Diabetes and Physical Disability Among Older U.S. Adults

EDWARD W. GREGG, PHD
GLORIA L.A. BECKLES, MBBS
DAVID F. WILLIAMSON, PHD
SUZANNE G. LEVEILLE, PHD
JEAN A. LANGLOIS, SCD
MICHAEL M. ENGELGAU, MD
K.M. VENKAT NARAYAN, MD

OBJECTIVE — To estimate the prevalence of physical disability associated with diabetes among U.S. adults ≥60 years of age.

RESEARCH DESIGN AND METHODS — We analyzed data from a nationally representative sample of 6,588 community-dwelling men and women ≥60 years of age who participated in the Third National Health and Nutrition Examination Survey. Diabetes and comorbidities (coronary heart disease, intermittent claudication, stroke, arthritis, and visual impairment) were assessed by questionnaire. Physical disability was assessed by self-reported ability to walk one-fourth of a mile, climb 10 steps, and do housework. Walking speed, lower-extremity function, and balance were assessed using physical performance tests.

RESULTS — Among subjects ≥60 years of age with diabetes, 32% of women and 15% of men reported an inability to walk one-fourth of a mile, climb stairs, or do housework compared with 14% of women and 8% of men without diabetes. Diabetes was associated with a 2- to 3-fold increased odds of not being able to do each task among both men and women and up to a 3.6-fold increased risk of not being able to do all 3 tasks. Among women, diabetes was also associated with slower walking speed, inferior lower-extremity function, decreased balance, and an increased risk of falling. Of the >5 million U.S. adults ≥60 years of age with diabetes, 1.2 million are unable to do major physical tasks.

CONCLUSIONS — Diabetes is associated with a major burden of physical disability in older U.S. adults, and these disabilities are likely to substantially impair their quality of life.

Diabetes Care 23:1272–1277, 2000

Physical functioning is a core element of health-related quality of life and predicts further functional decline, morbidity, health services use, and death (1–6). For example, compared with unimpaired individuals, people with impaired mobility have a >2-fold increased risk of falling, institutionalization, and death and 4–5 times the risk of functional dependence (4–6). Diabetes may increase the risk of disability because of its wide-ranging complications, including cardiovascular and peripheral vascular disease, vision loss, and peripheral neuropathy (7,8). Few studies, however, have examined the prevalence of physical disability associated with diabetes in the U.S. (7,9,10).

Nearly one-fifth of U.S. adults ≥60 years of age have diabetes, and some reports have predicted that older individuals will comprise two-thirds of the diabetic population in developed countries by the year 2025 (11,12). Thus, clarifying the contribution of diabetes to disability in older populations is important. This study estimates the physical disability burden associated with diabetes in a nationally representative sample of older U.S. adults. A secondary objective is to examine the degree to which diabetes-related comorbidities account for the relationship between diabetes and physical disability.

RESEARCH DESIGN AND METHODS

Study design and population

We analyzed data from the Third National Health and Nutrition Examination Survey (NHANES III), which was a nationally representative cross-sectional study of U.S. civilian noninstitutionalized individuals that was conducted from 1988 to 1994 (11,13). We analyzed data on 6,588 individuals ≥60 years of age who completed a household interview (3,475 women and 3,113 men) at which history of diabetes, health status, and physical disability data were collected. The response rate among individuals ≥60 years of age was 78% (13). Of these participants, 5,718 (87%) received a physical examination, which included anthropometric and physical function measurements. Attendance at the physical examination did not vary according to diabetes status. Informed consent was obtained from all participants, and the protocol was approved by the institutional review board of the National Center for Health Statistics.

Assessment of diabetes and physical functioning

Participants were asked whether a physician had ever told them they had diabetes (except during pregnancy), were asked their age at diagnosis, and were asked about their use of diabetes medications. Physical functioning was assessed by self-reported degree of difficulty (none, some difficulty, much difficulty, inability) in walking one-fourth of a mile, climbing 10 steps without rest, or doing housework (e.g., vacuuming, sweeping, dusting, or tidying up). Participants were also asked about their frequency of falls during the past year.

From the Divisions of Diabetes Translation (E.W.G., G.L.A.B., D.F.W., M.M.E., K.M.V.N.), Acute Care, Rehabilitation, and Disability Research (J.A.L.) Centers for Disease Control and Prevention, Atlanta, Georgia; and the Epidemiology, Demography, and Biometry Program (S.G.L.), National Institute on Aging, National Institutes of Health, Bethesda, Maryland.

Address correspondence and reprint requests to Edward W. Gregg, PhD, Division of Diabetes Translation, Centers for Disease Control and Prevention, 4770 Buford Highway N.E., Mailstop K-68, Atlanta, GA 30341. E-mail: edg7@cdc.gov.

Received for publication 10 February 2000 and accepted in revised form 18 May 2000.

Abbreviations: CHD, coronary heart disease; NHANES III, Third National Health and Nutrition Examination Survey; OR, odds ratio.

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

Table 1—*Characteristics of the study population for adults ≥60 years of age by self-reported diabetes status in NHANES III according to sex*

	Women		Men	
	Diabetes	No diabetes	Diabetes	No diabetes
n	584	2,891	446	2,667
Demographic characteristics				
Age (years)	70.9 ± 0.5	71.3 ± 0.3	70.5 ± 0.5	70.0 ± 0.2
BMI* (kg/m^2)	29.9 ± 0.3	26.2 ± 0.2	28.0 ± 0.4	26.6 ± 0.1
Ethnicity*				
Non-Hispanic black	14.8	7.8	10.4	7.5
Mexican-American	4.7	1.8	3.6	2.2
Non-Hispanic white and other	80.5	90.4	86.0	90.3
Education† (less than high school)	32.7	22.9	31.1	26.4
Smoking‡ (current)	11.7	14.9	11.2	18.2
Health status characteristics				
Self-rated health* (fair/poor)	53.8	27.2	43.6	27.6
Arthritis†	60.4	48.8	42.2	33.8
Hip fracture	5.2	4.7	1.6	2.1
Cancer†	7.8	10.5	8.7	7.9
Angina†	12.5	7.1	9.5	6.0
Heart attack*	19.3	7.1	21.8	14.3
Congestive heart failure*	17.6	5.5	16.0	6.6
CHD*	34.2	14.8	31.7	18.9
Stroke*	14.8	5.8	16.6	5.7
Claudication	3.0	1.2	4.4	1.6
Any cardiovascular disease*	43.3	18.9	43.8	23.5
Visual impairment*	30.5	17.3	20.8	14.8

Data are means ± SEM or % unless otherwise indicated. CHD includes heart attack, congestive heart failure, and angina. Cardiovascular disease includes CHD, stroke, and claudication. *Differences by diabetes status that were significant ($P < 0.05$) for both men and women; †differences by diabetes status that were significant ($P < 0.05$) for women only; ‡differences by diabetes status that were significant ($P < 0.05$) for men only.

Three tests of physical performance (walking speed, chair stands, and tandem stand) were assessed at the physical examination using a standardized protocol (6,13,14). Walking speed (in meters per second) was measured as the mean of 2 trials over an 8-foot course. Lower-extremity function was measured using the time to complete 5 stands (in seconds) from an armless chair 50-cm tall. Balance was measured using a tandem stand, which measures the number of seconds (maximum = 10) that the participant can stand with 1 foot directly in front of the other. Among attendees at the physical examination, 464 (8.1%), 421 (7.4%), and 520 (9.1%) subjects on the walking speed, chair stands, and tandem stand tasks, respectively, refused or had incomplete data. The proportion refusing or having incomplete data did not vary according to diabetes status or sex (<2% difference for all tests and sexes). Another 201 (3.5%), 481 (8.4%), and 518 (9.1%) subjects on the walking speed, chair stand, and tandem stand tasks, respectively, were unable to perform the tests because of physical limitations and were categorized in the poor performance group for statistical analyses.

Covariates

Age, ethnicity, education, and smoking were assessed by questionnaire. Height and weight were measured with a standard protocol and were used to calculate BMI (in kilograms per meters squared). Self-reported weight and height were used to compute BMI for subjects without physical measurements (*n* = 909, 14%). Participants were asked about their history of heart attack, congestive heart failure, stroke, cancer, arthritis, or hip fracture. Angina and intermittent claudication were assessed using the Rose Questionnaire (15). Visual impairment was defined as difficulty seeing with 1 or both eyes (even when wearing corrective lenses).

Statistical analyses

All analyses were conducted using SUDAAN to obtain estimates representative of the community-dwelling U.S. population ≥60 years of age (16). Our primary analyses estimated the prevalence (crude and age- and duration-specific prevalence) of levels of disability (none, some difficulty, much difficulty, inability) in walking one-fourth of a mile, climbing 10 steps without rest, and doing housework among participants with and without self-reported diabetes.

We used multiple polytomous logistical regression to estimate the association between diabetes and disability level while controlling for age, ethnicity, education, and BMI (17). Ordinary multiple logistical regression was used to estimate associations among diabetes and falls, injurious falls, and poor performance (defined as inability or performance in the lowest quartile) on walking speed, chair stands, and tandem stand tasks. For polytomous regression, both cumulative (proportional odds) and generalized (multinomial) logit models were evaluated. Cumulative logit models provide a single estimate of the odds ratio (OR), assuming that the association between the exposure (diabetes status) and the outcome (disability) is constant at all levels of the outcome variable. The generalized logit estimates separate diabetes ORs for each level of disability.

Coronary heart disease (CHD), stroke, poor vision, intermittent claudication, and arthritis were added separately to the base models to evaluate their contribution to associations between diabetes and disability. Finally, we evaluated the association of diabetes with disability while controlling simultaneously for all measured diabetes-related comorbidities.

RESULTS

The estimated prevalence of self-reported diabetes was 13.1% among women and 12.4% among men. Among subjects with diabetes, 23% of men and 23% of women were taking no diabetic medications, 48% of men and 43% of women were taking oral antidiabetic medications but not insulin, and 29% of men and 34% of women were taking insulin. People with diabetes had higher BMIs and were more likely to be nonwhite and to report fair or poor health, cardiovascular diseases, and visual impairment than individuals without diabetes (Table 1). Women with diabetes were also less educated, were more likely to have angina and arthritis, and were less likely to have had cancer than women without diabetes. Men with diabetes were less likely to be smokers than men without diabetes. Differences in BMI,

Table 2—*Prevalence and odds of disability* according to diabetes status*

	Women			Men		
	Diabetes	No diabetes	Adjusted OR*	Diabetes	No diabetes	Adjusted OR*
Walking one-fourth of a mile						
Some difficulty	15.4	13.2	1.36 (0.85–2.17)	14.2	10.2	1.54 (0.98–2.43)
Much difficulty	10.4	5.6	1.94 (1.23–3.06)	4.2	3.9	1.27 (0.58–2.78)
Unable	25.4	11.5	2.96 (1.90–4.62)	14.4	7.1	2.51 (1.62–3.89)
Total	51.2	30.3	2.12 (1.53–2.93)	32.8	21.2	1.86 (1.34–2.59)
Climbing steps						
Some difficulty	15.6	15.3	1.05 (0.72–1.54)	14.5	10.0	1.53 (0.91–2.58)
Much difficulty	11.6	6.1	1.83 (1.13–2.98)	4.9	4.1	1.34 (0.74–2.41)
Unable	18.7	8.6	2.30 (1.51–3.49)	8.4	4.5	2.06 (1.14–3.71)
Total	45.9	30.0	1.66 (1.26–2.19)	27.8	18.6	1.63 (1.13–2.36)
Housework						
Some difficulty	19.0	16.1	1.35 (0.84–2.15)	8.3	8.9	1.02 (0.60–1.71)
Much difficulty	11.1	5.1	2.28 (1.55–3.36)	4.1	1.6	2.95 (1.16–7.46)
Unable	13.5	6.4	2.79 (1.88–4.14)	8.2	4.0	2.67 (1.45–4.94)
Total	43.6	27.6	1.94 (1.42–2.66)	20.6	14.5	1.70 (1.12–2.59)
Difficulty on 1 or more tasks†	63.4	41.5	2.19 (1.58–3.05)	39.2	25.1	2.06 (1.49–2.86)
Inability on 1 or more tasks†	32.3	14.3	3.27 (2.01–5.38)	15.2	7.8	2.71 (1.74–4.23)
Inability on all 3 tasks†	9.1	3.6	2.70 (1.84–3.97)	6.6	2.2	3.62 (1.78–7.36)
Falls	36.3	24.9	1.58 (1.21–2.08)	21.9	18.6	1.19 (0.79–1.79)
More than 2 falls	7.1	4.2	1.64 (0.91–2.93)	4.5	3.4	1.34 (0.63–2.85)
Injurious falls	10.5	6.2	2.00 (1.25–3.22)	3.0	3.7	0.79 (0.33–1.88)

Data are % or ORs (95% CIs). *Odds of each level of disability associated with diabetes compared individuals without diabetes obtained from a generalized logit model wherein individuals with no disability are the reference group. ORs corresponding to total disability for each outcome were obtained from cumulative odds logit models (ORs represent overall odds of disability associated with diabetes). All ORs were controlled for age, ethnicity, education, and BMI. †Tasks include walking one-fourth of a mile, climbing 10 steps without rest, and doing housework.

self-rated health, cardiovascular diseases, and visual impairment according to diabetes status were generally greater in women than in men.

Diabetes and self-reported physical disability

Prevalence of self-reported physical disability on each of the 3 physical function tasks was markedly higher among both women and men with diabetes than among individuals without diabetes (Table 2). A total of 63% (95% CI 56–71) of diabetic women and 39% (32–47) of diabetic men reported some disability on at least 1 of the physical tasks compared with 42% (39–44) and 25% (23–28) of nondiabetic women and men, respectively. Diabetes was most strongly associated with more severe levels of disability. A total of 32% (26–39) of women and 15% (11–20) of men with diabetes reported disability on at least 1 of the 3 tasks compared with 14% (12–16) and 8% (6–9) of nondiabetic women and men, respectively. A total of 9% (6–13) of women and 7% (4–10) of men with diabetes reported an inability to do all 3 tasks compared with 4% (2.8–4.4) and 2% (1.5–2.9) of nondiabetic women and men, respectively.

Among both women and men, diabetes was associated with a 2- to 3-fold increased odds of being able to perform each physical task controlled for age, ethnicity, education, and BMI (Table 2). Women with diabetes also had substantially higher odds of reporting much difficulty in walking (OR 1.94 [1.23–3.06]), climbing steps (1.83 [1.13–2.98]), and doing housework (2.28 [1.55–3.36]) compared with women without diabetes. During the previous year, women with diabetes were also more likely to have fallen (1.58 [1.21–2.08]) and to have had injurious falls (2.00 [1.25–3.22]) than women without diabetes. No significant associations were evident between diabetes and falls in men.

Disability by age and duration of diabetes

The adjusted odds of having a physical disability were higher with longer duration of diabetes (P for trend <0.001 for both men and women). Compared with women without diabetes, the overall odds of disability among women with a diabetes duration of ≤5 years, 6–14 years, and ≥15 years were 1.42 (0.90–2.23), 3.09 (1.82–5.25), and 2.71 (1.73–4.26), respectively. Among men, the corresponding odds were 1.20 (0.74–1.94), 2.04 (1.20–3.49), and 2.45 (1.52–3.94), respectively.

Prevalence of inability to do 1 or more of the physical tasks increased with greater diabetes duration in all age–sex strata except for men 60–69 years of age, among whom this prevalence was <5% (Fig. 1). The prevalence was >30% among all women ≥70 years of age with ≥5 years' diabetes duration and was >50% among women ≥70 years of age with ≥15 years' diabetes duration. Among men, the prevalence of inability to do 1 or more task was ≥25% among individuals ≥70 years of age with a diabetes duration of at least 5 years.

Insulin-using individuals had the highest risk of physical disability. Compared with women and men without diabetes, the corresponding odds of overall disability were 3.29 (1.94–5.58) among insulin-using women and 2.89 (1.63–5.10) among insulin-using men controlled for age, ethnicity, education, and BMI.

Physical performance tests

Women with diabetes were significantly more likely to perform poorly on walking speed (2.05 [1.47–2.86]), chair stands (1.36 [1.03–1.79]), and balance (1.89 [1.41–2.52]) tasks controlled for age, ethnicity, education, and BMI. After adjustment for comorbidities, diabetes remained significantly associated with poor performance on all variables except chair stands. Men with diabetes were ~50% more likely to perform poorly on walking speed than men without diabetes (1.52 [1.03–2.24]), but no significant differences were evident on chair stands or balance, nor were differences evident on walking speed after controlling for diabetes-related comorbidities in men.

Effect of diabetes-related comorbidities

Among women, CHD and BMI were more important than other comorbidities in explaining the increased disability risk among individuals with diabetes (Table 3).

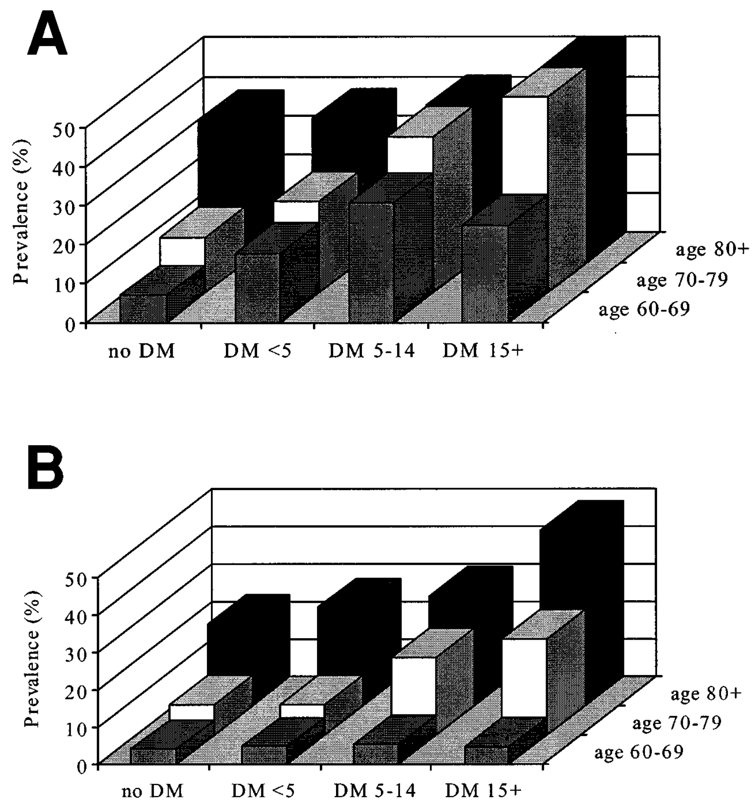

Figure 1—*Prevalence of inability to do 1 or more physical tasks for women (*A*) and men (*B*) stratified by age (in years) and diabetes duration. No DM, no diabetes; DM <5, diabetes duration of <5 years; DM 5–14, diabetes duration of 5–14 years; DM 15+, diabetes duration of >15 years.*

Controlling separately for BMI and CHD reduced diabetes-related odds of disability by 24 and 34%, respectively, whereas controlling for CHD and BMI together reduced the diabetes-related odds by 52%. Controlling for other comorbidities including stroke, poor vision, arthritis, and claudication led to more modest reductions in diabetes-related odds of disability. Among men, controlling for BMI had little effect on diabetes-associated disability, but controlling for CHD and stroke each reduced the odds of diabetes-associated disability by ~21–25%. After all measured comorbidities were added to the model, women and men with diabetes still had a 50 and 46% increased odds of disability, respectively, versus people without diabetes.

CONCLUSIONS— In this nationally representative sample of older U.S. adults, diabetes was associated with a 2- to 3-fold increased risk of being unable to do mobility-related tasks. When applying this sample to the U.S. population, we estimate that >1.2 million (or approximately one-fourth) of older American diabetic adults either cannot walk one-fourth of a mile, climb 10 stairs, or do housework. Approximately one-half (or >2.5 million) have some difficulty doing these tasks. Diabetes-related disability was also reflected in several physical function tests, including slower walking speed, chair stand performance, and balance. These findings are important because physical disability, whether measured by self-report or by objective physical function tests, predicts future declines in health status, institutionalization, and health services use as well as serious reductions in quality of life (1–6).

An excess risk of disability among adults with diabetes is not surprising given the associated comorbidities, including CHD, peripheral vascular disease, stroke, vision loss, and neuropathy. Previous studies have related diabetes to decreased quality of life, including decreased physical, role, and social functioning and increased dependence on others to perform activities of daily living (7,9,10,18–21). Diabetes has also been related to cognitive decline, which could affect physical functioning (22).

Our results suggest that CHD is a major contributor to diabetes-related disability among both men and women and that stroke is an important contributor to diabetes-related disability among men. Comparison of models with and without adjustment for BMI suggests that obesity is also an important factor influencing disability among women and raises the question of whether weight loss would decrease disability among people with diabetes (23). Visual impairment, arthritis, and claudication were also related to diabetes and were secondary contributors to diabetes-associated disability in this study. Unfortunately, we lacked data on other potential contributors to disability, including neuropathy,

Table 3—*Effect of separately controlling for diabetes comorbidities on the percentage of excess odds of overall disability associated with diabetes*

	Women		Men	
Model	Any disability	Percent reduction in excess odds*	Any disability	Percent reduction in excess odds*
Diabetes*	157 (83–260)	—	109 (52–187)	—
Diabetes, BMI	119 (58–205)	24	106 (49–186)	3
Diabetes, arthritis	144 (72–246)	8	96 (42–171)	12
Diabetes, any CHD	104 (47–184)	34	82 (26–164)	25
Diabetes, stroke	135 (63–237)	14	86 (38–150)	21
Diabetes, poor vision	132 (66–224)	16	99 (46–173)	9
Diabetes, claudication	154 (82–255)	2	97 (41–175)	11
Diabetes, BMI, any CHD	75 (27–141)	52	82 (24–166)	25
Diabetes, all variables	50 (5–112)	68	46 (1–110)	58

Data are % excess odds (95% CIs) or %. *Percent reduction in excess odds of diabetes compared with base model of diabetes, ethnicity, education, and age. For example, the model controlling for BMI results in 24% reduced excess odds of overall disability compared with the previous model without BMI.

subclinical cardiovascular disease, and cognitive impairment. We also lacked complete data on lower-extremity amputations and end-stage renal disease, but both of these conditions are likely to be rare in this noninstitutionalized sample.

Our findings suggest that, in people with diabetes, impairments in lower-extremity physical functioning are key contributors to loss of physical independence. Increased risk of walking and climbing disability were paralleled by decreases in gait, balance, and ability to do chair stands. Several pathophysiological factors could mediate these differences, including impaired blood flow and decreased muscle strength, motor coordination, and proprioception. Similarly, decreased cardiorespiratory capacity has been associated with type 2 diabetes and may influence disability risk (24). In addition, hyperglycemia has been associated with general weakness, muscle cramps, blurred vision, and dizziness (25).

This study is limited by its cross-sectional design, so disability may have preceded diabetes rather than the reverse. Cross-sectional studies are vulnerable to survivor bias, which may partially explain why the disability rates were higher for women than for men. Disabled individuals may have been more likely to be among the nonrespondents to NHANES III, which would lead to an underestimation of overall disability prevalence. Similarly, the fact that NHANES III was conducted among the noninstitutionalized U.S. population could lead to an underestimation of the total prevalence of physical disability.

Many of our variables were based on self-report, including diabetes status. Self-reported diabetes has been shown to be reliable as a measure of diagnosed diabetes (26,27), but some people with undiagnosed diabetes may have been misclassified in the nondiabetic group. We replicated our analyses among a subsample of adults in whom glucose measurements were available and were thus able to classify individuals with undiagnosed diabetes. These analyses yielded similar overall results and wider CIs because of the smaller sample size. However, the relationship between diabetes and walking disability was weaker when diabetes was defined by American Diabetes Association criteria because these criteria likely resulted in a healthier sample. Inherent limitations also exist in self-reports of physical disability. For example, reporting level of difficulty on tasks such as walking or housework could be affected by sex, home environment, and how much these activities are part of one's daily routine. Previous research has found these measures to have high predictive and face validity, however, and associations between problems with these tasks and diabetes in our study were supported by several objective physical performance measures (5,6).

The results of this study may have implications for disability prevention, clinical management, and disability-free life expectancy of people with diabetes. Potential strategies to limit disability include specialized lower-extremity strength and balance training, tai chi, and walking, which have been shown to be effective in maintaining muscle mass, in preventing falls, and in maintaining physical functioning (28,29). Because a substantial proportion of diabetes-related disability was accounted for by preventable comorbidities, other preventive care practices including weight control; management of blood lipids, blood pressure, and glycemia; aspirin use; and foot and eye care may improve long-term physical functioning. Continued surveillance of diabetes-related disability, increased awareness of disability as a potentially modifiable complication, and use of interventions to reduce disability should become health priorities for people with diabetes.

References

1. Fried LP, Bush TL: Morbidity as a focus of preventive health care in the elderly. *Epidemiol Rev* 10:48–64, 1988
2. Corti MC, Guralnik JM, Salive ME, Sorkin JD: Serum albumin and physical disability as predictors of mortality in older persons. *JAMA* 272:1036–1042, 1994
3. Branch LG, Jette AM: A prospective study of long-term care institutionalization among the aged. *Am J Public Health* 72: 1373–1379, 1982
4. Tinetti ME, Inouye SK, Gill TM, Doucette JT: Shared risk factors for falls, incontinence, and functional dependence. *JAMA* 273:1348–1353, 1995
5. Nevitt MC, Cummings SR, Kidd S, Black D: Risk factors for recurrent nonsyncopal falls: a prospective study. *JAMA* 261:2663–2668, 1989
6. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Blazer RB: A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol Med Sci* 49:M85–M94, 1994
7. Centers for Disease Control and Prevention: *Diabetes Surveillance, 1997*. Atlanta, GA, Centers for Disease Control and Prevention, 1997
8. Nathan DM: Long-term complications of diabetes mellitus. *N Engl J Med* 328:1676–1685, 1993
9. Moritz DJ, Ostfeld AM, Blazer D II, Curb D, Taylor JO, Wallace RB: The health burden of diabetes for the elderly in four communities. *Public Health Rep* 109:782–790, 1994
10. Songer T: Disability in diabetes. In *Diabetes in America*. 2nd ed. Eds. Harris MI, Cowie CC, Stern MP, Boyko EJ, Reiber GE, Bennett PH: Washington, DC, U.S. Govt. Printing Office, 1995, p. 429–448 (NIH publ. no. 95-1468)
11. Harris MI, Flegal KM, Cowie CC, Eberhardt MS, Goldstein DE, Little RR, Wiedemeyer HM, Byrd-Holt DD: Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults. *Diabetes Care* 21:518–524, 1998
12. King H, Aubert RE, Herman WH: Global burden of diabetes, 1995–2025: prevalence, numerical estimates and projections. *Diabetes Care* 21:1414–1431, 1998
13. U.S. Department of Health and Human Services, National Center for Health Statistics: *Third National Health and Nutrition Examination Survey, 1988–1994: Reference Manuals and Reports* (CD-ROM). Hyattsville, MD (Available from the National Technical Information Service, Springfield, VA), 1996
14. Jette AM, Branch LG: Impairment and disability in the aged. *J Chronic Dis* 38:59–65, 1985
15. Rose GA, Blackburn H, Gillum RF, Prineas RJ: *Cardiovascular Surgery Methods*. 2nd ed. Geneva, World Health Org., 1982
16. Shah BV, Barnwell BG, Bieler GS: *SUDAAN User's Manual, Version 6.4*. 2nd ed. Research Triangle Park, NC, Research Triangle Institute, 1996
17. Hosmer DW, Lemeshow S: *Applied Logistic Regression*. New York, Wiley, 1989
18. Clark DO, Stump TE, Wolinsky FD: Predictors of onset of and recovery from mobility difficulty among adults aged 51–61 years. *Am J Epidemiol* 148:63–71, 1998
19. Stewart AL, Greenfield S, Hays RD, Wells K, Rogers WH, Berry SD, McGlynn EA, Ware JE Jr: Functional status and well-being of patients with chronic conditions: results from the Medical Outcomes Study. *JAMA* 262:907–913, 1989
20. Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PWF, Kelly-Hayes M, Wolf PA, Kreger BE, Kannel WB: The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. *Am J Public Health* 84: 351–358, 1994
21. Perkowski LC, Stroup-Benham CA, Markides KS, Lichtenstein MJ, Angel RJ,

Guralnik JM, Goodwin JS: Lower-extremity functioning in older Mexican Americans and its association with medical problems. *J Am Geriatr Soc* 46:411–418, 1998
22. Gregg EW, Yaffe K, Cauley JA, Rolka DR, Blackwell TL, Narayan KMV, Cummings SR: Diabetes is associated with cognitive impairment and cognitive decline among older women. *Arch Intern Med* 160:174–189, 2000
23. Launer LJ, Harris T, Rumpel C, Madans J: Body mass index, weight change, and risk of mobility disability in middle-aged and older women. *JAMA* 271:1093–1098, 1994
24. Estacio RO, Regensteiner JG, Wolfel EE, Jeffers B, Dickenson M, Schrier RW: The association between diabetic complications and exercise capacity in NIDDM patients. *Diabetes Care* 21:291–295, 1998
25. Testa MA, Simonson DC: Health economic benefits and quality of life during improved glycemic control in patients with type 2 diabetes mellitus: a randomized, controlled, double-blind trial. *JAMA* 280: 1490–1496, 1998
26. Bush TL, Miller SR, Golden AL, Hale WE: Self-report and medical record report of agreement of selected medical conditions in the elderly. *Am J Public Health* 79:1554–1556, 1989
27. Harlow SD, Linet MS: Agreement between questionnaire data and medical records: the evidence for accuracy of recall. *Am J Epidemiol* 129:233–247, 1989
28. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM: Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* 315:1065–1069, 1997
29. Province MA, Hadley EC, Hornbrook MC, Lipsitz LA, Miller JP, Mulrow CD, Ory MG, Sattin RW, Tinetti ME, Wolf SL: The effects of exercise on falls in elderly patients: a preplanned meta-analysis of the FICSIT trials. *JAMA* 273:1341–1347, 1995