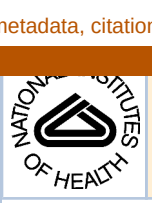



Published in final edited form as:

*J Am Diet Assoc*. 2009 August ; 109(8): 1367–1375. doi:10.1016/j.jada.2009.05.016.

# Action for Health in Diabetes (Look AHEAD) Trial:

## Baseline evaluation of selected nutrients and food group intake

**Mara Z. Vitolins, DrPH, MPH, RD**, **Andrea M. Anderson, MS**, **Linda Delahanty, MS, RD**, **Hollie Raynor, PhD**, **Gary D. Miller, PhD, RD**, **Connie Mobley, PhD, RD**, **Rebecca Reeves, PhD, RD**, **Monica Yamamoto, PhD, RD**, **Catherine Champagne, PhD, RD**, **Rena R. Wing, PhD**, **Elizabeth Mayer-Davis, PhD, RD**, and **Look AHEAD Research Group**

## Abstract

**Background—**Little has been reported regarding food and nutrient intake in persons diagnosed with type 2 diabetes and most reports have been based on findings in select groups or persons who self-reported having diabetes.

**Objective—**To describe the baseline food and nutrient intake of the Look AHEAD trial participants, compare participant intake to national guidelines, and describe demographic and health characteristics associated with food group consumption.

**Methods—**The Look AHEAD trial is evaluating the effects of a lifestyle intervention (calorie control and increased physical activity for weight loss) compared to diabetes support and education on long-term cardiovascular and other health outcomes. Participants are 45-75 years old, overweight or obese [Body Mass Index (BMI) $\geq$ 25 kg/m$^2$], and have type 2 diabetes. Baseline food consumption was assessed in 2,757 participants between September 2000 and December 2003 by food frequency questionnaire in this cross-sectional analysis.

**Statistical Analysis—**Descriptive statistics were used to summarize intake by demographic characteristics. Kruskal-Wallis tests assessed univariate effects of characteristics on consumption. Multiple linear regression models assessed factors predictive of intake. Least square estimates were based on final models and logistic regression determined factors predictive of recommended intake.

**Results—**Ninety-three percent of the participants exceeded the recommended amount of percent calories from fat, 85 % exceeded the saturated fat recommendation, and 92% consumed too much sodium. Also, less than half met the minimum recommended servings of fruit, vegetables, dairy, and grains.

**Conclusions—**These participants with pre-existing diabetes fell short of consuming foods that met recommended food and nutrition guidelines. These overweight adults diagnosed with diabetes are exceeding recommended intake of fat, saturated fats, and sodium which may contribute to increasing their risk of cardiovascular disease and other chronic diseases.



Address correspondences to: Mara Z. Vitolins, Dr.P.H., M.P.H., R.D., Associate Professor, Department of Epidemiology and Prevention, Division of Public Health Sciences, Wake Forest University School of Medicine, Winston-Salem, NC 27104, Phone: (336) 716-2886, Fax: (336) 713-4157, mvitolin@wfubmc.edu.

## Introduction

The Dietary Guidelines for Americans (1) and the Institute of Medicine (IOM) Dietary Reference Intakes (2-4) are based on sound scientific evidence regarding consumption of foods and specific nutrients in relation to physiologic health outcomes. The American Diabetes Association (ADA) models food intake recommendations in persons with type 2 diabetes on these recommendations along with evidence-based nutrition research conducted in persons who have type 2 diabetes (5,6). The American Diabetes Association nutrition recommendations for persons who have diabetes emphasize the goals of medical nutrition therapy that encompasses the following; maintaining or achieving 1) normal glycemia or as close to normal, in a range that is safe for the patient, 2) a lipid and lipoprotein profile that reduces risk of cardiovascular disease, and 3) blood pressure in the normal range or as close to normal that can be safely achieved.

There is an array of scientific literature pertaining to food intake and risk of developing type 2 diabetes. However, little has been reported regarding food consumption patterns and quality of food intake in persons diagnosed with type 2 diabetes and most reports have been based on findings in international populations (7-10), in very select groups (11,12), or in persons who self-reported having type 2 diabetes (13). The Action for Health in Diabetes (Look AHEAD) trial is being conducted in sites across the nation and offers a unique opportunity to evaluate the food and nutrient intake of a large number of individuals diagnosed with type 2 diabetes and allows for comparison of the participants baseline nutrient and food group consumption to the intake guidelines recommended by the IOM and those in the United States Department of Agriculture-Food Guide Pyramid (USDA FGP) (1-4). This important evaluation may provide insights into dietary practices of persons with type 2 diabetes across the nation.

The purpose of this report is to: 1) describe baseline food intake of the Look AHEAD (LA) participants, 2) compare nutrient and food intake of LA participants to the recommendations of the IOM and those contained in the USDA FGP and, 3) describe participant characteristics (i.e., sex, ethnicity, age, income) associated with consumption of specific food groups. It was hypothesized that, in general, few LA participants would meet the food and nutrient intake recommendations, and that gender, ethnicity, and age would be associated with meeting recommendations.

## Methods

This is a cross-sectional analysis of food and nutrient intake measured at the baseline visit of the LA trial. A comprehensive description of the LA trial design and intervention has been published elsewhere (14,15). Briefly, approximately 5,000 people aged 45-75 years who are overweight or obese (BMI ≥25 kg/m$^2$) and have type 2 diabetes are taking part in the trial which is being conducted in 16 sites across the nation. Type 2 diabetes was confirmed by medical record, current diabetes treatment, confirmation from a primary health care provider, or fasting glucose ≥126 mg/dL, symptoms of hyperglycemia with non-fasting plasma glucose ≥200 mg/dL or 2-hour plasma glucose ≥200 mg/dL after ingestion of a 75-g oral glucose solution on at least two tests. The inclusion criteria for age changed from 45-75 years to 55-75 years during the second year of participant recruitment to increase the cardiovascular event rate.

The trial is evaluating the effects of a lifestyle intervention (calorie control and increased physical activity to achieve and maintain weight loss) compared to a diabetes support and education intervention on long-term cardiovascular and other important health outcomes. Participants will be followed for approximately 11.5 years. Prior to randomization all trial participants completed a 2-week run-in period that included self-monitoring of food and

physical activity and attended an initial session of diabetes education that focused on aspects of diabetes care. The education session emphasized the importance of eating healthy foods and being physically active for both weight loss and improved glycemic control. All participants gave written informed consent and clinical centers obtained local Institutional Review Board approval for use of human subjects.

## Nutrition assessment

The LA semi-quantitative, previously validated, food frequency questionnaire (LA FFQ) was selected to measure food and nutrient intake in 50% of the subjects seen at each clinic site (16). The questionnaire is a modified version of the Diabetes Prevention Program (DPP) Food Frequency Questionnaire and was designed to collect information on usual intake of food items over the past six months (16-17). The DPP food list, developed for regional and ethnic sensitivity, formed the basis of the LA FFQ food list. The body of the questionnaire contains 134 line items, 20 items that are used to adjust the 134 items (type of oil used when cooking, fat added to vegetables, potatoes at the table, etc.), and 3 quality control questions. Meal replacement beverages and snack bars were added as line items to the LA FFQ as the intervention component of the trial was structured to utilize these products. Information regarding nutritional supplements was not collected, therefore, the analyses were conducted only on foods and beverages consumed.

The LA FFQ is primarily self-administered with limited staff assistance. Staff instructed participants in how to complete the LA FFQ and upon its return; staff reviewed it with the participant. For each line item, participants reported frequency of consumption and portion size. The nine frequency categories for food items included “never or less than once per month” to “2 or more times per day” and, for beverages, from “never or less than once per month” to “6 or more times per day.” Portion sizes were listed as small, medium, or large.

## Quality Control

The implementation and management of the nutrition assessment for the trial is centralized at the LA Diet Assessment Center. One primary diet interviewer for each site was certified by Diet Assessment Center staff to administer and edit the LA FFQ. Certification of the primary diet interviewer is conducted annually. The LA FFQs were edited initially at the clinical sites, and additional editing and quality control checks including internal consistency and range, were conducted at the Diet Assessment Center using the edit checks internal to the National Cancer Institute Health Habits and History Questionnaire /DietSys program (version 3.0, 1993, National Cancer Institute, Rockville, MD) followed by a DAC staff review of forms in which a food or nutrient value was extreme.

## Food groupings and nutrients

Estimates of food group and nutrient intake were conducted using the HHHQ/ DietSys software and LA-specific programming written to incorporate the LA modifications to the questionnaire. The nutrient database was modified from the DPP database to incorporate foods added for the LA FFQ. These nutrient values were obtained primarily from the Nutrition Data System for Research (version 4.01_30, 1999, Nutrition Coordinating Center, Minneapolis, MN). The portion size database, including gram weights for small, medium, and large portions according to age and sex, was also modified to accommodate the new foods.

The current values of the Dietary Reference Intakes established between 1997 and 2004 and written to serve as standards for nutrient intakes for individuals in the United States and Canada were used to evaluate macro- and micronutrient intake (2-4). For this analysis, to coincide with the time the baseline trial data were collected, the recommendations contained in the USDA

FGP were used to make decisions regarding the inclusion of foods within the main groupings (1).

### Anthropometric measures

All anthropometric measurements were taken with the participants wearing light weight clothing (e.g., a short sleeve shirt or blouse or surgical gown, shorts, socks) and without shoes. All measurements were taken twice and the mean of the two measures was used in the analysis. Generic wall-mounted stadiometers graduated in centimeters with a horizontal measuring block (or fixed angle) were used to measure height. Participant's height was recorded to the nearest 0.5 cm. Weight was measured using a digital scale (BWB 800, Tanita Corp., Arlington Heights, IL). Weight was recorded in kilograms to the nearest 0.1 kg. Body Mass Index (BMI) was calculated using the following formula: weight in kg/ ht in $m^2$.

## Statistical analysis

Descriptive statistics, means, standard deviations, medians, inter-quartile ranges, frequencies, and percents, were used to summarize intake of nutrients and food groups. Kruskal-Wallis tests, non-parametric analysis of variance used to rank data that is not normally distributed, were used to assess the univariate effects of these characteristics on food group consumption, ANOVAs were used to assess the univariate effects of these characteristics on nutrient consumption, and Chi-square tests were used to assess the effects of these characteristics on meeting recommended consumption of nutrients and food groups. Multiple linear regression models were used to assess which factors were predictive of meeting intake of each of the major food groups. Logistic regression was used to determine which factors were predictive of recommended intake defined for each food group as consuming as much or more of the specified food group as recommended in the USDA FGP guidelines. A p-value of <.05 was used to denote statistical significance. The Statistical Analysis System (version 9.2, 1998, SAS Institute, Cary, NC) was utilized to conduct the analyses.

## Results

Of the 2,793 baseline LA FFQs received, three questionnaires were deleted immediately because most of the line items had not been completed; the remaining 2,790 questionnaires were scanned. Thirty-three forms were excluded after being scanned for the following reasons: 1) less than 4 foods per day reported, (n=23); 2) more than 30 foods per day reported (n=8); and 3) more than 2 errors flagged (n=2). Therefore, only 1.2% of the forms were not included in the final dataset and the nutrition analysis reported in this paper was conducted using data obtained from 2,757 LA FFQs.

Table 1 illustrates demographic and health characteristics of participants who completed the LA FFQ. Participants who completed the LA FFQ were younger than those who did not (57.2 ± 7.2 vs. 60.5 ± 5.9, p<.0001) due to the change in the age inclusion criteria during year 2 of the recruitment period. There were no other significant differences between the two groups with respect to sex, race, and educational attainment.

In Table 2 percent of study participants who met the recommendations for nutrient intake illustrated. With respect to calories consumed, unadjusted total energy intake was found to be higher among males, 2,000 kcal/d compared to 1,744 kcal/d females. Higher intake of calories was also found in the younger age groups, Hispanic participants, more educated participants, those with higher incomes, and those with higher BMI.

Table 3 enumerates the recommended servings per day for each food group, as compared to the overall actual consumption of the sample. Unadjusted comparisons of each of the five food

groups; 1) grains, 2) fruit, 3) vegetables, 4) dairy, 5) meat, and the discretionary calories group, fats/sweets with the characteristics of the sample were also performed. There was greater consumption of fruits and vegetables in females, and greater consumption of meats in males. Younger individuals consumed more grains, meat, and fats/sweets. Hispanic participants consumed the greatest amount of grain, fruits and vegetables, and meat, whereas non-Hispanic whites consumed the largest amount of dairy and fats/sweets. African American participants generally had the lowest levels of consumption. Higher levels of education and income were both associated with consumption of more dairy, meat, and fats/sweets. Higher BMI was associated with higher consumption of all food groups except fruit and vegetables, where there are no differences in consumption between BMI groups. When sex, age, race, education, income, and BMI were simultaneously accounted for in a multiple linear regression model, similar results were seen, although income was no longer associated with any food group, and education level was no longer associated with intake of dairy products.

Table 4 shows the number and percent of the trial population meeting food group intake recommendations. In multiple logistic regression models (data not shown), younger age, non-white race, and higher BMI were significantly ($p \leq .05$) associated with meeting the recommended grain servings. Non-white race, lower income, and lower BMI were significantly ($p \leq .05$) associated with meeting the recommendation of 1 serving or less of fats/sweets per day.

## Discussion

In this evaluation of dietary intake in overweight individuals diagnosed with type 2 diabetes only a limited number of participants met nutrient intake recommendations for total fat, saturated fat, sodium, and fiber. Also, less than half consumed the minimum recommended daily servings of fruit, vegetables, dairy, and grains based on the year 2000 version of the FGP recommendations.

Overall, the participants consumed a diet that provided approximately 44% of calories from carbohydrates, 40% from fat, and 17% from protein. Notable is the lower contribution of carbohydrates and higher contribution of fat to their diets. Similar results have been reported showing that persons with type 2 diabetes are not consuming healthful diets (7-13). Nelson et al., (13) reported nutrient intake data of 1,480 adults 17 years of age and older who self-reported type 2 diabetes in the Third National Health and Nutrition Examination Survey. Mean age of the population was 61 years old, most were white, and 20% of the sample reported income levels below the federal poverty level and 45% had less than a high school education. Eighty-two percent of the participants had a BMI $\geq 25$ kg/m$^2$, 36% were overweight, and 46% were obese. Forty-two percent of the respondents reported consuming 30-40% of daily calories from fat, and 26% consumed more than 40% of calories from fat. Approximately two thirds consumed more than 10% of total calories from saturated fat. Additionally participants over the age of 65 years consumed a lower percentage of total calories from fat than those participants who were younger than 65 years, similar findings to those of the current trial in which older age was associated with meeting the recommendations for percent total fat intake.

As for food group consumption, the LA participants consumed less than the recommended intake of the fruits and vegetables. Intake of diets rich in fruits and vegetables have been shown to prevent heart disease (18,19) the leading cause of death in persons with type 2 diabetes (20). As fruit and vegetables provide fiber, are nutrient dense, and filled with antioxidants and other planted- based phytochemicals, counseling to increase consumption in this population has the potential to improve biochemical markers of disease risk such as lipids and antioxidant levels (21).

Raynor et al., (22) reported that the three most commonly reported weight control practices in this Look AHEAD cohort at baseline were increasing fruits and vegetables, cutting out sweets, and eating less high-carbohydrate foods, each of which could impact on the overall amount and type of carbohydrate consumed. These three weight control practices were reported by over 50% of the participants for an average of > 20 weeks over the previous year and yet were not the most important correlates of lower BMI (22). It may be that people with type 2 diabetes are more commonly focusing on eating less carbohydrates, regardless of type (simple versus complex) due to the belief that restricting carbohydrates will help control blood glucose levels, yet in doing so they need to also understand the potential adverse effects of the higher cholesterol, saturated fat and total fat intakes that can result in terms of cardiovascular risk factors.

All participants were overweight or obese and based on the evaluation of their nutrient intake are over-consuming foods that are high in fat, saturated fat, and salt. While the overall calorie intake of the participants may seem low it is not uncommon for calorie levels to be surprisingly low for overweight, sedentary individuals. Small increases in calorie intake on the positive side of the energy balance equation over many years can lead to substantial weight gain.

Interestingly, more participants in the highest BMI range (40+) met the recommended food group intake for grains, dairy, meat but were also less likely to consume one serving/d or less of fats, oils and sweets compared to participants in the other BMI ranges. All of these participants would benefit from counseling to encourage consumption of high fiber, low-fat grains, low-fat dairy, and guidance to select leaner cuts of meat. In addition, counseling to reduce consumption of discretionary calories would improve the likelihood of meeting fat and cholesterol intake guidelines and improve the overall quality of foods consumed.

Interestingly, the only factor that did not affect food group intake was duration of diabetes. It would seem likely that participants who had managed diabetes over a greater length of time would be more likely to understand the importance of consuming a healthful diet, but this was not supported by the data. This also speaks to the necessity of providing ongoing nutrition education in persons with diabetes regardless of the duration of diabetes.

Several limitations should be mentioned. Most participants reported having more than a high school education, therefore, these trial results may not be generalizable to less educated populations. However, similar results were reported by Nelson et al who evaluated the Third National Health and Nutrition Examination Survey data (13). Food frequency questionnaires are known to underestimate calorie intake overall, however, this questionnaire was used because the study investigators were less focused on the absolute value of calories, and more so on the capacity of the LA FFQ to do a reasonable job in ranking participants. Under reporting has also been found to be more common in overweight individuals and those who have diabetes so under reporting of intake may be higher in this trial population compared to the general population (23-26). However, while all foods appear to be underreported in general, foods that may be considered less socially acceptable such as discretionary calorie food items appear to have the highest levels of underreporting (27). This could mean that discretionary calorie servings consumed by the participants may be even higher than reported. Nevertheless, this evaluation of food and nutrient intake demonstrates that overall, these adults with type 2 diabetes are failing to meet recommended food and nutrient intake guidelines and are consuming diets that may exacerbate cardiovascular and other chronic disease risk.

## Conclusion

Optimizing glycemic, lipid, blood pressure and weight control in persons with type 2 diabetes is essential to reduce risk for long-term complications and chronic disease, including

cardiovascular disease. Consuming a low-saturated fat, high-fiber diet that includes high quality, nutrient-dense foods can assist in achieving and maintaining this type of metabolic control. Evidence-based nutrition principles and recommendations as well as national guidelines have been established to help inform and educate the public on healthful eating practices. Unfortunately, in this evaluation, it was found that the LA participants fell short of consuming foods that would help them meet these guidelines. The findings illustrate that these participants need encouragement and support in their efforts to make healthful food choices. Approaches to guide their selection of foods, such as substituting highly processed foods for less processed foods and reducing saturated fat intake may greatly improve their overall dietary quality. Additionally, research efforts to better understand the types of barriers these overweight persons with type 2 diabetes must face in their attempts to consume a healthful diet appear warranted.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Appendix

Andrea M. Anderson, M.S., Biostatistician, Department of Biostatistical Sciences, Division of Public Health Sciences, Wake Forest University School of Medicine, Winston-Salem, NC 27157, Phone: (336) 713-5174, Fax: (336) 731-5308, amanders@wfubmc.edu

Linda Delahanty M.S., R.D., Director of Nutrition and Behavioral Research, Massachusetts General Hospital Diabetes Center, 50 Staniford St, Suite 340, Boston. MA 02114, Phone (617) 724-9727, Fax: (617) 726-1871, ldelahanty@partners.org

Hollie Raynor, Ph.D., R.D., Assistant Professor, Department of Nutrition, University of Tennessee Knoxville, 1215 W. Cumberland Dr, JHB 229, Knoxville, TN 37996, Phone: (865) 974-6259, Fax: (865) 974-3491, hraynor@utk.edu

Gary Miller, Ph.D., R.D., Associate Professor, Department of Health and Exercise Science, Wake Forest University, Room 315 Reynolds Gymnasium, Winston-Salem, NC 27109, Phone: (336) 758-1901, Fax: (336) 758-4680, millergd@wfu.edu

Connie Mobley, Ph.D., R.D., Associate Dean of Research, Professor, Department of Professional Studies, University of Nevada Las Vegas School of Dental Medicine, 1001 Shadow Lane, Las Vegas, NV 89106, Phone: (702) 774-2643, Fax: (702) 774-2647, connie.mobley@unlv.edu

Rebecca Reeves Dr.P.H., R.D., Assistant Professor, Baylor College of Medicine, 6655 Travis St. Suite 320, Houston, TX 77030, Phone: (713) 798-5764, Fax: (713) 798-4888, rreeves@bcm.tmc.edu

Monica Yamamoto Dr.P.H., F.A.D.A., R.D., L.D.N., Assistant Professor, Dept. of Epidemiology, Graduate School of Public Health University of Pittsburgh, Pittsburgh, PA 15260, Phone: (412) 967-9477, FAX: (412) 826-9590, mey@pitt.edu

Catherine Champagne Ph.D., R.D., Professor, Chief, Nutrition Epidemiology/Dietary Assessment & Counseling, Pennington Biomedical Research Center, Dietary Assessment and Food Analysis Core, 6400 Perkins Road, Baton Rouge, Louisiana 70808-4124, Phone: (225) 763-2553, Fax (225) 763-3045, champacm@pbrc.edu

Rena R. Wing, Ph.D., Professor, Brown University, Department of Psychiatry and Human Behavior, 196 Richmond Street, Providence, Rhode Island 02903, Phone: (401) 793-8959, Fax: (401) 793-8944, rwing@lifspan.org

Elizabeth Mayer-Davis, Ph.D., R.D., Professor, University of North Carolina at Chapel Hill, Chapel Hill NC 27599, Phone: (919) 966-1991, ejmayer_davis@unc.edu

Look AHEAD Research Group at Baseline

Clinical Sites

The Johns Hopkins Medical Institutions Frederick Brancati, MD, MHS; Debi Celnik, MS, RD, LD; Jeff Honas, MS; Jeanne Clark, MD, MPH; Jeanne Charleston, RN; Lawrence Cheskin, MD; Kerry Stewart, EdD; Richard Rubin, PhD; Kathy Horak, RD

Pennington Biomedical Research Center George A. Bray, MD; Kristi Rau; Allison Strate, RN; Frank L. Greenway, MD; Donna H. Ryan, MD; Donald Williamson, PhD; Elizabeth Tucker; Brandi Armand, LPN; Mandy Shipp, RD; Kim Landry; Jennifer Perault

The University of Alabama at Birmingham Cora E. Lewis, MD, MSPH; Sheikilya Thomas MPH; Vicki DiLillo, PhD; Monika Safford, MD; Stephen Glasser, MD; Clara Smith, MPH; Cathy Roche, RN; Charlotte Bragg, MS, RD, LD; Nita Webb, MA; Staci Gilbert, MPH; Amy Dobelstein; L. Christie Oden; Trena Johnsey

Harvard Center

*Massachusetts General Hospital*: David M. Nathan, MD; Heather Turgeon, RN; Kristina P. Schumann, BA; Enrico Cagliero, MD; Kathryn Hayward, MD; Linda Delahanty, MS, RD; Barbara Steiner, EdM; Valerie Goldman, MS, RD; Ellen Anderson, MS, RD; Laurie Bissett, MS, RD; Alan McNamara, BS; Richard Ginsburg, PhD; Virginia Harlan, MSW; Theresa Michel, MS

*Joslin Diabetes Center*: Edward S. Horton, MD; Sharon D. Jackson, MS, RD, CDE; Osama Hamdy, MD, PhD; A. Enrique Caballero, MD; Sarah Ledbury, MEd, RD; Maureen Malloy, BS; Ann Goebel-Fabbri, PhD; Kerry Ovalle, MS, RCEP, CDE; Sarah Bain, BS; Elizabeth Bovaird, BSN,RN; Lori Lambert, MS, RD

*Beth Israel Deaconess Medical Center*: George Blackburn, MD, PhD; Christos Mantzoros, MD, DSc; Ann McNamara, RN; Heather McCormick, RD

University of Colorado Health Sciences Center James O. Hill, PhD; Marsha Miller, MS, RD; Brent VanDorsten, PhD; Judith Regensteiner, PhD; Robert Schwartz, MD; Richard Hamman, MD, DrPH; Michael McDermott, MD; JoAnn Phillipp, MS; Patrick Reddin, BA; Kristin Wallace, MPH; Paulette Cohrs, RN, BSN; April Hamilton, BS; Salma Benchekroun, BS; Susan Green; Loretta Rome, TRS; Lindsey Munkwitz, BS

Baylor College of Medicine John P. Foreyt, PhD; Rebecca S. Reeves, DrPH, RD; Henry Pownall, PhD; Peter Jones, MD; Ashok Balasubramanyam, MD; Molly Gee, MEd, RD

University of California at Los Angeles School of Medicine Mohammed F. Saad, MD; Ken C. Chiu, MD; Siran Ghazarian, MD; Kati Szamos, RD; Magpuri Perpetua, RD; Michelle Chan, BS; Medhat Botrous

The University of Tennessee Health Science Center

*University of Tennessee East.* Karen C. Johnson, MD, MPH; Leeann Carmichael, RN; Lynne Lichtermann, RN, BSN

*University of Tennessee Downtown*. Abbas E. Kitabchi, PhD, MD; Jackie Day, RN; Helen Lambeth, RN, BSN; Debra Force, MS, RD, LDN; Debra Clark, LPN; Andrea Crisler, MT, Donna Green, RN; Gracie Cunningham; Maria Sun, MS, RD, LDN; Robert Kores, PhD; Renate Rosenthal, PhD; and Judith Soberman, MD

University of Minnesota Robert W. Jeffery, PhD; Carolyn Thorson, CCRP; John P. Bantle, MD; J. Bruce Redmon, MD; Richard S. Crow, MD; Jeanne Carls, MEd; Carolyne Campbell; La Donna James; T. Ockenden, RN; Kerrin Brelje, MPH, RD; M. Patricia Snyder, MA, RD; Amy Keranen, MS; Cara Walcheck, BS, RD; Emily Finch, MA; Birgitta I. Rice, MS, RPh, CHES; Vicki A. Maddy, BS, RD; Tricia Skarphol, BS

St. Luke's Roosevelt Hospital Center Xavier Pi-Sunyer, MD; Jennifer Patricio, MS; Jennifer Mayer, MS; Stanley Heshka, PhD; Carmen Pal, MD; Mary Anne Holowaty, MS, CN; Diane Hirsch, RNC, MS, CDE

University of Pennsylvania Thomas A. Wadden, PhD; Barbara J. Maschak-Carey, MSN, CDE; Gary D. Foster, PhD; Robert I. Berkowitz, MD; Stanley Schwartz, MD; Shiriki K. Kumanyika, PhD, RD, MPH; Monica Mullen, MS, RD; Louise Hesson, MSN; Patricia Lipschutz, MSN; Anthony Fabricatore, PhD; Canice Crerand, PhD; Robert Kuehnel, PhD; Ray Carvajal, MS; Renee Davenport; Helen Chomentowski

University of Pittsburgh David E. Kelley, MD; Jacqueline Wesche -Thobaben, RN,BSN,CDE; Lewis Kuller, MD, DrPH.; Andrea Kriska, PhD; Daniel Edmundowicz, MD; Mary L. Klem, PhD, MLIS; Janet Bonk, RN, MPH; Jennifer Rush, MPH; Rebecca Danchenko, BS; Barb Elnyczky, MA; Karen Vujevich, RN-BC, MSN, CRNP; Janet Krulia, RN,BSN,CDE; Donna Wolf, MS; Juliet Mancino, MS, RD, CDE, LDN; Pat Harper, MS, RD, LDN; Anne Mathews, MS, RD, LDN

Brown University Rena R. Wing, PhD; Vincent Pera, MD; John Jakicic, PhD; Deborah Tate, PhD; Amy Gorin, PhD; Renee Bright, MS; Pamela Coward, MS, RD; Natalie Robinson, MS, RD; Tammy Monk, MS; Kara Gallagher, PhD; Anna Bertorelli, MBA, RD; Maureen Daly, RN; Tatum Charron, BS; Rob Nicholson, PhD; Erin Patterson, BS; Julie Currin, MD; Linda Foss, MPH; Deborah Robles; Barbara Bancroft, RN, MS; Jennifer Gauvin, BS; Deborah Maier, MS; Caitlin Egan, MS; Suzanne Phelan, PhD; Hollie Raynor, PhD, RD; Don Kieffer, PhD; Douglas Raynor, PhD; Lauren Lessard, BS; Kimberley Chula-Maguire, MS; Erica Ferguson, BS, RD; Richard Carey, BS; Jane Tavares, BS; Heather Chenot, MS; JP Massaro, BS

The University of Texas Health Science Center at San Antonio Steve Haffner, MD; Maria Montez, RN, MSHP, CDE; Connie Mobley, PhD, RD; Carlos Lorenzo, MD

University of Washington / VA Puget Sound Health Care System Steven E. Kahn, MB, ChB; Brenda Montgomery, MS, RN, CDE; Robert H. Knopp, MD; Edward W. Lipkin, MD, PhD; Matthew L. Maciejewski, PhD; Dace L. Trence, MD; Roque M. Murillo, BS; S. Terry Barrett, BS

Southwestern American Indian Center, Phoenix, Arizona and Shiprock, New Mexico William C. Knowler, MD, DrPH; Paula Bolin, RN, MC; Tina Killean, BS; Cathy Manus, LPN; Carol Percy, RN; Rita Donaldson, BSN; Bernadette Todacheenie, EdD; Justin Glass, MD; Sarah Michaels, MD; Jonathan Krakoff, MD; Jeffrey Curtis, MD, MPH; Peter H. Bennett, MB, FRCP; Tina Morgan; Ruby Johnson; Janelia Smiley; Sandra Sangster; Shandiin Begay, MPH; Minnie Roanhorse; Didas Fallis, RN; Nancy Scurlock, MSN, ANP; Leigh Shovestull, RD

Coordinating Center

Wake Forest University School of Medicine Mark A. Espeland, PhD; Judy Bahnson, BA; Lynne Wagenknecht, DrPH; David Reboussin, PhD; W. Jack Rejeski, PhD; Wei Lang, PhD; Alain Bertoni, MD, MPH; Mara Vitolins, DrPH; Gary Miller, PhD; Paul Ribisl, PhD; Kathy Dotson, BA; Amelia Hodges, BS; Patricia Hogan, MS; Kathy Lane, BS; Carrie Combs, BS; Christian Speas, BS; Delia S. West, PhD; William Herman, MD, MPH

Central Resources Centers

DXA Reading Center, University of California at San Francisco Michael Nevitt, PhD; Ann Schwartz, PhD; John Shepherd, PhD; Jason Maeda, MPH; Cynthia Hayashi; Michaela Rahorst; Lisa Palermo, MS, MA

Central Laboratory, Northwest Lipid Research Laboratories Santica M. Marcovina, PhD, ScD; Greg Strylewicz, MS

ECG Reading Center, EPICARE, Wake Forest University School of Medicine

Ronald J. Prineas, MD, PhD; Zhu-Ming Zhang, MD; Charles Campbell, AAS, BS; Sharon Hall

Diet Assessment Center, University of South Carolina, Arnold School of Public Health, Center for Research in Nutrition and Health Disparities Elizabeth J Mayer-Davis, PhD; Cecilia Farach, DrPH

Federal Sponsors

National Institute of Diabetes and Digestive and Kidney Diseases: Barbara Harrison, MS; Susan Z.Yanovski, MD; Van S. Hubbard, MD PhD

National Heart, Lung, and Blood Institute: Lawton S. Cooper, MD, MPH; Eva Obarzanek, PhD, MPH, RD; Denise Simons-Morton, MD, PhD

Centers for Disease Control and Prevention: David F. Williamson, PhD; Edward W. Gregg, PhD

## References

1. US Department of Health and Human Services. US Department of Agriculture. Dietary Guidelines for Americans, 2000. US Department of Health and Human Services, US Department of Agriculture; Washington, DC: 2000.
2. Institute of Medicine Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. National Academy Press; Washington, DC: 1997. p. 71-145.
3. Institute of Medicine Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). National Academy Press; Washington, DC: 2002. p. S1-S18.
4. Institute of Medicine Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. National Academy Press; Washington DC: 2004. p. 270
5. Franz MJ, Bantle J, Beebe CA, Brunzell JD, Chiasson JL, Garg A, Holzmeister LA, Hoogwerf B, Mayer-Davis E, Mooradian A, Purnell JQ, Wheeler M. American Diabetes Association Position Statement: Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. J Am Diet Assoc 2002;102:109–118. [PubMed: 11794490]
6. Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson JL, Garg A, Holzmeister LA, Hoogwerf B, Mayer-Davis E, Mooradian AD, Purnell JQ, Wheeler M. Evidence-based nutrition principles and

recommendations for the treatment and prevention of diabetes and related complications (Technical Review). Diabetes Care 2002;25:148–198. [PubMed: 11772915]

7. Cruz AF, Calle-Pascual AL, Diabetes and Nutrition Study Group; Spanish Diabetes Association. Diabetes Nutrition and Complications Trial: Trends in nutritional pattern between 1993 and 2000 and targets of diabetes treatment in a sample of Spanish people with diabetes. Diabetes Care 2004;27:984–987. [PubMed: 15047660]
8. Gauthier-Chelle K, Mennen L, Arnault N, Rigalleau V, Hercberg S, Gin H. Comparison of the diet of self-declared diabetics with non-diabetic patients in the SU.VI.MAX study: Did the diabetics modify their nutritional behavior? Diabetes Metab 2004;30:535–542. [PubMed: 15671923]
9. Helmer C, Bricout H, Gin H, Barberger-Gateau P. Macronutrient intake and discrepancy with nutritional recommendations in a group of elderly diabetic subjects. Br J Nutr 2007;29:1–7.
10. Toeller M, Klischan A, Heitkamp G, Schumacher W, Milne R, Buyken A, Karamanos B, Gries FA, EURODIAB IDDM Complications Study Group. Nutritional intake of 2868 IDDM patients from 30 centres in Europe. Diabetologia 1996;39:929–939. [PubMed: 8858215]
11. Parker DR, McPhillips JB, Lapane KL, Lasater TM, Carleton RA. Nutrition and health practices of diabetic and nondiabetic men and women from two southeastern New England communities. Nutr Health 1995;10:255–268. [PubMed: 8684734]
12. Shimakawa T, Herrera-Acena MG, Colditz GA, Manson JE, Stampfer MJ, Willett WC, Stamper MJ. Comparison of diets of diabetic and nondiabetic women. Diabetes Care 1993;16:1356–1362. [PubMed: 8269793]
13. Nelson KM, Reiber G, Boyko EJ. Diet and Exercise Among Adults With Type 2 Diabetes: Findings from the Third National Health and Nutrition Examination Survey (NHANES III). Diabetes Care 2002;25:1722–1728. [PubMed: 12351468]
14. Ryan DH, Espeland MA, Foster GD, Haffner SM, Hubbard VS, Johnson KC, Kahn SE, Knowler WC, Yanovski SZ, Look AHEAD Research Group. Look AHEAD (Action for Health in Diabetes): design and methods for a clinical trial of weight loss for the prevention of cardiovascular disease in type 2 diabetes. Controlled Clinical Trials 2003;24:610–628. [PubMed: 14500058]
15. Look AHEAD Research Group. Wadden TA, West DS, Delahanty L, Jakicic J, Rejeski J, Williamson D, Berkowitz RI, Kelley DE, Tomchee C, Hill JO, Kumanyika S. The Look AHEAD study: a description of the lifestyle intervention and the evidence supporting it. Obesity 2006;1:737–752. [PubMed: 16855180]
16. Mayer-Davis EJ, Vitolins MZ, Carmichael SL, Hemphill S, Tsaroucha G, Rushing J, Levin S. Validity and reproducibility of a food frequency interview in a multi-cultural epidemiologic study. Ann Epidemiol 1999;9:314–324. [PubMed: 10976858]
17. Block, G.; Hartman, AM. Data collection and data management. In: Block, G.; Hartman, AM., editors. DIETSYS Version 3.0 User's Guide. National Cancer Institute; Bethesda, MD: 1994. p. 15
18. Joshipura KJ, Hu FB, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, Colditz G, Ascherio A, Rosner B, Spiegelman D, Willett WC. The effect of fruit and vegetable intake on risk for coronary heart disease. Ann Intern Med 2001;134:1106–1114. [PubMed: 11412050]
19. Hung HC, Joshipura KJ, Jiang R, Hu FB, Hunter D, Smith-Warner SA, Colditz GA, Rosner B, Spiegelman D, Willett WC. Fruit and vegetable intake and risk of major chronic disease. J Natl Cancer Inst 2004;96:1577–1584. [PubMed: 15523086]
20. Winer N, Sowers JR. Epidemiology of diabetes. J Clin Pharmacol 2004;44:397–405. [PubMed: 15051748]
21. Lampe JW. Health effects of vegetables and fruit: assessing mechanisms of action in human experimental studies. Am J Clin Nut 1999;70:475S–490S.
22. Raynor HA, Jeffery RW, Ruggiero AM, Clark JM, Delahanty LM, the Look AHEAD Research Group. Weight loss strategies associated with body mass index in overweight adults with type 2 diabetes at entry into the Look AHEAD Trial. Diabetes Care 2008;31:1299–1304. [PubMed: 18375417]
23. Seale JL, Klein G, Friedmann J, Jensen GL, Mitchell DC, Smiciklas-Wright H. Energy expenditure measured by doubly labeled water, activity recall, and diet records in the rural elderly. Nutrition 2002;18:568–573. [PubMed: 12093431]

24. Goris AH, Westerterp-Plantenga MS, Westerterp KR. Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. Am J Clin Nutr 2000;71:130–134. [PubMed: 10617957]

25. Briefel RR, Sempos CT, McDowell MA, Chien S, Alaimo K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. Am J Clin Nutr 1997;65:1203S–1209S. [PubMed: 9094923]

26. Salle' A, Ryan M, Ritz P. Underreporting of Food Intake in Obese Diabetic and Nondiabetic Patients. Diabetes Care 2006;12:2726–2727.

27. Krebs-Smith SM, Graubard BI, Kahle LL, Subar AF, Cleveland LE, Ballard-Barbash R. Low energy reporters vs others: a comparison of reported food intakes. Eur J Clin Nutr 2000;54:281–287. [PubMed: 10745278]

## Table 1

Demographic and health characteristics of Look AHEAD participants who completed the Food Frequency Questionnaire (FFQ)

| | Completed FFQ |
|---|---|
| **Total** | **N (%) 2757 (100)** |
| **Sex** | |
| Male | 1122 (41) |
| Female | 1635 (59) |
| **Age (years)** | |
| 45-55 | 1191 (43) |
| 56-65 | 1183 (43) |
| 66-75 | 383 (14) |
| **Race** | |
| White | 1758 (64) |
| African-American | 414 (15) |
| Hispanic | 350 (13) |
| Other | 234 (8) |
| **Education (years)** | |
| < HS Degree | 534 (20) |
| HS to Some College | 1030 (38) |
| Bachelor's Degree or More | 1133 (42) |
| **Income level** | |
| <$40,000 | 780 (31) |
| $40,00-69,999 | 736 (29) |
| ≥$70,000 | 996 (40) |
| **Body Mass Index** | |
| 25 - < 30 | 395 (14) |
| 30 - <35 | 960 (35) |
| 35 - <40 | 741 (27) |
| 40 + | 661 (24) |
| **Diabetes Treatment** | |
| No Medications | 323 (12) |
| Oral Diabetes Medications | 1858 (68) |
| Insulin only | 117 (4) |
| Insulin and Oral Diabetes Medications | 418 (15) |
| **Diabetes Duration (years)** | |
| 0-2 | 465 (17) |
| >2-5 | 793 (29) |
| >5 -10 | 790 (29) |
| >10 | 681 (25) |

## Table 2

Recommended Daily Nutrient Intake by Sex and Gender and Overall Percent of Look AHEAD Participants Meeting Recommendations

| Nutrient | | Recommended Daily Intake | Actual Daily Intake (Median, IQR[a]) | % Meeting Recommendation |
|---|---|---|---|---|
| % Total Fat | | ≤ 30 | 40 (35-45) | 7 |
| % Saturated Fat | | ≤ 10 | 13 (11-15) | 15 |
| Cholesterol (mg/d) | | ≤ 300 | 297 (202-422) | 51 |
| Sodium (mg/d) | Age 31-50 | ≤ 1500 | 2846 (2006-3910) | 8 |
| | Age 50-70 | ≤ 1300 | 2551 (1895-3426) | |
| | Age >70 | ≤ 1200 | 2026 (1400-2744) | |
| Calcium (mg/d) | Age 31-50 | ≥ 1000 | 744 (522-1087) | 20 |
| | Age 50-70 | ≥ 1200 | 689 (484-1014) | |
| | Age >70 | ≥ 1200 | 604 (409-839) | |
| Fiber (g/d) | Age 31-50 - Male | ≥ 38 | 20 (16-25) | 20 |
| | Age 50-70 - Male | ≥ 30 | 19 (14-25) | |
| | Age >70 - Male | ≥ 30 | 16 (12-21) | |
| | Age 31-50 - Female | ≥ 25 | 18 (13-22) | |
| | Age 50-70 - Female | ≥ 21 | 17 (12-22) | |
| | Age >70 - Female | ≥ 21 | 15 (12-19) | |

[a] IQR=Interquartile range which shows the 25$^{th}$ to 75$^{th}$ percentiles of intake

## Table 3

Look AHEAD participants Food Guide Pyramid Food Group Consumption: Recommended daily servings versus actual servings

| Food Group | Minimum Recommended Servings per Day | Actual Servings Consumed per Day (Median, IQR[a]) | % Meeting Recommendation[b] |
|---|---|---|---|
| Grains | 6 | 3 (2 - 4) | 7 |
| Fruits | 2 | 2 (1 - 3) | 36 |
| Vegetables | 3 | 3 (2 - 4) | 38 |
| Dairy | 2 | 2 (1 - 3) | 40 |
| Meat | 2 | 2 (2 - 3) | 82 |
| Fats, Oils, Sweets | Limit | 2 (1 - 3) | 28 |

[a] IQR=Interquartile range which shows the 25$^{th}$ to 75$^{th}$ percentiles of intake.

[b] Percent consuming at least the recommended intake for grains, fruit, vegetables, dairy, and meat; % consuming no more than 1 serving for fats/oils/sweets.

**Table 4**

Number and Percent of Look AHEAD Participants Meeting Daily Recommended Servings of Food Guide Pyramid Food Group Intake

| | N | Grain | Fruit | Vegetables | Dairy | Meat | Fats, Oils, Sweets |
|---|---|---|---|---|---|---|---|
| **Sex** | | | *a* | *a* | | *a* | |
| Male | 1122 | 73 (7) | 403 (36) | 431 (38) | 465 (41) | 753 (67) | 292 (26) |
| Female | 1635 | 126 (8) | 669 (41) | 735 (45) | 645 (40) | 1005 (62) | 466 (29) |
| **Age (years)** | | *a* | *a* | | | *a* | |
| 45-55 | 1191 | 119 (10) | 422 (35) | 517 (43) | 494 (42) | 810 (68) | 308 (26) |
| 56-65 | 1183 | 67 (6) | 475 (40) | 503 (43) | 471 (40) | 745 (63) | 327 (28) |
| 66-75 | 383 | 13 (3) | 175 (46) | 146 (38) | 145 (38) | 203 (53) | 123 (32) |
| **Race** | | *a* | *a* | *a* | *a* | *a* | *a* |
| White | 1754 | 99 (6) | 615 (35) | 796 (45) | 806 (46) | 1106 (63) | 417 (24) |
| African American | 414 | 21 (5) | 192 (46) | 128 (31) | 110 (27) | 260 (63) | 134 (32) |
| Hispanic | 346 | 50 (14) | 175 (51) | 151 (44) | 114 (33) | 244 (71) | 122 (35) |
| Other | 233 | 28 (12) | 84 (36) | 89 (38) | 76 (33) | 141 (61) | 83 (36) |
| **Education (years)** | | | *a* | | *a* | *a* | |
| < High School Degree | 534 | 48 (9) | 248 (46) | 211 (40) | 192 (36) | 316 (59) | 169 (32) |
| High School- Some College | 1029 | 69 (7) | 370 (36) | 417 (40) | 390 (38) | 652 (63) | 277 (27) |
| Bachelor's or More | 1132 | 79 (7) | 432 (38) | 503 (44) | 502 (44) | 757 (67) | 295 (26) |
| **Income** | | *a* | *a* | | *a* | *a* | *a* |
| <$40,000 | 780 | 72 (9) | 355 (46) | 314 (40) | 288 (37) | 480 (62) | 254 (33) |
| $40,000-69,999 | 736 | 53 (7) | 276 (38) | 316 (43) | 298 (41) | 457 (62) | 197 (27) |
| $70,000+ | 995 | 61 (6) | 353 (36) | 440 (44) | 435 (44) | 665 (67) | 227 (23) |
| **Body Mass Index** | | *a* | | | *a* | *a* | *a* |
| 25-<30 | 395 | 18 (5) | 168 (43) | 152 (39) | 153 (39) | 233 (59) | 141 (36) |
| 30-<35 | 960 | 56 (6) | 377 (39) | 399 (42) | 367 (38) | 563 (59) | 294 (31) |
| 35-<40 | 741 | 53 (7) | 282 (38) | 319 (43) | 293 (40) | 498 (67) | 172 (23) |
| 40+ | 661 | 72 (11) | 245 (37) | 296 (45) | 297 (45) | 464 (70) | 151 (23) |
| **Diabetes Treatment** | | *a* | *a* | | | *a* | |
| No Medications | 323 | 15 (5) | 159 (49) | 120 (37) | 133 (41) | 181 (56) | 93 (29) |

| | N | Grain | Fruit | Vegetables | Dairy | Meat | Fats, Oils, Sweets |
|---|---|---|---|---|---|---|---|
| Oral Diabetes Medications | 1858 | 134 (7) | 752 (41) | 715 (39) | 754 (41) | 1193 (64) | 513 (28) |
| Insulin only | 117 | 4 (4) | 51 (44) | 53 (45) | 37 (32) | 72 (62) | 33 (28) |
| Insulin and Oral Diabetes Medications | 418 | 40 (10) | 190 (46) | 170 (41) | 169 (40) | 288 (69) | 109 (26) |
| **Diabetes Duration** | | | | | | | |
| 0-2 Years | 460 | 36 (8) | 207 (45) | 174 (38) | 194 (42) | 295 (64) | 140 (30) |
| 2-5 Years | 785 | 59 (8) | 322 (41) | 309 (39) | 298 (38) | 482 (61) | 216 (28) |
| 5-10 Years | 784 | 56 (7) | 326 (42) | 279 (36) | 327 (42) | 498 (64) | 209 (27) |
| 10+ Years | 677 | 43 (6) | 288 (43) | 282 (42) | 269 (40) | 448 (66) | 183 (27) |

[a]will indicate p<.05 based on Chi Square tests.