Diet and Exercise Among Adults With Type 2 Diabetes

Findings from the Third National Health and Nutrition Examination Survey (NHANES III)

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OBJECTIVE — To describe diet and exercise practices from a nationally representative sample of U.S. adults with type 2 diabetes.

METHODS — We analyzed data from 1,480 adults older than 17 years with a self-reported diagnosis of type 2 diabetes in the Third National Health and Nutrition Examination Survey (NHANES III). Fruit and vegetable consumption was obtained from a food frequency questionnaire; the percentages of total calories from fat and saturated fat were obtained from a 24-h food recall. Physical activity was based on self report during the month before the survey.

RESULTS — Of individuals with type 2 diabetes, 31% reported no regular physical activity and another 38% reported less than recommended levels of physical activity. Sixty-two percent of respondents ate fewer than five servings of fruits and vegetables per day. Almost two thirds of the respondents consumed >30% of their daily calories from fat and >10% of total calories from saturated fat. Mexican Americans and individuals over the age of 65 years ate a higher number of fruits and vegetables and a lower percentage of total calories from fat. Lower income and increasing age were associated with physical inactivity. Thirty-six percent of the sample were overweight and another 46% were obese.

CONCLUSIONS — The majority of individuals with type 2 diabetes were overweight, did not engage in recommended levels of physical activity, and did not follow dietary guidelines for fat and fruit and vegetable consumption. Additional measures are needed to encourage regular physical activity and improve dietary habits in this population.

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Diet and exercise are considered important components of the treatment strategy for adults with type 2 diabetes. Appropriate use of diet and exercise can improve insulin sensitivity and glycemic control and decrease the need for oral medications or insulin (1,2). Although there is some controversy over the optimal diet for adults with type 2 diabetes (high fiber, glycemic index approaches, low versus moderate fat) (3,4), there is a consensus to increase consumption of fruits and vegetables and decrease daily consumption of saturated fats (4,5). Regular, moderate-intensity physical activity for 30 min at least 5 times per week is recommended for most Americans (6).

Previous studies suggest that individuals with diabetes may not follow recommended guidelines for diet and exercise, although there have been no nationally representative U.S. studies examining nutritional intake among adults with type 2 diabetes. In a survey of >2,000 adults with diabetes, the most frequently reported barriers in diabetes self-management were adherence to diet and exercise (7). Only 60% of individuals with diabetes in the National Health Interview Survey report that they "follow a diabetic diet" (8), and several non-U.S. studies have reported that actual nutrient intake among individuals with diabetes may be suboptimal (9–12). In addition, the majority of individuals in the U.S., including those with diabetes, are not meeting national physical activity goals (13).

The purpose of this study is to describe both dietary intake and physical activity from a nationally representative sample of adults with type 2 diabetes. We assessed compliance with national guidelines for physical activity (6,14) and total fat, saturated fat, and fruit and vegetable consumption (4,5). In addition, we examined the association of socioeconomic factors with diet and exercise practices. This information will be critical to assess the effectiveness of current clinical practice and help identify groups at high risk for poor dietary intake and physical inactivity.

RESEARCH DESIGN AND METHODS

— The Third National Health and Nutrition Examination Survey (NHANES III), was conducted by the National Center for Health Statistics at 89 U.S. survey locations between 1988 and 1994. The survey used a stratified, multistage probability cluster design with oversampling of Mexican Americans, African Americans, and the elderly to ensure minimum sample sizes of these populations.

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Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; NHANES III, the Third National Health and Nutrition Examination Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Population characteristics*

	n	Data (mean ± SE or %)
Age (years)	1,480	61 ± 0.6
HbA_{1c} (%)	1,253	7.6 ± 0.1
Female	840	56
Race/ethnicity		
White	592	78
African American	408	16
Mexican American	452	6
Income (% of federal poverty level)*		
≤100%	380	17
101–200%	422	28
201–300%	220	20
>301%	269	35
Education		
Less than high school	923	45
High school	315	32
College	229	23
Diabetes treatment		
Diet alone	352	27
Oral medication	667	45
Insulin	461	28
BMI (kg/m^2)†		
<25	268	18
25–29.9	510	36
≥30.0	531	46
Physical activity‡		
Inactive	563	31
Insufficient	524	38
Recommended level	393	31
Dietary intake		
Daily calories from fat		
30–40%	480	42
>40%	289	26
>10% of daily calories from saturated fat	695	61
<5 daily servings of fruits and vegetables	812	62

Adults with type 2 diabetes in NHANES III, $n = 1,480$. Data for age and HbA_{1c} are given as mean ± SE; the rest are %. Percentages are weighted to account for complex survey design. Column totals may vary due to missing data or rounding error. *Data available for $n = 1,291$. †Data available for $n = 1,309$. ‡Physical activity: inactive; no reported leisure-time physical activity; insufficient; some physical activity, but less than recommended; recommended; 5 or more episodes of moderate physical activity/week or 3 or more episodes of vigorous physical activity per week.

The survey consists of multiple components including a household interview, a physical examination, and laboratory tests. Descriptions of the standardized protocols used for participant recruitment, interviews, and examinations have been previously published (15).

Information on a medical history of diabetes was obtained during the household interview among all adults over the age of 17 years ($n = 20,005$). A total of 1,608 adults reported a diagnosis of diabetes. For this analysis, we excluded women who were diagnosed with diabetes only during pregnancy ($n = 105$) and individuals with type 1 diabetes, defined as those who were diagnosed at <30 years of age and who had continuous insulin use since diagnosis ($n = 23$). The remaining 1,480 respondents were considered to have type 2 diabetes. Based on previous studies demonstrating that self-reported diagnosis is valid and reliable, we believe this sample accurately represents a national population of adults with type 2 diabetes (16,17). Individuals were considered to be treated with diet alone if they reported taking neither oral hypoglycemic medications nor insulin.

Standing height and weight were obtained during the physical exam for 1,312 individuals and were used to calculate BMI. Individuals were considered obese if their BMI was ≥30 kg/m^2 and were considered overweight if their BMI was 25–29.9 kg/m^2 (18). HbA_{1c} values were collected during the laboratory exam and were available for 1,253 subjects.

Dietary assessment was based on data from both the food frequency questionnaire and a 24-h food recall (19,20). Food frequency information was collected during the household interview and has been shown to be a valid and reliable method for assessing average consumption (19). Respondents were asked how often over the past month they had eaten the specified food items. Foods were reported as number of items consumed per day, per week, per month, or never. All frequencies of consumption variables were standardized as times per day using the conversion factor of 30.4 days/month. If the frequency of consumption was reported as "never," the value was recorded as zero. For this analysis, we created a combined variable for daily fruit and vegetable intake that includes all portions from both the fruit and vegetable groups. The fruit group included all fresh, frozen, dried, and canned fruit and fruit juices but excluded fruit drinks. The vegetable group included all raw or cooked fresh, frozen, or canned vegetables and juices (19). Information on the percentage of daily calories from total fat and saturated fat was based on a 24-h food recall interview. We used the cut points of five fruits and vegetables per day, 30% of daily calories from fat, and 10% of daily calories from saturated fat based on recommendations from national guidelines (4,5).

Individuals were classified as inactive if they did not report engaging in any of the following activities during the previous month: walking, jogging, bike riding, swimming, aerobics, dancing, calisthenics, gardening, lifting weights, or other physical activity outside of their occupation. Physical activity was classified as moderate or vigorous intensity based on metabolic equivalent intensity levels (21). Individuals were considered to fulfill national recommendations for physical activity if they reported five or more episodes per week of moderate-intensity physical activity or three or more episodes per week of vigorous-intensity physical activity (6). Those reporting some physi-

Table 2—*Bivariate associations with level of physical activity in adults with type 2 diabetes in NHANES III,* n = *1480*

	Inactive	Insufficient activity	Recommended levels of physical activity
Age (years)			
<65	25 (20, 31)	44 (37, 52)	31 (24, 38)*
≥65	38 (35, 43)	29 (24, 35)	32 (27, 38)
Sex			
Female	40 (36, 44)	34 (29, 38)	27 (22, 36)†
Male	20 (15, 26)	42 (34, 51)	37 (31, 45)
Race/ethnicity			
White	30 (26, 34)	38 (32, 45)	32 (27, 38)*
African American	39 (34, 44)	39 (34, 44)	22 (19, 26)
Mexican American	35 (29, 41)	37 (31, 44)	28 (20, 38)
Income (% of federal poverty level)			
≤100%	50 (40, 59)	29 (21, 38)	22 (16, 29)†
101–200%	36 (28, 44)	29 (24, 34)	36 (28, 45)
201–300%	27 (20, 36)	47 (37, 58)	26 (16, 38)
>301%	17 (12, 24)	47 (37, 58)	36 (26, 47)
Education			
Less than high school	40 (34, 45)	35 (29, 41)	26 (21, 31)*
High school	27 (21, 33)	38 (29, 47)	35 (27, 44)
College	20 (14, 28)	43 (33, 54)	37 (28, 47)
BMI (kg/m^2)			
<25	31 (22, 41)	31 (22, 42)	38 (29, 47)
25–29.9	25 (20, 31)	43 (36, 50)	32 (25, 40)
≥30.0	33 (27, 40)	40 (32, 48)	27 (20, 35)
Diabetes treatment			
Diet alone	30 (23, 38)	41 (30, 52)	30 (22, 39)*
Oral medication	26 (21, 31)	40 (35, 46)	34 (27, 41)
Insulin	41 (34, 48)	30 (23, 38)	29 (23, 36)
No difficulty			
Walking 1/4 mile	16 (13, 21)	43 (35, 51)	41 (34, 48)†
Walking 10 steps without resting	17 (13, 22)	43 (36, 51)	40 (32, 47)†

Data are % (95% CI). Percentages are weighted to account for complex survey design; row percentages may vary due to missing data or rounding error. Pearson's χ^2 *$P < 0.05$ †$P < 0.001$. Physical activity classification: Inactive, no reported leisure-time physical activity; insufficient; some physical activity, but less than recommended; recommended, 5 or more episodes of moderate physical activity/week or 3 or more episodes of vigorous physical activity per week.

cal activity during the preceding month but not at the recommended levels were classified as obtaining insufficient physical activity. To assess disability and immobility, all respondents were asked if they had difficulty "walking for a quarter of a mile" and "walking up 10 steps without resting" (13).

Data were weighted to account for the unequal probability of selection that resulted from the survey cluster design, nonresponse, and oversampling of certain target populations (22,23). Sampling weights were used to calculate population estimates, and sampling strata and primary sampling units were accounted for to estimate variances and test for significant differences. Statistical analysis was performed using STATA 6.0 software (24) to take into account the complex sampling design. All results are presented as unweighted counts (*n*) and weighted percentages and odds ratios.

Bivariate and multivariate logistic regression analyses were used to determine associations between socioeconomic and health characteristics and *1*) consumption of fewer than five servings of fruits and vegetables per day, *2*) >30% of total calories from fat, *3*) >10% of daily calories from saturated fat, and *4*) level of physical activity. Pearson's χ^2 test was used to compare bivariate associations between socioeconomic and health characteristics and these nutritional and physical activity variables. Multivariate logistic analyses were used to assess the independent associations of socioeconomic and health characteristics with obtaining no regular physical activity, having a diet high in saturated fats, and reporting low consumption of fruits and vegetables.

RESULTS — Table 1 displays the population characteristics from this nationally representative sample of individuals with type 2 diabetes. The mean age was 61 years, and the majority of the sample was white. Almost one fifth had incomes below the federal poverty level, and 45% had less than a high school education. Eighty-two percent of the sample had a BMI ≥25 kg/m^2, with 36% classified as overweight and 46% as obese. Almost one third of the sample reported no regular physical activity in the month before the survey, and another 38% reported an insufficient amount of physical activity. Forty-two percent of respondents reported consumption of 30–40% of their daily calories from fat, and 26% reported intakes of >40% of their daily calories from fat. Sixty-two percent of individuals reported eating fewer than five servings of

Table 3—*Bivariate associations with dietary intake in adults with type 2 diabetes in NHANES III*, n = *1,480*

	>30% of daily calories from fat	>10% of total calories from saturated fats	<5 servings of fruits or vegetables/day
Age (years)			
<65	77 (70, 82)*	69 (62, 74)*	70 (64, 76)*
≥65	56 (50, 62)	50 (45, 55)	51 (46, 56)
Sex			
Female	66 (58, 72)	60 (54, 65)	63 (57, 68)
Male	72 (65, 79)	63 (56, 70)	60 (53, 66)
Race/ethnicity			
White	71 (65, 77)	64 (58, 69)	62 (57, 68)†
African American	66 (61, 72)	60 (54, 65)	65 (58, 72)
Mexican American	60 (53, 67)	53 (47, 59)	44 (37, 51)
Income (% of federal poverty level)			
≤100%	65 (55, 73)†	57 (48, 66)†	62 (52, 72)
101–200%	65 (56, 73)	61 (52, 69)	61 (54, 69)
201–300%	83 (76, 88)	73 (65, 80)	68 (60, 76)
>301%	66 (58, 73)	60 (52, 66)	60 (52, 67)
Education			
Less than high school	66 (61, 71)	62 (57, 67)	62 (56, 68)
High school	71 (63, 77)	59 (50, 67)	66 (58, 73)
College	72 (58, 82)	65 (53, 75)	55 (45, 64)
BMI (kg/m^2)			
<25	65 (55, 73)	57 (49, 64)	57 (47, 66)†
25–29.9	69 (63, 73)	61 (54, 68)	55 (48, 61)
≥30.0	70 (61, 78)	63 (54, 71)	68 (62, 74)
Diabetes treatment			
Diet alone	70 (61, 78)	62 (54, 70)	64 (57, 70)
Oral medication	71 (62, 77)	61 (53, 68)	62 (55, 68)
Insulin	64 (54, 73)	61 (52, 70)	60 (53, 66)

Data are % (95% CI). Percentages are weighted to account for complex survey design. Pearson's χ^2. *$P < 0.001$; †$P < 0.05$.

fruits and vegetables per day, and 61% consumed >10% of their daily calories from saturated fats.

Bivariate associations between socioeconomic characteristics and level of physical activity are displayed in Table 2. Individuals over age 65 years, women, Mexican Americans, African Americans, and those using insulin were more likely to report engaging in no physical activity. Half of individuals with an income below the poverty level and 40% of those with less than a high school education reported no physical activity. Of individuals who reported no difficulty in walking a quarter-mile or in walking 10 steps without resting, 43% reported insufficient physical activity. BMI was not associated with level of physical activity. In a multivariate logistic regression, age ≥ 65 years, female sex, and low income were independently associated with inactivity (Table 4). Physical inactivity was not associated with level of education, BMI, or type of diabetes treatment in multivariate analyses. When ability to walk a quarter-mile was included in this multivariate model, age was no longer independently associated with reporting no physical activity (data not shown).

Bivariate associations between nutritional intake and socioeconomic and health variables are displayed in Table 3. Individuals ≥65 years were less likely to consume a high-fat diet and more likely to report eating more than five servings of fruits and vegetables per day. There were no associations between the three nutrition intake variables and sex, education, or type of diabetes treatment. In multivariate analysis, individuals ≥65 years and Mexican Americans were less likely to consume >10% of their daily calories from saturated fats and eat fewer than five servings of fruits and vegetables per day (Table 4).

CONCLUSIONS — The majority of adults with type 2 diabetes in this nationally representative sample ate a diet high in saturated fat and consumed fewer than the minimum daily recommended servings of fruits and vegetables. In addition, almost one third reported no regular physical activity, and another 38% reported insufficient levels of physical activity. Higher consumption of fruits and vegetables and diets lower in fat were more common among individuals over the age of 65 years and among Mexican Americans. Older individuals, women, and those with low incomes were more likely to report no regular exercise. The majority of this sample was overweight or obese, consistent with recent reports about the increasing prevalence of both diabetes and obesity in the U.S. (25).

The main limitations to this data are the potential biases introduced by the self-report of food frequency data, the 24-h food recall, and level of physical activity. In addition, we do not know the actual duration of physical activity. Previous studies have shown that white-collar workers were more active during leisure

Table 4—*Multivariate logistic regression of physical activity and nutritional intake*

	No regular physical activity	>10% of daily calories from saturated fat	<5 servings of fruits or vegetables/day
n	1,149	1,051	1,127
Age ≥65 years[a]	1.9 (1.2, 3.0)†	0.4 (0.3, 0.6)‡	0.4 (0.3, 0.6)‡
Female gender	2.3 (1.5, 3.4)‡	1.0 (0.6, 1.6)	1.1 (0.8, 1.7)
Race/ethnicity			
White	Reference	Reference	Reference
African American	1.0 (0.7, 1.5)	0.9 (0.6, 1.3)	1.0 (0.6, 1.7)
Mexican American	1.0 (0.7, 1.5)	0.6 (0.4, 0.9)†	0.4 (0.3, 0.6)‡
Income (% of federal poverty level)			
>301%	Reference	Reference	Reference
201–300%	1.6 (0.9, 3.2)	2.1 (1.3, 3.6)†	1.6 (1.0, 2.5)
101–200%	1.8 (1.0, 3.6)	1.4 (0.8, 2.4)	1.2 (0.7, 2.1)
<100%	4.2 (2.0, 9.2)‡	1.0 (0.6, 1.9)	0.9 (0.5, 1.6)
Education			
College	Reference	Reference	Reference
High school	1.4 (0.6, 2.9)	0.7 (0.4, 1.5)	1.7 (1.0, 2.9)
< high school	1.8 (1.0, 3.3)	1.0 (0.5, 1.9)	1.7 (1.0, 2.9)
BMI (kg/m^2)			
<25	Reference	Reference	Reference
25–29.9	0.8 (0.5, 1.2)	1.1 (0.6, 1.9)	0.9 (0.5, 1.5)
≥30.0	1.2 (0.7, 2.2)	1.0 (0.6, 1.6)	1.4 (0.9, 2.2)
Diabetes treatment			
Diet alone	Reference	Reference	Reference
Oral Medication	0.9 (0.5, 1.4)	1.0 (0.6, 1.6)	0.7 (0.5, 1.0)
Insulin	1.4 (0.8, 2.4)	0.9 (0.5, 1.9)	0.8 (0.6, 1.2)

Data are odds ratios (95% CI). Adults with type 2 diabetes in NHANES III. Odds ratio >1 indicates reporting no regular exercise, consuming greater than 10% of calories from fat or less than 5 servings of fruits and vegetables/day. *Compared to individuals less than 65 years of age. †$P < 0.05$; ‡$P < 0.001$.

time than blue-collar workers, those who were retired, or homemakers (26). Because we do not have information on nonleisure physical activity, total activity levels may be underestimated. Despite these limitations, our study is consistent with other national data from the general U.S. population regarding poor dietary quality (27–29) and low levels of physical activity (30). The most recent Behavioral Risk Factor Surveillance System (BRFSS) survey reported that almost one third of adults did not engage in any physical activity and another third were not regularly active (30). In the National Health Interview Survey from 1990, only one third of people with diabetes reported exercising regularly (13).

Although poor nutrient intake among individuals with diabetes has been reported outside of the U.S. (9–12), we are not aware of any data on the dietary intake from a nationally representative sample of individuals with type 2 diabetes in the U.S. Our results are consistent with studies of dietary intake in the general population suggesting that a majority of Americans are consuming an inadequate quantity of fruits and vegetables (25,31). Only one quarter of the participants interviewed in the most recent BRFSS consumed the recommended five servings of fruits and vegetables (25). In addition, our data regarding healthier diets among Mexican Americans are consistent with previous reports suggesting that on average, Latinos have healthier diets than whites or African Americans (27,32,33).

Previous studies have reported low levels of physical activity (13) and higher levels of disability among individuals with diabetes than in the general population (34). Disability among individuals with diabetes is primarily from coronary heart disease and obesity, followed by poor vision (34). For individuals with significant disability, an individualized program for physical activity is essential. In our study, individuals who reported the inability to walk a quarter-mile were less likely to report regular exercise. However, >40% of those who reported that they could walk a quarter-mile engaged in insufficient physical activity and could be an important target population for interventions to increase exercise activity.

Healthy diets and regular physical activity can improve glycemic control among individuals with type 2 diabetes (35–38). Intervention studies have shown that physical activity plays an important role in glucose tolerance and insulin sensitivity (35). A recent meta-analysis found that, on average, moderate-intensity physical activity can reduce HbA_{1c} by 0.6% among individuals with type 2 diabetes (39). According to data from the U.K. Prospective Diabetes Study, this is a level sufficient to reduce the risk of microvascular complications by 22% (40). Lifestyle modification involving nutrition and physical activity also has the potential to improve cardiovascular risk factors such as blood pressure and lipid levels (39,41). Because physical activity and suboptimal dietary behaviors are associated (42), targeting both exercise and diet may be needed for the optimal treatment of individuals with type 2 diabetes.

A recent systematic review of diabetes self-management studies suggests that tai-

lored interventions actively involving patient participation can change lifestyle behaviors, including diet and exercise (43). Increasing physical activity levels can be achieved by a variety of means, including public health programs and community-based interventions (14). Primary care–based physical activity counseling is also moderately effective (44), although few studies have been specifically designed for individuals with type 2 diabetes. The current challenge is translating research findings into routine clinical practice and public health efforts to improve health outcomes for all individuals with type 2 diabetes (45).

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References

1. Chandalia M, Garg A, Lutjohann D, von Bergmann K, Grundy SM, Brinkley LJ: Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. *N Engl J Med* 342:1392–1398, 2000
2. Horton ES: Exercise and diabetes mellitus. *Med Clin North Am* 72:1301–1321, 1988
3. Garg A: High-monounsaturated fat diet for diabetic patients: Is it time to change the current dietary recommendations? *Diabetes Care* 17:242–246, 1994
4. American Diabetes Association: Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications (Position Statement). *J Am Diet Assoc* 102:109–118, 2002
5. *Nutrition and Your Health: Dietary Guidelines for Americans.* Washington, DC, US Department of Agriculture, US Department of Health and Human Services, 1995 (Home and Garden Bulletin no. 232)
6. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC: Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 273: 402–407, 1995
7. Glasgow RE, Hampson SE, Strycker LA, Ruggiero L: Personal-model beliefs and social-environmental barriers related to diabetes self-management. *Diabetes Care* 20:556–561, 1997
8. Harris MI: Medical care for patients with diabetes: epidemiologic aspects. *Ann Intern Med* 124:117–122, 1996
9. Toeller M, Klischan A, Heitkamp G, Schumacher W, Milne R, Buyken A, Karamanos B, Gries FA: Nutritional intake of 2868 IDDM patients from 30 centres in Europe. EURODIAB IDDM Complications Study Group. *Diabetologia* 39:929–939, 1996
10. Eeley EA, Stratton IM, Hadden DR, Turner RC, Holman RR. UKPDS 18: estimated dietary intake in type 2 diabetic patients randomly allocated to diet, sulphonylurea or insulin therapy. UK Prospective Diabetes Study Group. *Diabet Med* 13:656–662, 1996
11. Campbell LV, Barth R, Gosper J: Unsatisfactory nutritional parameters in non-insulin-dependent diabetes mellitus. *Med J Aust* 151:146, 149–150, 1989
12. Virtanen SM, Feskens EJ, Rasanen L, Fidanza F, Tuomilehto J, Giampaoli S, Nissinen A, Kromhout D: Comparison of diets of diabetic and non-diabetic elderly men in Finland, The Netherlands and Italy. *Eur J Clin Nutr* 54:181–186, 2000
13. Ford ES, Herman WH: Leisure-time physical activity patterns in the U.S. diabetic population: findings from the 1990 National Health Interview Survey–Health Promotion and Disease Prevention Supplement. *Diabetes Care* 18:27–33, 1995
14. Increasing physical activity: a report on recommendations of the Task Force on Community Preventive Services. *MMWR Recomm Rep* 50 (RR-18):1–14, 2001
15. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988–94. *Vital Health Stat* 1:1–407, 1994
16. Kehoe R, Wu SY, Leske MC, Chylack LT Jr: Comparing self-reported and physician-reported medical history. *Am J Epidemiol* 139:813–818, 1994
17. Bush TL, Miller SR, Golden AL, Hale WE: Self-report and medical record report agreement of selected medical conditions in the elderly. *Am J Public Health* 79:1554–1556, 1989
18. Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *Arch Intern Med* 158:1855–1867, 1998
19. Hu FB, Rimm E, Smith-Warner SA, Feskanich D, Stampfer MJ, Ascherio A, Sampson L, Willett WC: Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. *Am J Clin Nutr* 69:243–249, 1999
20. Feskanich D, Rimm EB, Giovannucci EL, Colditz GA, Stampfer MJ, Litin LB, Willett WC: Reproducibility and validity of food intake measurements from a semiquantitative food frequency questionnaire. *J Am Diet Assoc* 93:790–796, 1993
21. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR Jr, Schmitz KH, Emplaincourt PO, Jacobs DR Jr, Leon AS: Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* 32 (Suppl.):S498–S504, 2000
22. National Health and Nutrition Examination Survey III: Weighting and Estimation Methodology. Rockville, MD, Westat, 1996
23. Korn EL Graubard BI: Epidemiologic studies utilizing surveys: accounting for the sampling design. *Am J Public Health* 81:1166–1173, 1991
24. Stata Corporation, College Station, Texas, version 6:0, 1999
25. Mokdad AH, Bowman BA, Ford ES, Vinicor F, Marks JS, Koplan JP: The continuing epidemics of obesity and diabetes in the United States. *JAMA* 286:1195–1200, 2001
26. Crespo CJ, Smit E, Carter-Pokras O, Andersen R: Acculturation and leisure-time physical inactivity in Mexican American adults: results from NHANES III, 1988–1994. *Am J Public Health* 91:1254–1257, 2001
27. Kant AK: Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional and health implications. The Third National Health and Nutrition Examination Survey 1988–1994. *Am J Clin Nutr* 72:929–936, 2000
28. Subar AF, Heimendinger J, Patterson BH, Krebs-Smith SM, Pivonka E, Kessler R: Fruit and vegetable intake in the United States: the baseline survey of the Five A Day for Better Health Program. *Am J Health Promot* 9:352–360, 1995
29. Gillman MW: Enjoy your fruits and vegetables. *BMJ* 313:765–766, 1996
30. Physical activity trends—United States, 1990–1998. *MMWR Morb Mortal Wkly Rep* 50:166–169, 2001
31. Heimendinger J, Van Duyn MA: Dietary behavior change: the challenge of recasting the role of fruit and vegetables in the American diet. *Am J Clin Nutr* 61 (Suppl.): 1397S–1401S, 1995
32. Dixon LB, Sundquist J, Winkleby M: Differences in energy, nutrient, and food intakes in a US sample of Mexican-American women and men: findings from the Third National Health and Nutrition Examination Survey, 1988–1994. *Am J Epidemiol* 152:548–557, 2000
33. Guendelman S, Abrams B: Dietary intake among Mexican-American women: generational differences and a comparison with white non-Hispanic women. *Am J Public Health* 85:20–25, 1995
34. Gregg EW, Beckles GL, Williamson DF,

Leveille SG, Langlois JA, Engelgau MM, Narayan KM: Diabetes and physical disability among older U.S. adults. *Diabetes Care* 23:1272–1277, 2000
35. Clark DO: Physical activity efficacy and effectiveness among older adults and minorities. *Diabetes Care* 20:1176–1182, 1997
36. Pastors JG, Warshaw H, Daly A, Franz M, Kulkarni K: The evidence for the effectiveness of medical nutrition therapy in diabetes management. *Diabetes Care* 25:608–613, 2002
37. Evidence-based: nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. *Diabetes Care* 25:202–212, 2002
38. Franz MJ, Monk A, Barry B, McClain K, Weaver T, Cooper N, Upham P, Bergenstal R, Mazze RS: Effectiveness of medical nutrition therapy provided by dietitians in the management of non-insulin-dependent diabetes mellitus: a randomized, controlled clinical trial. *J Am Diet Assoc* 95:1009–1017, 1995
39. Boule NG, Haddad E, Kenny GP, Wells GA, Sigal RJ: Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *JAMA* 286: 1218–1227, 2001
40. Stratton IM, Adler AI, Neil HA, Matthews DR, Manley SE, Cull CA, Hadden D, Turner RC, Holman RR: Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 321:405–412, 2000
41. 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. *Diabetes Care* 25:148–198, 2002
42. Gillman MW, Pinto BM, Tennstedt S, Glanz K, Marcus B, Friedman RH: Relationships of physical activity with dietary behaviors among adults. *Prev Med* 32:295–301, 2001
43. Norris S, Engelgau MM, Venkat Narayan KM: Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. *Diabetes Care* 24:561–587, 2001
44. Eakin EG, Glasgow RE, Riley KM: Review of primary care-based physical activity intervention studies: effectiveness and implications for practice and future research. *J Fam Pract* 49:158–168, 2000
45. Venkat Narayan KM, Gregg EW, Engelgau MM, Moore B, Thompson TJ, Williamson DF, Vinicor F: Translation research for chronic disease: the case of diabetes. *Diabetes Care* 23:1794–1798, 2000