What Can We Do to Improve Physical Function in Older Persons With Type 2 Diabetes?

Lisa B. Caruso, Rebecca A. Silliman, Serkalem Demissie, Sheldon Greenfield, and Edward H. Wagner

Background. Older persons with type 2 diabetes are at higher risk for functional impairment than are their age-matched counterparts without diabetes. We therefore sought to identify factors associated with impaired physical function in older persons with type 2 diabetes by using a cross-sectional study design.

Methods. We studied 1238 persons with type 2 diabetes who were 55 years of age or older and enrolled in the Type II Diabetes Patient Outcomes Research Team (PORT) project. Subjects were primary care patients at a large staff model health maintenance organization who had completed a mailed survey that collected information about demographics (age, race, marital status, income, education, gender, and body mass index [BMI]), health behaviors (exercise, smoking, and alcohol), care and control of diabetes (therapy, self-reported glucose control, home glucose monitoring, and disease duration), mood (Center for Epidemiologic Studies—Depression Scale [CES-D]), comorbidity, and the Short-Form-36 health survey (SF-36).

We evaluated the bivariate relationships between the PFI-10, a 10-item measure of physical function from the SF-36, and candidate independent variables from the domains described previously. Variables that were significant at an α level of .10 were entered into a multiple linear regression model.

Results. There were eight independent predictors of impaired physical function (all $p < .05, R^2 = .40$). Factors associated with impaired function in order of their relative importance were as follows: a higher comorbidity score, older age, obesity, lack of regular exercise, CES-D score higher than 20, taking insulin, lower formal education, and abstinence from alcohol.

Conclusions. Increased comorbidity and older age are associated with poorer function, as is the severity of diabetes and less formal education. Exercise, lower BMI, and better mood are associated with better function. Therefore, promoting regular exercise and weight loss, in addition to treating depression, are likely to preserve or even improve the functional status of older persons with type 2 diabetes. Moderate alcohol use may be beneficial as well. The extent to which these relationships persist in prospective studies or clinical trials remains to be evaluated.
We minimized the number of persons with type 1 diabetes in the sample by determining that subjects had to be older than 30 years and have no history of diabetic ketoacidosis.

A total of 8668 subjects met the initial inclusion criteria. Because the PORT study was evaluating clinical outcomes and effectiveness of physician care, only subjects who were cared for by primary care providers who practiced full time and whose providers had 20 or more eligible patients were considered. There were 192 eligible primary care providers. From this group, 80 providers were randomly selected, stratified by age and sex.

Subjects of these providers were excluded for the following reasons: (i) a diagnosis of cancer; (ii) an inability to communicate in English without a family member to interpret; (iii) an illness too severe for longitudinal follow-up as determined by the primary care provider; or (iv) a report by the primary care provider that they did not have diabetes.

Measurements
Subjects completed a mailed questionnaire that included the Short-Form-36 health survey (SF-36), demographic information, health behaviors, information on care and control of diabetes, assessment of depression, and questions regarding comorbidity. A detailed description of the survey design has been reported previously (6). The SF-36 was chosen as a measure of health in our survey because of its ease of administration, its appropriateness for a community-dwelling sample of older adults, and for its well-documented reliability and validity. The SF-36 has been used extensively in diabetes research to address health-related quality of life issues. Our dependent variable was physical function, as measured by the PFI-10 scale, a 10-item subscale of the SF-36 shown in the Appendix. It includes items ranging from basic activities of daily living, such as bathing and dressing, to vigorous physical activities, such as running or lifting heavy objects. It is scaled 0–100, with a lower score indicating more impaired function. For example, an adult in the 35–44 age group has a mean PFI-10 score of 89.70, whereas an adult with a recent myocardial infarction has a mean score of 69.68, as taken from norms developed by Ware and others (7).

We considered independent variables from five categories that we hypothesized to be associated with impaired physical function. First, we considered demographic characteristics. These included the following: (i) age (55–64, or late middle age; 65–74, or the younger old; and older than 75 years, or the older old; (ii) race (white/nonwhite); (iii) gender; (iv) yearly income of <$10,000, $10,000–$19,999, $20,000–$39,999, and >$40,000; (v) marital status (married/single/other); (vi) education (=high school/>high school); and (vii) body mass index [BMI] as calculated from the subject’s self-reported height and weight, using the formula, weight/height$^2$. Second, we considered health behaviors, including smoking habits (never/former/current) and exercise. Subjects were asked which ten forms of exercise they performed. These forms included such activities as walking, swimming, jogging, and heavy housework. The questionnaire did not ask about the intensity or frequency of exercise. We also considered alcohol use. Although the questionnaire included questions about the frequency, the type, and the amount of alcohol used, complete data were available for only 54% of the subjects because of the complex skip patterns in the questionnaire. We therefore defined alcohol use by the questions “Have you ever had a drink of alcohol?” and “Do you still drink any alcohol?” Those subjects who answered “yes” to both questions were classified as drinkers; the rest were considered nondrinkers.

Third, we considered several variables reflecting diabetes care and control. We considered intensity of therapy (on insulin/not on insulin), self-report of glucose control (subject was given five choices ranging from “very well” to “not at all”), frequency of home glucose monitoring (<once per month/once per month/>once per month), and disease duration (<10 years/>10 years).

Fourth, we considered depressive symptoms because there is strong evidence that depression as well as the presence of chronic medical conditions contribute to impaired physical function (8). Our measure for depression was a modified version of the Center for Epidemiologic Studies—Depression Scale (CES-D), a 20-item self-report depression scale. Although it was originally designed to identify depression in the general population (9), it has been found to be an appropriate measure for older adults as well (10,11). The scale score range is 0–60, with a higher score indicating more depressive symptoms.

The version of the CES-D that was fielded differed from the original version in two ways. First, we asked subjects to give their responses based on how they felt during the past four weeks instead of during the past week. Second, instead of using “rarely or none of the time” as a choice for the lowest frequency of symptoms, we used simply “none of the time.” This change in phraseology might have caused subjects to report more depressive symptoms in that they may have chosen “some or a little” of the time rather than “none of the time.” To minimize the impact of this possibility, we used a more conservative cut point of 19/20 rather than 15/16, which has been shown to decrease the number of false positives in older adults (12,13).

Finally, we considered comorbidity because physical function is integrally related to disease burden. We used the Total Illness Burden Index (TIBI) as developed by Greenfield and colleagues (2). Briefly, this index is derived from subjects’ report of their medical conditions, physical symptoms, and diseases from 15 body systems; disease measures are then weighted by their severity. The index is designed to control for comorbidity in comparisons of functional status and quality-of-life outcomes among ambulatory patients. A higher score reflects a greater disease burden (14).

Statistical Analyses
Bivariate analyses were performed using Student’s t tests for dichotomous independent variables (race, gender, education, alcohol use, therapy severity, disease duration, and CES-D); analysis of variance for categorical independent variables (age, income, marital status, home glucose monitoring, glucose control, smoking, and exercise); and simple linear regression for continuous independent variables (BMI and comorbidity). Independent variables found to be significantly associated with physical function ($\alpha = 0.10$) in our bivariate analyses were candidates for inclusion in our multivariate analysis. We em-
ployed a stepwise strategy in our multiple linear regression analysis, retaining statistically significant variables in our final model. Of these, eight were significant at the .05 level. Data were analyzed using SAS software, version 6.11 (15).

**Results**

Study Sample

A total of 2585 subjects met the inclusion/exclusion criteria. Nine percent were excluded by the primary care physician, 467 (18%) refused to participate, and 380 (15%) failed to return the survey. Participants and nonparticipants did not differ by sex, but participants were older (mean age, 63.9 vs 62.2 years; $p < .001$) and had more provider visits per year (11.6 vs 10.0; $p < .001$) (16). Of the 1738 (67%) participating subjects, 1296 were over 55 years old, and 1238 of these completed the PFI-10. The mean PFI-10 score was 64.31 ± 26.96. Quartile scores were 44.44, 70.00, and 85.00 for the 25th, 50th, and 75th percentile, respectively. The norm for 26.96. Quartile scores were 44.44, 70.00, and 85.00 for the 25th, 50th, and 75th percentile, respectively. The norm for direction.

Subject demographic characteristics are shown in Table 1. Participants in the oldest old group (75+ years) were well represented. Most participants were white, and there was a fairly equal representation of women and men. The majority of subjects had household annual incomes of more than $20,000 and were married. They were fairly well educated, with almost half having more than a high school education. They were also overweight. Only 247 subjects were of normal weight (BMI < 25), and 467 subjects were obese (BMI > 30). A total of 461 subjects were overweight (BMI 25–25.9).

Health behaviors and information regarding diabetes care and control in our sample are shown in Table 2. Few were current smokers but nearly half were classified as drinkers. About half stated that they engaged in some form of exercise. Most subjects were not being treated with insulin. Members of this group reported that their glucose was either “controlled” or “very well controlled” and that they performed home blood glucose monitoring more than once per month. Subjects carried a diagnosis of diabetes for a mean of 9.78 years (range 0–50 years).

CES-D scores ranged from 0 to 48, with 27% ($n = 308$) of subjects scoring ≥20. The comorbidity score ranged from −23.2 to +73.66, with a higher score indicating more disease burden.

Factors Associated with Physical Function

Table 3 shows the results of our multiple linear regression analysis. Controlling for other variables in the model, we found that the oldest old (75 years and older) scored 14.25 points lower on the PFI-10 than the younger old (55–64 years). Other factors independently associated with lower physical function were lower education, higher BMI, not engaging in exercise, no alcohol use, more severe diabetes (i.e., being treated with insulin), having a depressed mood, and having a higher comorbidity score. The relative importance of the association of each independent variable to physical function as shown by the standardized regression coefficients were as follows (from strongest to weakest): comorbidity (TIBI), age, obesity (i.e., a higher BMI), exercise, depression, therapy severity, education, and alcohol use.

**Discussion**

Our results, derived from a cross-sectional study of older community-dwelling subjects with type 2 diabetes, are similar to those of other studies showing that increased comorbidity and older age are strongly associated with impaired physical function. Providers continue to seek ways to prevent, treat, and delay the often disabling effects of cardiovascular disease, lung disease, cancer, and other comorbid conditions in order to promote healthy aging, especially in those with type 2 diabetes. While it is difficult to change the level of formal education obtained by an individual or the severity of his or her diabetes mellitus, there are other mutable factors associated with impaired physical function.

Attention to regular exercise and weight control is of great importance to type 2 diabetes care. Physical activity enhances insulin sensitivity of muscle tissue. Reduction of adipose tissue mass further reduces insulin resistance in obese persons with type 2 diabetes. There is evidence that even older adults with uncontrolled type 2 diabetes have improved glucose metabolism when they engage in a moderate exercise program (17). Concurrent comorbidities and low compliance rates, however, may reduce the effectiveness of exercise programs for older persons with type 2 diabetes. A recent Swedish study enrolled male diabetics with an average age of 60 in a physical training program to evaluate whether exercise improved glucose tolerance and lipoprotein metabolism. Of 48 eligible subjects, 39 had to be excluded on the basis of physical limitations (18). In a study of middle-aged persons with types 1 and 2 diabetes enrolled in a lifestyle modification program, only 10% were still fully enrolled after one year. The program consisted of aerobic exercise three to four times a week, nutrition counseling,
Depressive symptoms are common in older persons. Prevalence estimates for community-dwelling older persons are greater than 10%. For example, in a community sample of older adults living in Kentucky, 13.7% of men and 18.2% of women scored at or above 20 on the CES-D (20). Furthermore, a study from the Epidemiologic Catchment Area Program determined the prevalence of major depression to be 1.8% and a prevalence of depression with dysphoria and nondysphoric depression to be 15.7% in adults over age 50 (21). Among community-dwelling older persons with type 2 diabetes, the prevalence of depressive symptomatology has been shown to be even higher. The French PAQUID epidemiological survey found 21.3% of persons over age 65 with type 2 diabetes to have depressive symptoms as measured by the CES-D (4). In our cohort of community-dwelling persons with type 2 diabetes over the age of 55, the prevalence of depressive symptomatology was 27%.

The link between functional impairment and depressive symptoms in adults is well established. A recent longitudinal study found that older adults with depressive symptoms are at higher risk for functional decline (22). Comorbidity has also been established as a risk factor for impaired physical function. Patients who have chronic medical conditions and depressive symptoms are likely to be more functionally impaired than are those patients without chronic medical conditions and depressive symptoms (8). Although health care providers treating patients with diabetes should continue to work hard to prevent end organ damage as a strategy to preserve physical function, our findings suggest that attention to depressive symptoms may provide additional benefits. Clinical trials are also needed to test the hypothesis that treating depressive symptoms in older persons with type 2 diabetes will help to improve or at least to maintain functional status.

Another factor we found to be associated with impaired physical function was abstinence from alcohol. In general, older adults drink less than younger adults, and persons with type 2 diabetes drink less than those without diabetes. The percentage of older persons with type 2 diabetes (65–74 years) who reported drinking any alcohol according to the National Health and Nutrition Examination Survey II (NHANES II) was lower than the percentage of older persons with type 2 diabetes (65–74 years) who reported drinking any alcohol among those without diabetes (43%). There is growing evidence that moderate alcohol use is associated with such health benefits as a decreased risk of coronary artery disease (24,25), ischemic stroke (26,27), and better cognitive functioning (28). At the same time, alcohol use has also been identified as a risk factor for type 2 diabetes, perhaps by the damaging effect of alcohol on the liver and the pancreas, or by weight gain secondary to the added ingested calories and truncal adipose tissue deposition (23). In addition, because alcohol is an inhibitor of gluconeogenesis, its ingestion without food puts the diabetic at risk for hypoglycemia. Our study shows a positive relationship between alcohol use and physical function in older persons with type 2 diabetes. Although we could hypothesize that those subjects who were sicker and therefore had a lower functional status drank less, we controlled for comorbidity in our model, suggesting that there is an independent relationship between physical function and alcohol. In fact, a recent prospective

| Table 2. PFI-10 Scores in Relation to Subject Health Behaviors and Information on Diabetes Care and Control |
|-------------------------------------------------|----------------|----------------|----------------|
| Variable | PFI-10 Mean ± SD | p Value |
| Smoking
  Never | 485 (40) | 64.73 ± 27.04 | .4667 |
  Former | 562 (47) | 64.89 ± 27.09 | |
  Current | 151 (13) | 61.92 ± 26.81 | |
| Alcohol use
  Nondrinkers | 676 (57) | 60.85 ± 27.81 | .0000 |
  Drinkers | 513 (43) | 68.85 ± 25.47 | |
  Exercise | | | .0000 |
| Therapy severity
  On insulin | 370 (30) | 54.70 ± 28.47 | |
  Not on insulin | 842 (70) | 68.85 ± 25.15 | |
| Self-reported glucose control
  Very well | 222 (19) | 67.57 ± 2740 | .0038 |
  Controlled | 429 (37) | 64.37 ± 27.38 | |
  So-so | 364 (31) | 65.72 ± 25.69 | |
  Not well | 119 (10) | 59.55 ± 26.23 | |
  Not at all | 32 (3) | 51.28 ± 27.51 | |
| Home glucose monitoring
  Less than once a month | 389 (33) | 61.98 ± 27.62 | .0015 |
  Once a month | 109 (9) | 70.63 ± 25.66 | |
  More than once a month | 669 (57) | 66.30 ± 26.31 | |
| Disease duration
  <10 years | 743 (60) | 67.46 ± 25.83 | .0000 |
  ≥10 years | 495 (40) | 59.58 ± 27.94 | |
| CES-D Score <20 | 851 (73) | 69.63 ± 24.68 | .0000 |
| Score ≥20 | 308 (27) | 50.49 ± 27.17 | |

And weight monitoring (19). We do not yet know if a safer, less intense exercise regimen would protect physical functioning in older persons with type 2 diabetes as well as improve patient participation and adherence.

Depressive symptoms are common in older persons. Prevalence estimates for community-dwelling older persons are greater than 10%. For example, in a community sample of older adults living in Kentucky, 13.7% of men and 18.2% of women scored at or above 20 on the CES-D (20). Further, a study from the Epidemiologic Catchment Area Program determined the prevalence of major depression to be 1.8% and a prevalence of depression with dysphoria and nondysphoric depression to be 15.7% in adults over age 50 (21). Among community-dwelling older persons with type 2 diabetes, the prevalence of depressive symptomatology has been shown to be even higher. The French PAQUID epidemiological survey found 21.3% of persons over age 65 with type 2 diabetes to have depressive symptoms as measured by the CES-D (4). In our cohort of community-dwelling persons with type 2 diabetes over the age of 55, the prevalence of depressive symptomatology was 27%.

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Another factor we found to be associated with impaired physical function was abstinence from alcohol. In general, older adults drink less than younger adults, and persons with type 2 diabetes drink less than those without diabetes. The percentage of older persons with type 2 diabetes (65–74 years) who reported drinking any alcohol according to the National Health and Nutrition Examination Survey II (NHANES II) was lower than the percentage of older persons without diabetes drinking any alcohol (40% vs 52%) (23) and was comparable to our sample (43%). There is growing evidence that moderate alcohol use is associated with such health benefits as a decreased risk of coronary artery disease (24,25), ischemic stroke (26,27), and better cognitive functioning (28). At the same time, alcohol use has also been identified as a risk factor for type 2 diabetes, perhaps by the damaging effect of alcohol on the liver and the pancreas, or by weight gain secondary to the added ingested calories and truncal adipose tissue deposition (23). In addition, because alcohol is an inhibitor of gluconeogenesis, its ingestion without food puts the diabetic at risk for hypoglycemia. Our study shows a positive relationship between alcohol use and physical function in older persons with type 2 diabetes. Although we could hypothesize that those subjects who were sicker and therefore had a lower functional status drank less, we controlled for comorbidity in our model, suggesting that there is an independent relationship between physical function and alcohol. In fact, a recent prospective

| Table 3. Factors Associated With Physical Function |
|-----------------------------------------------|----------------|----------------|----------------|
| Independent Variables | Regression Coefficient | p Value | Standardized Regression Coefficient |
| Demographic variables
  Age, years
    55–64 (referent) | — | — | — |
    65–74 | −7.96 | .0001 | −0.1498 |
    75+ | −14.25 | .0001 | −0.2121 |
| Education
  ≤High school vs >high school | 4.89 | .0005 | 0.0916 |
| BMI (kg/m²) | −0.73 | .0001 | −0.1568 |
| Health behaviors
  Exercise
    No exercise vs 1+ forms | 6.54 | .0001 | 0.1238 |
    Alcohol use
      Nondrinkers vs drinkers | 2.81 | .0419 | 0.0527 |
  Therapy severity
    No insulin vs insulin | −6.02 | .0001 | −0.1050 |
| CES-D Score <20 vs score ≥20 | −7.14 | .0001 | −0.1185 |
| Total illness burden index | −0.80 | .0001 | −0.4049 |

Note: Model R² = .40.
cohort study of older persons with type 2 diabetes has demonstrated a beneficial effect of alcohol use on coronary heart disease mortality, at the same time controlling for other cardiac risk factors and comorbidities (29). The risks of excessive alcohol consumption are well known. How to safely reap the benefits of moderate alcohol use among patients at risk for vascular disease is an important clinical challenge.

Our study has several limitations. First, the study sample was homogeneous. Participants were mostly white, well educated, and financially stable. Second, our study was cross-sectional, precluding definitive statements about cause and effect. Third, the exclusion of individuals too ill for longitudinal follow-up may have introduced systematic bias into the study by truncating the distribution of functional status. Fourth, our alcohol variable was less well specified than we would have liked. We were unable to determine how amount, type, and frequency of alcohol use were related to physical function. The high prevalence of missing data from these questions was probably due to the complex skip pattern design used in the questionnaire. More complete data on this variable would have helped in interpreting how alcohol use relates to functional status. Fifth, we did not sample a matched comparison group of older adults without diabetes. Thus, we are unable to determine the extent to which our risk factors may be unique to an aging sample of persons with type 2 diabetes. A sixth concern is that our data were self-reported. Although we were unable to validate these reports, pharmacy and laboratory data available for a subsample of the initial cohort of 1738 subjects indicate that variables related to the care and control of diabetes were consistent with the self-report data (16).

With these limitations in mind, we believe that the following conclusions can be made. Increased comorbidity and older age are associated with poorer function, as is the severity of diabetes and less formal education. Exercise, lower BMI, and better mood are associated with better function. Therefore, promoting regular exercise and weight loss, in addition to treating depression, are likely to preserve or even improve the functional status of older persons with type 2 diabetes. Moderate alcohol use may be beneficial as well. The extent to which these relationships persist in prospective studies or clinical trials remains to be evaluated.

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Address correspondence to Dr. Lisa B. Caruso, Boston Medical Center, 88 East Newton Street, F4, Boston, MA 02118. E-mail: Lisa.Caruso@bmc.org

References


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Appendix

**PFI-10 Scale (7)**

The following items are activities you might do during a typical day. Does your health limit you in these activities?

<table>
<thead>
<tr>
<th>(Circle One Number on Each Line)</th>
<th>Yes, I am LIMITED</th>
<th>Yes, I am LIMITED</th>
<th>No, I am LIMITED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Lot</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A Little</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>At All</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

Lifting or carrying groceries

Climbing several flights of stairs

Climbing one flight of stairs

Bending, kneeling, or stooping

Walking more than a mile

Walking several blocks

Walking one block

Bathing or dressing yourself

The raw score is between 10 and 30. The raw score is transformed into a 0–100 point scale using the following equation:

\[
\text{Transformed Scale} = \left( \frac{\text{Actual raw score} - \text{lowest possible raw score}}{\text{Possible raw score range}} \right) \times 100
\]