Obesity, Inactivity, and the Prevalence of Diabetes and Diabetes-Related Cardiovascular Comorbidities in the U.S., 2000–2002

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OBJECTIVE — Obesity and physical inactivity are established risk factors for type 2 diabetes and cardiovascular comorbidities. Whether adiposity or fitness level is more important to health is controversial. The objective of this research is to determine the relative associations of physical activity and BMI with the prevalence of diabetes and diabetes-related cardiovascular comorbidities in the U.S.

RESEARCH DESIGN AND METHODS — The Medical Expenditure Panel Survey (MEPS) is a nationally representative survey of the U.S. population. From 2000 to 2002, detailed information on sociodemographic characteristics and health conditions were collected for 68,500 adults. Normal weight was defined as BMI 18.5 to <25 kg/m^2, overweight 25 to ≤30 kg/m^2, obese (class I and II) 30 to <40 kg/m^2, and obese (class III) ≥40 kg/m^2. Physical activity was defined as moderate/vigorous activity ≥30 min ≥3 days per week.

RESULTS — The likelihood of having diabetes and diabetes-related cardiovascular comorbidities increased with BMI regardless of physical activity and increased with physical inactivity regardless of BMI. Compared with normal-weight active adults, the multivariate-adjusted odds ratio (OR) for diabetes was 1.52 (95% CI 1.25–1.86) for normal-weight inactive adults and 1.65 (1.40–1.96) for overweight inactive adults; the OR for diabetes and comorbid hypertension was 1.71 (1.32–2.19) for normal-weight inactive adults and 1.84 (1.47–2.32) for overweight inactive adults.

CONCLUSIONS — Both physical inactivity and obesity seem to be strongly and independently associated with diabetes and diabetes-related comorbidities. These results support continued research investigating the independent causal nature of these factors.

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T he prevalence of diabetes has been significantly increasing in the U.S. (1). Current estimates suggest that 6–8% of adults have diabetes, with the true prevalence likely closer to 10% when undiagnosed diabetes is also considered (2–4). Importantly, the prevalence of diabetes has increased nearly 50% over the last decade; >5 million U.S. adults are newly suffering from the disease (1,3). The burden of diabetes is significant in terms of human and economic costs and is expected to increase in the future (2,5,6).

Obesity and physical inactivity are well-established risk factors for the development of type 2 diabetes (7–11). It is estimated that for every 1-kg increase in weight, the prevalence of diabetes increases by 9% (1). Physical inactivity is associated with increased insulin resistance and poorer glycemic control independent of body weight (12).

Evidence from randomized controlled trials on three continents has clearly demonstrated that maintenance of modest weight loss through diet and physical activity reduces the incidence of type 2 diabetes in high-risk individuals by ~40–60% over 3–4 years (13–16). Lifestyle improvements, including weight control and increased physical activity, are also the cornerstone of diabetes management (11,12).

However, despite the known association of obesity and inactivity with diabetes-related morbidity and mortality, there is limited national data reporting the independent association of each risk factor with the prevalence of diabetes and related cardiovascular comorbidities in the U.S. population. The objective of this study was to determine the relative prevalence of diabetes and related cardiovascular comorbidities among overweight and inactive adults in a nationally representative population.

RESEARCH DESIGN AND METHODS

Data source
The Medical Expenditure Panel Survey (MEPS) is cosponsored by the Agency for Healthcare Research and Quality and the National Center for Health Statistics. The MEPS Household Component (HC), a na-

Table 1—*Prevalence of diabetes, obesity, and physical activity by selected characteristics (MEPS 2000–2002)*

Selected characteristics	Diabetes	Obese (BMI $\geq$30 kg/m^2)	Active
Total	6.3 ± 0.16	23.5 ± 0.31	56.0 ± 0.41
Sex			
Men	6.4 ± 0.22	23.0 ± 0.43	60.1 ± 0.49
Women	6.2 ± 0.20	24.0 ± 0.36	52.2 ± 0.48
Age-groups (years)			
18–29	0.8 ± 0.09	17.0 ± 0.51	64.0 ± 0.63
30–39	2.0 ± 0.15	24.3 ± 0.54	57.5 ± 0.69
40–49	4.2 ± 0.22	26.7 ± 0.53	55.5 ± 0.61
50–59	9.5 ± 0.41	27.9 ± 0.68	52.8 ± 0.73
60–69	14.5 ± 0.59	27.5 ± 0.80	54.4 ± 0.99
$\geq$70	15.9 ± 0.58	19.5 ± 0.63	45.2 ± 0.86
Race/ethnicity			
White	5.9 ± 0.15	22.8 ± 0.32	56.9 ± 0.44
Black	9.3 ± 0.51	33.5 ± 0.88	51.6 ± 1.15
Hispanic	6.8 ± 0.35	25.9 ± 0.76	51.5 ± 0.91
Asian, Pacific Islander, Native Hawaiian	5.03 ± 0.62	7.3 ± 0.93	51.2 ± 1.81
Native American, Aleut, Eskimo	9.1 ± 1.58	34.2 ± 2.85	48.3 ± 3.08
Education levels			
Less than high school	9.5 ± 0.39	25.8 ± 0.58	47.8 ± 0.69
High school	6.0 ± 0.19	25.4 ± 0.39	55.9 ± 0.50
Some college (<4 years)	4.8 ± 0.50	25.4 ± 0.97	58.3 ± 1.04
College degree (4 years)	4.7 ± 0.31	18.0 ± 0.59	61.2 ± 0.65
Graduate degree (>4 years)	4.1 ± 0.42	15.2 ± 0.85	64.3 ± 1.09
Smoking status			
Not current	6.5 ± 0.18	24.2 ± 0.36	57.0 ± 0.44
Current	5.0 ± 0.25	20.1 ± 0.51	52.6 ± 0.69
BMI			
Normal (18.5–24.9 kg/m^2)	3.1 ± 0.14	—	62.5 ± 0.55
Overweight (25.0–29.9 kg/m^2)	6.0 ± 0.22	—	58.6 ± 0.50
Obese, class I and II (30.0–39.9 kg/m^2)	11.4 ± 0.37	—	46.0 ± 0.62
Obese, class III ($\geq$40 kg/m^2)	19.5 ± 1.20	—	32.3 ± 1.35
Physical activity (moderate/vigorous)			
Active ($\geq$3 times/week)	4.4 ± 0.15	18.4 ± 0.35	—
Inactive (<3 times/week)	8.7 ± 0.26	30.2 ± 0.38	—

Data are % ± SE.

tionally representative survey of the U.S. civilian noninstitutionalized population, collects detailed information on demographic characteristics, health conditions, health status, and use of medical care services and income and employment (17). The sampling frame for the MEPS-HC is drawn from respondents to the National Health Interview Survey. The National Health Interview Survey provides a nationally representative sample of the U.S. civilian noninstitutionalized population, with oversampling of Hispanics and blacks. The MEPS Medical Provider Component supplements and validates information on medical care and pharmacy events at the person level. Medical condition diagnoses are based on ICD-9 Clinical Modification codes (17). The sample design of the MEPS-HC survey includes stratification, clustering, multiple stages of selection, and disproportionate sampling (18). MEPS sampling weights incorporate adjustment for the complex sample design and reflect survey nonresponse and population totals from the current population survey.

Ascertainment of diabetes and cardiovascular comorbidities

The primary outcome was the prevalence of diabetes and comorbid heart disease, hypertension, or hyperlipidemia stratified by physical activity and BMI. The current analysis used self-reported information resulting from the MEPS-HC survey, in which respondents were asked the following: if they had ever been diagnosed as having diabetes (excluding gestational diabetes), if they had been told on two or more different medical visits that they had high blood pressure, if they had ever been diagnosed as having coronary heart disease, if they had ever been diagnosed as having angina or angina pectoris, if they had ever been diagnosed as having a heart attack or myocardial infarction, and if they had ever been diagnosed with any other kind of heart disease or condition. Individuals who responded positively to questions regarding coronary heart disease, angina, heart attack, or other heart disease were classified as having heart disease. In addition, MEPS

Table 2—*Prevalence of diabetes and cardiovascular comorbidities by BMI and physical activity (MEPS 2000–2002)*

Health condition	All adults*	BMI			
		Normal	Overweight	Obese, class I and II	Obese, class III
n	68,500	24,444	23,730	14,538	2,252
Diabetes	6.3 ± 0.16				
Active	4.4 ± 0.15	2.2 ± 0.16	4.6 ± 0.22	8.7 ± 0.45	14.1 ± 0.19
Inactive	8.7 ± 0.26	4.5 ± 0.28	8.0 ± 0.36	13.7 ± 0.55	22.1 ± 0.15
Diabetes and heart disease	2.2 ± 0.08				
Active	1.2 ± 0.08	0.7 ± 0.09	1.2 ± 0.13	2.5 ± 0.25	3.0 ± 0.75
Inactive	3.4 ± 0.14	1.8 ± 0.18	3.3 ± 0.22	5.3 ± 0.33	8.2 ± 0.92
Diabetes and hypertension	4.1 ± 0.12				
Active	2.5 ± 0.10	1.1 ± 0.10	2.5 ± 0.16	5.7 ± 0.36	9.1 ± 1.46
Inactive	5.8 ± 0.21	2.5 ± 0.20	5.1 ± 0.29	9.6 ± 0.45	15.3 ± 1.27
Diabetes and hyperlipidemia	1.8 ± 0.09				
Active	1.3 ± 0.09	0.6 ± 0.09	1.3 ± 0.11	2.7 ± 0.29	2.9 ± 0.77
Inactive	2.4 ± 0.14	0.9 ± 0.15	2.2 ± 0.21	4.4 ± 0.33	6.3 ± 0.80

Data are % ± SE. *Total equals all adults, including those underweight (BMI <18.5 kg/m^2).

mapped medical conditions to 3-digit ICD-9 codes based on medical and pharmacy utilization and self-report. Then, 259 mutually exclusive clinical classification categories were mapped from ICD-9 codes in order to provide clinically homogenous groupings. The ICD-9 to clinical classification categories crosswalk is available from www.meps.ahrq.gov (appendix 2) (17). The current research used clinical classification categories 053 "Disorders of Lipid Metabolism" to identify individuals with hyperlipidemia.

Assessment of BMI, physical activity, and other covariates

Self-reported information from the MEPS-HC survey was used for the assessment of BMI, physical activity, and other covariates. Respondents were asked to estimate their current body weight and height, if they engaged in moderate or vigorous physical activity for ≥30 min three or more times per week, and to report on current smoking status, age, sex, race, ethnicity, and years of schooling. The following formula (from the Centers for Disease Control and Prevention, available from http://www.cdc.gov/) was used to calculate the BMI for adults in MEPS based on reported height and weight: BMI = [weight in pounds/(height in inches)^2] × 703. Full documentation is provided on page 97 of the MEPS H60 documentation file (17). Normal weight was defined as BMI 18.5 to <25 kg/m^2, overweight 25 to <30 kg/m^2, obese (class I and II) 30 to <40 kg/m^2, and obese

(class III) ≥40 kg/m^2 based on the National Heart, Lung, and Blood Institute classification scheme (19).

Data analysis

To incorporate adjustment for the complex sample design, the current research used MEPS person-level and variance adjustment weights, using STATA 8.1 in all analyses to ensure nationally representative estimates. Logistic regression analysis was used to estimate the adjusted odds of having diabetes and diabetes-related cardiovascular comorbidities.

RESULTS — The general prevalence of diabetes among U.S. adults was 6.3% (Table 1). Blacks, Hispanics, and Native Americans/Aleut/Eskimos were more likely and Asians/Pacific Islanders/Native Hawaiians less likely to have diabetes than whites. Overweight, obese, and inactive individuals, as well as those with less education and current nonsmokers, were more likely to have diabetes.

The pooled prevalence of obesity was 23.5%, affecting more women than men and disproportionately affecting those of middle age. Again, blacks, Hispanics, and Native Americans/Aleut/Eskimos were more likely and Asians/Pacific Islanders/Native Hawaiians less likely to be obese than whites. Inactive adults and those with less schooling were more likely while current smokers were less likely to be obese.

Approximately 56% of the U.S. population reported engaging in moderate to

vigorous physical activity for ≥30 min three or more times per week. Men, younger adults, whites, individuals with more schooling, nonsmokers, and those with lower BMI were more likely to report engaging in physical activity. The unadjusted prevalence of diabetes, diabetes and hypertension, diabetes and hyperlipidemia, and diabetes and heart disease was higher for categories of increasing BMI and inactivity (Table 2).

After controlling for sociodemographic characteristics and smoking status, overweight, obesity, and inactivity were significantly and independently associated with increased likelihood of diabetes, diabetes and comorbid hypertension, diabetes and comorbid hyperlipidemia, and diabetes and comorbid heart disease (Table 3). For example, compared with normal-weight and active adults, the multivariate-adjusted odds of diabetes was 1.52 (95% CI 1.25–1.86) times greater for normal-weight inactive adults and 1.65 (1.40–1.96) times greater for overweight active adults. Whether active or inactive, extremely obese (class III) individuals had the greatest increased likelihood of diabetes and diabetes-related cardiovascular disease.

CONCLUSIONS — The current study shows an independent association between obesity and inactivity and diabetes and diabetes-related cardiovascular comorbidities in a nationally representative sample of the noninstitutionalized U.S. population. Previous research (13–

Table 3—*Likelihood of diabetes and cardiovascular comorbidities by BMI and physical activity (MEPS 2000–2002)*

	BMI			
Health condition	Normal	Overweight	Obese, class I and II	Obese, class III
Diabetes				
Active	1.00 (ref)	1.65 (1.40–1.96)	3.62 (2.95–4.43)	8.37 (5.81–12.07)
Inactive	1.52 (1.25–1.86)	2.62 (2.18–3.16)	5.10 (4.34–6.00)	11.00 (8.61–14.04)
Diabetes and heart disease				
Active	1.00 (ref)	1.32 (0.97–1.80)	3.22 (2.34–4.43)	6.15 (3.42–11.04)
Inactive	1.83 (1.32–2.54)	3.19 (2.42–4.22)	5.62 (4.22–7.47)	11.97 (7.92–18.10)
Diabetes and hypertension				
Active	1.00 (ref)	1.84 (1.47–2.32)	4.80 (3.69–6.25)	11.59 (7.59–17.69)
Inactive	1.71 (1.32–2.19)	3.32 (2.63–4.19)	6.85 (5.49–8.54)	14.57 (10.89–19.50)
Diabetes and hyperlipidemia				
Active	1.00 (ref)	1.69 (1.22–2.35)	3.84 (2.69–5.49)	5.16 (2.68–9.91)
Inactive	1.27 (0.85–1.90)	2.55 (1.79–3.65)	5.36 (3.77–7.62)	9.33 (5.98–14.55)

Data are OR (95% CI). ORs were obtained from multivariate logistic regression models adjusting for age, sex, educational level, race, ethnicity, and smoking status.

16) has shown that lifestyle improvements, including weight control and increased physical activity, reduce the incidence of obesity and type 2 diabetes.

These results directly address the "fitness versus fatness" debate that has been popularized by the media. This debate has centered on whether obesity is a major health problem once the level of physical activity is considered. Some have suggested in this debate that it is acceptable to be "fat" from a health risk standpoint as long as you are "fit" (20). The argument being that fitness level is more important to health than body fatness, and fit obese individuals are at less risk than unfit normal weight individuals. Interestingly, in this dataset, the likelihood of having diabetes increases with increasing BMI regardless of level of physical activity. For example inactive normal-weight individuals are at lower risk (OR 1.52 [95% CI 1.25–1.86]) than obese active individuals (3.62 [2.95–4.43]). As such, these data do not support the concept that fitness level overrides body fatness. Similarly, the likelihood of having diabetes increases with physical inactivity regardless of BMI. At any given BMI classification, it is better to be active than inactive. Both physical inactivity and obesity seem to be independently associated with diabetes and diabetes-related comorbidities. This finding is critically important since it highlights that interventions should target both fatness and fitness in improving the health of the general population.

There has been much debate regarding the relative importance of obesity and inactivity as causal factors in the development of diabetes and cardiovascular morbidity and mortality (20–25). It is important to note that the current analysis is an examination of the association between obesity and physical inactivity and diabetes and diabetes-related cardiovascular comorbidities in a nationally representative cross-sectional dataset and as such does not provide information on the direct causal nature of these relationships.

The diabetes, physical activity, and obesity prevalence estimates presented here are consistent with other survey-based national-level estimates in the U.S. (2–4,26). However, it is likely that the diabetes and obesity rates in this study are underestimates and physical activity rates are overestimates of national prevalence. First, similar to the National Health Interview Survey and the Behavioral Risk Factor Surveillance System, MEPS is based on self-report. There is evidence that self-reported conditions may be underreported in general (27) and that blacks, whites, and Hispanics differ in reporting of disease labeling and levels of illness and disability (28–30). Second, previous studies (31,32) have shown that overweight respondents tend to underestimate their weight and overestimate their height. In addition, respondents tend to overestimate their level of physical activity. Third, unlike the National Health and Nutrition Examination Survey, MEPS does not contain information on undiagnosed diabetes. Recent estimates suggest that ~35% of individuals with diabetes have not been diagnosed (33).

The dramatically increasing epidemics of obesity and diabetes are well-known threats to public health in the U.S. The consistent independent association between obesity and physical inactivity and increased prevalence of diabetes and diabetes-associated cardiovascular comorbidities seen in this nationally representative study is disturbing. It is important to focus national attention on these trends and combat them with weight management and physical activity interventions.

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