women (n=165)	P[1]
	Mean (SD) or %	Mean (SD) or %	
Age (years)	51.07 (11.86)	51.82 (10.52)	0.688
Body mass index (Kg/m[2])	34.62 (4.85)	37.01 (6.88)	**0.011**
Waist circumference (cm)	114.8 (11.81)	116.2 (14.71)	0.557
Education (years)	13.21 (2.06)	13.35 (2.09)	0.704
Smoking status			
Never	31.7%	40.8%	
Former	56.1%	35.2%	
Current	12.2%	23.9%	**0.047**
Alcohol drinking status			
Never	7.3%	11.3%	
Former	41.4%	43.4%	
Current	51.2%	45.2%	0.742
Fasting plasma glucose (mg/dL)	114.1 (50.12)	110.6 (41.53)	0.643
HbA1c[2] (%)	6.67 (1.93)	6.59 (1.51)	0.805
Total cholesterol	168 (35.25)	172.2 (37.47)	0.519
LDL-C[3] (mg/dL)	98.69 (32.82)	98.44 (32.28)	0.964
HDL-C[4] (mg/dL)	42.49 (10.91)	45.70 (9.51)	0.066
TG[5] (mg/dL)	133.8 (73.1)	139.8 (66.19)	0.618
Log(TG)	4.72 (0.62)	4.82 (0.50)	0.307
Log(UACR[7])	2 .00 (1.64)	2.17 (1.01)	0.546
Albuminuria[6]	7.5%	8.7%	1.000
Urinary sodium (mEq/L/day)	113.3 (55.74)	116.3 (57.72)	0.764
Urinary potassium (mEq/L/day)	60.9 (30.58)	58.99 (32.42)	0.737
SBP (mm Hg)	131.7 (16.18)	125.8 (16.73)	**0.043**
DBP (mm Hg)	82.27 (10.31)	76.66 (10.06)	**0.001**
Average of 7-day step count	6775.7 (3018.8)	4011.9 (3072.1)	**0.001**

[1] *p*-value for testing difference between two groups

[2] hemoglobin A1c

[3] low-density lipoprotein cholesterol

[4] high-density lipoprotein cholesterol

[5] triglycerides

[6] if UACR>=30 mg/g

[7] urinary albumin/creatinine ratio

Table 2

Displays the daily dietary recommendations for macronutrients, minerals, and vitamins by age and gender, and only those recommendations applicable to Balance participants are presented.

Table 2: Daily Dietary Recommendations[1]			
	Age Group (Years)	**Women**	**Men**
Macronutrients			
Protein (% of calories)	30+	10-35	10-35
Carbohydrate (% of calories)	30+	45-65	45-65
Total fiber (g)	30 31-50 51+	≥28 ≥25 ≥22	≥34 ≥31 ≥28
Total fat (% of calories)	30+	20-35	20-35
Saturated fat (% of calories)	30+	<7	<7
Polyunsaturated fat (% of calories)	30+	≤10	≤10
Monounsaturated fat (% of calories)	30+	≤20	≤20
Cholesterol (mg)	30+	<200	<200
Minerals			
Calcium (mg)	30-50 51+	1,000-2500 1,200-2,500	1,000-2,500 1,200-2,500
Iron (mg)	30-50 51+	18-45 8-45	8-45 8-45
Magnesium (mg/d)	30 31+	≥310 ≥320	≥400 ≥420
Potassium (mg)	30+	≥4700	≥4700
Sodium (g)	30-50 51-70 71+	1.5-2.3 1.3-2.3 1.2-2.3	1.5-2.3 1.3-2.3 1.2-2.3
Vitamins			
Vitamin A (mcg)[2]	30+	700-3,000	900-3,000
Vitamin D (mcg)	30-70 71+	15-50 20-50	15-50 20-50
Vitamin E (mg)	30+	15-1,000	15-1,000
Vitamin C (mg)	30+	75-2,000	90-2,000
Thiamin (mg)	30+	≥1.1	≥1.2
Riboflavin (mg)	30+	≥1.1	≥1.3
Niacin (mg)[3]	30+	14-35	16-35
Folate (mcg)[4]	30+	400-1,000	400-1,000
Vitamin B6 (mg)	30-50 51+	1.3-100 1.5-100	1.3-100 1.7-100
Vitamin B12 (mcg)	30+	≥2.4	≥2.4
Vitamin K (mcg)	30+	≥90	≥120

[1]Source for all nutrient recommendations except for saturated fat, polyunsaturated fat, monounsaturated fat, cholesterol is the Dietary Reference Intakes series. Full reports are available from the National Academies Press at www.nap.edu. Recommendations for saturated fat, polyunsaturated

fat, monounsaturated fat, and cholesterol come from the National Cholesterol Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III).

[2]As Retinol activity equivalents (RAEs) 1RAE = 1 mcg retinol.

[3]As niacin equivalents (NE).

[4]As dietary folate equivalents (DFE)

Table 3

Daily Mean Nutrient Intake and Proportion of Participants Below and Above Nutritional Recommendations

		Women			Men		
	Age Group (Yrs.)	**Mean (95% CI) N = 134**	**% (N) Below Rec.[1] Values**	**% (N) Above Rec. Values**	**Mean (95% CI) N = 32**	**% (N) Below Rec.[1] Values**	**% (N) Above Rec. Values**
Macronutrients							
Protein[2]	**30+**	14.96 (14.47-15.46)	3.7 (5)	0	15.28 (14.42-16.14)	0	0
Carbohydrate[2]	**30+**	46.95 (45.63-48.26)	42.5 (57)	1.4 (2)	44.14 (41.35-46.93)	50 (16)	0
Total fiber (g)	**30** **31-50** **51+**	10.81 (8.98-12.63) 19.92 (16.27-23.57) 17.00 (14.54-19.46)	100 (3) 82.5(52) 67.6(46)	0 0 0	0 16.77 (12.90-20.64) 13.20 (9.17-17.23)	0 94.4 (17) 92.8 (13)	0 0 0
Total fat[2]	**30+**	39.26 (38.21-40.32)	0	75.3 (101)	40.53 (38.36-42.70)	0	81.2 (26)
Saturated fat[2]	**30+**	12.13* (11.73-12.53)	0	99.2 (133)	13.09 (12.14-14.05)	0	100 (32)
Polyunsaturated fat[2]	**30+**	8.41 (8.09-8.73)	0	16.4 (22)	8.08 (7.50-8.65)	0	12.5 (4)
Monounsaturated fat[2]	**30+**	15.56 (15.08-16.05)	0	5.2 (7)	15.97 (15.08-16-86)	0	6.2 (2)
Cholesterol (nig)	**30+**	330.7 (290.12-371.35)	0	70.1* (94)	372.6 (301.00-444.10)	0	87.5 (28)
Minerals							
Calcium (mg)	**30-50** **51+**	919.40 (748.25-1090.56) 712.07 (622.02-802.12)	63.6 (42) 94.1 (64)	1.5 (1) 0	806.73 (626.39-987.08) 654.25 (482.12-826.38)	61.1 (11) 100 (14)	0 0
Iron (mg)	**30-50** **51+**	17.10 (13.82-20.38) 13.94 (11.91-15.97)	62.1* (41) 29.4 (20)	3 (2) 1.4 (1)	15.83 (12.48-19.18) 12.11 (9.21-15.02)	11.1 (2) 35.7 (5)	0 0
Magnesium (mg)	**30** **31+**	193.98 (167.42-220.54) 318.04 (282.39-353.70)	100 (3) 58* (76)	0 0	0 269.52 (226.74-312.31)	0 87.5 (28)	0 0
Potassium (mg)	**30+**	2775.1 (2503.08-3047.21)	92.5 (124)	N/A	2589.7 (2136.06-3043.26)	93.7 (30)	0
Sodium (g)	**30-50** **51-70** **71+**	4.45 (3.63-5.27) 3.43 (2.91-3.95) 1.80 (0.95-2.66)	9 (6) 9.3 (6) 0	83.3 (55) 67.1 (43) 0	4.16 (3.30-5.03) 3.20 (2.24-4.17) 3.54 (−13.50-20.60)	0 8.3 (1) 0	83.3 (15) 66.6 (8) 50 (1)
Vitamins							
Vitamin A (mcg)	**30+**	748.94 (663.91-833.97)	52.9 (71)	0.75 (1)	702.54 (542.91-862.18)	71.8 (23)	0
Vitamin D (mcg)	**30-70** **71+**	2.86 (2.49-3.23) 1.61 (0.13-3.09)	100 (130) 100 (4)	0 0	2.44 (1.87-3.0) 2.41 (−10.40-15.22)	100 (30) 100 (2)	0 0
Vitamin E (mg)	**30+**	8.61 (7.64-9.59)	91 (122)	0	7.08 (5.77-8.40)	90.6 (29)	0
Vitamin C (mg)	**30+**	101.86 (90.47-113.26)	43.2 (58)	0	109.78 (73.94-145.62)	59.3 (19)	0
Thiamin (mg/d)	**30+**	1.74 (1.50-1.98)	32.84 (44)	0	1.55 (1.30-1.80)	40.63 (13)	0
Riboflavin (mg)	**30+**	2.19 (1.93-2.46)	17.16 (23)	0	2.02 (1.71-2.33)	21.88 (7)	0
Niacin (mg)	**30+**	24.13 (20.92-27.35)	30.6 (41)	17.91 (24)	21.76 (18.09-25.42)	34.38 (11)	15.63 (5)
Folate (mcg)	**30+**	564.10 (483.20-654.00)	39.55 (53)	6.72 (9)	505.80 (422.46-589.13)	40.63 (13)	0
Vitamin B6 (mg)	**30-50** **51+**	2.12 (1.70-2.55) 1.85 (1.57-2.12)	31.82 (21) 41.18 (28)	0 0	1.95 (1.48-2.42) 1.59 (1.21-1.96)	33.33 (6) 50 (7)	0 0
Vitamin B12 (mcg)	**30+**	5.49 (4.70-6.27)	20.9 (28)	N/A	5.22 (4.22-6.22)	12.5 (4)	0

		Women			Men		
	Age Group (Yrs.)	**Mean (95% CI) N = 134**	**% (N) Below Rec.[1] Values**	**% (N) Above Rec. Values**	**Mean (95% CI) N = 32**	**% (N) Below Rec.[1] Values**	**% (N) Above Rec. Values**
Vitamin K (mcg)	**30+**	168.35 (144.46-192.25)	26.87* (36)	0	177.90 (100.69-255.10)	62.5* (20)	0

[1] recommeded

[2] as percent of calories

* $p < 0.05$ vs. males

Table 4

Average Daily Food Group Intake and USDA Recommendations[1]

		Women (N = 134)		Men (N = 32)	
Food Group	**Age Group (Years)**	**Mean (CI) (N)**	**Daily Rec.[2]**	**Mean (CI) (N)**	**Daily Rec.**
Grains (oz. equiv./day)	30 31-50 51+	6.09 (1.43-10.75) (3) 7.84 (6.08-9.59) (63) 5.60 (4.66-6.54) (68)	6 6 5	0 6.14 (4.74-7.55) (18) 4.56 (2.94-6.19) (14)	8 7 6
Whole Grains (oz. equiv/ day)	30 31-50 51+	0.65 (-0.23-1.55) (3) 1.44* (1.12-1.76) (63) 1.28 (1.06-1.49) (68)	3 3 3	0 0.88 (0.61-1.15)(18) 0.92 (0.51-1.33) (14)	4 3.5 3
Vegetables (cups/day)	30 31-50 51+	0.95 (-0.24-2.16) (3) 2.03 (1.73-2.33) (63) 1.73 (1.43-2.03) (68)	2.5 2.5 2	0 2.07 (1.37-2.77) (18) 1.49 (0.99-1.99) (14)	3 3 2.5
Fruits (cups/day)	30 31-50 51+	0.49 (-0.13-1.11) (3) 0.78 (0.61-0.94) (63) 0.87 (0.70-1.03) (68)	2 1.5 1.5	0 1.06 (0.49-1.63) (18) 0.73 (0.32-1.13) (14)	2 2 2
Milk (cups/day)	30 31-50 51+	1.10 (−0.19-2.39) (3) 1.33 (1.03-1.63) (63) 0.94 (0.80-1.09) (68)	3 3 3	0 0.99 (0.70-1.28) (18) 0.92 (0.57-1.27) (14)	3 3 3
Protein Foods (oz. equiv/ day)	30 31-50 51+	5.41 (2.90-7.91) (3) 7.68 (6.12-9.25) (63) 6.24 (5.06-7.41) (68)	5.5 5 5	0 8.00 (5.86-10.14) (18) 5.83 (4.27-7.39) (14)	6.5 5 5.5

[1]These amounts are appropriate for individuals who get less than 30 minutes per day of moderate physical activity, beyond normal daily activities. This footnote is not applicable to the milk group

[2]Daily recommendation

*$p < 0.05$ vs. males