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Modifiable Risk Factors Predict Functional Decline Among Older Women: A Prospectively Validated Clinical Prediction Tool

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OBJECTIVE: To identify modifiable predictors of functional decline among community-residing older women and to derive and validate a clinical prediction tool for functional decline based only on modifiable predictors.

DESIGN: A prospective cohort study.

SETTING: Four geographic areas of the United States.

PARTICIPANTS: Community-residing women older than age 65 recruited from population-based listings between 1986 and 1988 (n = 6632).

MEASUREMENTS: Modifiable predictors were considered to be those that a clinician seeing an older patient for the first time could reasonably expect to change over a 4-year period: benzodiazepine use, depression, low exercise level, low social functioning, body-mass index, poor visual acuity, low bone mineral density, slow gait, and weak grip. Known predictors of functional decline unlikely to be amenable to intervention included age, education, medical comorbidity, cognitive function, smoking history, and presence of previous spine fracture. All variables were measured at baseline; only modifiable predictors were candidates for the prediction tool. Functional decline was defined as loss of ability over the 4-year interval to perform one or more of five vigorous or eight basic daily activities.

RESULTS: Slow gait, short-acting benzodiazepine use, depression, low exercise level, and obesity were significant modifiable predictors of functional decline in both vigorous and basic activities. Weak grip predicted functional decline in vigorous activities, whereas long-acting benzodiazepine use and poor visual acuity predicted functional decline in basic activities. A prediction rule based on these eight modifiable predictors classified women in the derivation set into three risk groups for decline in vigorous activities (12%, 25%, and 39% risk) and two risk groups for decline in basic activities (2% and 10% risk). In the validation set, the probabilities of functional decline were nearly identical.

CONCLUSIONS: A substantial portion of the variation of functional decline can be attributed to risk factors amenable to intervention over the short term. Using eight modifiable predictors that can be identified in a single office visit, clinicians can identify older women at risk for functional decline.
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Key words: activities of daily living; aged; cohort studies; prediction rule; risk factors

Functional dependence among older adults is associated with increased mortality,[1,2] higher rates of hospital and nursing home admission,[3,4] and lower quality of life.[5,6] More than 20% of Americans aged 65 and over live with disability,[7] and as the size of the older population increases over the next decades, functional impairment will afflict an unprecedented number of older adults, most of them women.[8,9] Reducing functional decline has been called one of our most important public health issues.[10]

Several longitudinal studies have identified demographic factors, medical conditions, and behavioral factors[11–28] that predict functional decline. Unfortunately, many of the strongest predictors – such as age and socioeconomic status – are not directly modifiable. Other preventable risk factors, such as cerebrovascular and cardiovascular disease, are, all too often, already present in older patients when they present for care in the outpatient setting. Thus, clinicians caring for older adults face a formidable challenge: to prevent functional decline despite the presence of fixed or progressive risk factors. Although the use of a prediction tool based on all known risk factors for functional decline would be the most accurate way to risk-stratify older women, such a tool would not differentiate between risk factors that are fixed (such as age)

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and those that are potentially modifiable (such as depression). A tool based on modifiable characteristics alone, however, could be utilized by clinicians (1) to identify patients whose increased risk is based on characteristics the physician and the patient could potentially do something about and (2) to facilitate discussion between physician and patient regarding potential interventions to reduce the risk of functional decline.

To our knowledge, no previous study has attempted to use modifiable characteristics to create a clinical prediction tool[29] for functional decline. We used data from the Study of Osteoporotic Fractures to identify and examine the role of modifiable predictors of functional decline among community-residing older women and to derive and validate a clinical prediction tool for functional decline based on predictors that a treating clinician could potentially change over a 4-year period of time.

METHODS

Subjects

From September 1986 through October 1988, a volunteer sample of 9704 women aged 65 years or older was recruited from several sources.[30] In Portland, Oregon, and Minneapolis, Minnesota, women were identified from membership lists for large health maintenance organizations. In Minneapolis, women were also identified from lists of residents that had been produced for the Hypertension Detection and Follow-up and the Systolic Hypertension in the Elderly studies and from jury selection lists for Hennepin County. In the Monongahela Valley, women were identified from 1985 voter registration lists. In Baltimore, women were selected from county lists of holders of drivers' licenses and identification cards. Women received a letter and brochure inviting them to participate in the study. The Study of Osteoporotic Fractures excluded black women because of their lower incidence of hip fractures,[31] women unable to walk without the help of another person, and women with bilateral hip replacements. At baseline and at 2-year intervals, participants underwent evaluations that included performance tests and interviews to assess functional status. Potential predictors of functional decline were measured at visit 1 (1986–1988) or visit 2 (1988–1990), and function was reassessed at visit 4 (1992–1994). We excluded from our analysis women who died (n = 847) or were lost to follow-up (n = 492), those who did not complete functional status questionnaires at visits 2 and 4 (n = 623), and women missing information regarding their level of exercise, who did not complete a survey of depressive symptoms or social network, or who did not complete physical performance tests (n = 1110). This left 6632 women eligible for our analysis. Women who were excluded were more likely to have each of the predictor variables and more likely to reside in a nursing home than those remaining in our cohort (chi-square P value $<.05$ for all). All participants provided written informed consent.

Predictor Variables

We reviewed published longitudinal studies of functional decline in community-residing older adults to identify potential predictors for our analysis. Two co-authors (CS and CM) independently categorized predictors as modifiable or fixed: modifiable predictors were those that a clinician seeing an older patient for the first time could act upon and reasonably expect to change over a 4-year period. There was 100% agreement between co-authors. Only modifiable predictors — depression, high body mass index (BMI), poor visual acuity, low bone mineral density (BMD), benzodiazepine use, weak grip, slow gait, low social functioning, and low exercise level — became candidates for the decision tool. Fixed predictors of functional decline included age, education, medical comorbidity, cognitive function, presence of spine fracture, and smoking history. Some investigators have regarded smoking history as a modifiable risk factor for functional decline in older adults.[28] We classified smoking (never, former, or current) as fixed, because most older adults who smoke have smoked for over 50 years and have already accrued most of their increased risk from smoking.[32] Alcohol use has been shown to be protective for functional decline.[15,22] However, because of the large number of older adults taking medications that interact with alcohol, we felt it would be unrealistic and dangerous to recommend alcohol intake to nondrinking older adults, and, therefore, we did not include alcohol use as a modifiable predictor. Exercise level and visual acuity were measured at visit 1; all other modifiable predictors were measured at visit 2.

In order to create a simple tool that could be used by clinicians without much calculation, we dichotomized the continuous predictor variables. Whenever possible, we used validated clinical cutpoints. For continuous variables without established cutpoints, we examined the bivariable associations between each variable by quintile and functional decline. If there was a linear trend suggesting a consistent dose-response effect, we dichotomized the variable at the lowest quintile versus all others.

Depressed mood was assessed with the 15-item Geriatric Depression Scale (GDS), using a cutpoint of 6 or greater.[33–35] Body mass index (BMI) was measured using standard techniques.[36] We used the cutpoints at which obese older women are at increased risk of mortality[37,38]: <27 (reference group), 27–29, and ≥29. Poor visual acuity was defined as binocular vision 20/40[39] or worse because this is the level generally needed to obtain an unrestricted driver's license. Bone mineral density of the femoral neck was determined by dual-energy X-ray absorptiometry.[40] We used T-scores from NHANES III cutpoints[41] that categorized women in accordance with WHO definitions of osteopenia and osteoporosis.[42] Long-acting benzodiazepines were defined as those with a half-life of at least 24 hours.

Maximum grip strength was measured with a grip dynamometer in both hands[43] and averaged. Interrater reliability was assessed in 15 subjects at each clinic who were tested 15 minutes apart by two examiners and averaged for all clinics ($r = 0.93$). Gait speed was determined by measuring the time in seconds needed to walk 6 meters at a rapid pace. A social network score was computed using the 10-item Lubben Social Network Scale.[44] Exercise level was examined with a modified Paffenbarger survey, which has been validated in postmenopausal women.[45–47]

Education was coded as less than 12 years, 12 years, or more than 12 years. A modified version of the Folstein Mini-Mental Status exam was administered.[48,49] Because this version does not have an established clinical cutpoint for dementia, and more than 92% of women answered ≥24 of 26 items correctly, the score was used as a continuous fixed covariable.

At the time of data collection, no validated measures of comorbidity were in existence. Therefore, to adjust for the confounding influence of medical conditions associated with functional decline, we constructed a weighted comorbidity score for each participant based on the self-reported history of eight medical conditions (diabetes, arthritis, Parkinson's disease, COPD, congestive heart failure, angina, heart attack, stroke). We chose these conditions from an extensive list available to us because these have been shown in the medical literature to be associated with functional impairment.[15,16,20,50–52] To derive the comorbidity score, we performed a logistic regression using the eight medical conditions as independent correlates of functional impairment at visit 2 (baseline) and assigned points based on the relative magnitudes of the corresponding beta-coefficients (details available by request). Although many of these medical conditions are treatable, it is unclear whether treatment of most of these conditions would modify the 4-year risk of functional decline; for this reason, the comorbidity score was classified conservatively as a fixed covariable in the subsequent models used to derive the prediction tool. Spine fracture was determined by thoracic and lumbar spine radiographs[40] and was examined as a separate fixed (0,1) covariable in the models.

Measurement and Definition of Functional Decline

At visits 2 and 4, participants were interviewed about their ability to carry out 13 daily activities from the 1984 National Health Interview Survey Supplement on Aging[53] and a modified Health Assessment Questionnaire.[54] Maximum likelihood factor analysis with promax rotation performed on the 13 items at visit 4 identified two domains that appeared to represent "vigorous" and "basic" activities (Table 1).

Although functional decline is not an "all or none" phenomenon, we modeled functional decline as a binary outcome in order to create a tool that would be feasible for use in clinical settings. The vast majority of women in our cohort who experienced functional decline in either vigorous or basic activities experienced a decrease of only one activity; therefore, for both vigorous and basic activities, functional decline was defined as a decrease of one or more between visits 2 and 4 in the number of activities reported able to complete without assistance.

Derivation and Validation of the Clinical Prediction Tool

We developed two prediction rules, one for predicting functional decline in vigorous activities and one for predicting functional decline in basic activities. A random two-thirds of the cohort was used to derive the prediction rules (derivation set). The accuracy of the scoring system and predictive categories was validated on the remaining one-third (validation set). In the derivation set, all modifiable predictors were entered into a backward-stepwise logistic regression model for each type of functional decline. The inclusion level for modifiable predictors was set at $P \leq .10$.[55] Models were adjusted for enrollment site and fixed characteristics associated with functional decline.

The modifiable predictors having a significant, and in the case of obesity and BMD, a dose-response relationship with either type of functional decline were used to construct the prediction rules. To generate a prediction rule score that would be practical in clinical settings without using a calculator, we examined the beta-coefficients in each model, multiplied them by a common factor, and rounded to the nearest integer.[29] The integer then became the point(s) assigned to each participant with that predictor. In order to keep the prediction rule simple, the factor by which we multiplied the beta-coefficients was selected so that all points generated were "1" or "2". For each individual, the points were summed, the sum indicating the level of risk for functional decline. Performance of the risk-stratification system was quantified and compared using receiver operating characteristic (ROC) analysis.[56] The area under the ROC curve was estimated from the Somers' D statistic using the formula: Somers' D + 1 = 2(ROC). To estimate the maximum proportion of functional decline that could be attributed to modifiable predictors, and to determine how much predictive power was lost dichotomizing the continuous predictors,

Table 1. Two Factors Identified for Self-Reported Inability to Perform Activities of Daily Living*

Factor One: Vigorous Activities		Factor Two: Basic Activities	
Activity	$(r)^{\dagger}$	Activity	$(r)^{\dagger}$
Doing other chores around the house (like vacuuming, sweeping, dusting or straightening up)	.75	Getting in or out of bed	.91
Doing heavy housework (like scrubbing floors or washing windows)	.70	Turning faucets on and off	.77
Doing your own shopping for groceries or clothes	.69	Getting in and out of a car	.75
Climbing up 10 steps without resting	.67	Dressing yourself including tying shoelaces, working zippers and buttons	.67
Walking 2 to 3 blocks on level ground	.64	Washing and drying your entire body	.65
		Bending down to pick up clothing from the floor	.56
		Preparing your own meals	.50
		Lifting a full cup or glass to your mouth	.42

*732 women in the derivation set (16.6%) decreased by one or more the number of Vigorous Activities able to complete without assistance; 204 women in the derivation set (4.6%) decreased by one or more the number of Basic Activities able to complete without assistance.

$^{\dagger}r$ = Item-factor correlation coefficients from maximum likelihood with promax rotation matrix.

rounding the beta-coefficients, and collapsing the point-system into risk-strata, we constructed models with the prediction tool variables in their original continuous state. We compared the ROC values of these models with those of the prediction tool itself.

Because decisions regarding sample inclusion criteria, model selection, and predictor variable cutpoints may have influenced our findings, we conducted the following sensitivity analyses: (1) to determine whether the stability of our models was dependent on baseline functional status, we re-derived each of our models adjusting for the number of vigorous or basic activities participants were unable to perform independently at baseline; (2) to evaluate the impact of excluding deceased women, we re-derived the model for functional decline in vigorous activities including as "functional decliners" 375 participants who died before visit 4 who were not missing key independent predictors; (3) to assess the impact of excluding women missing scores on the GDS and the social network scale (n = 1002), we constructed models including these women with scores re-coded with the median values "not depressed" and "not having low social functioning"; (4) we re-derived our prediction tools, with smoking categorized as a modifiable rather than a fixed characteristic; (5) to assess the influence of using a backward-selection strategy, we re-derived the decision rules using a forward-selection procedure; and (6) to evaluate the appropriateness of dichotomizing exercise level and social network score into the lowest quintile versus all others, we re-ran our models with separate indicator variables for each quintile. All statistical analyses were carried out using SAS 6.12.[57]

RESULTS

Baseline characteristics of the participants are shown in Table 2. The only statistically significant difference between the derivation and validation sets was that more women in the derivation set reported being unable to perform at least one vigorous activity without assistance (22.1% versus 19.6%, $P = .020$). At 4-year follow-up, 732 (16.6%) women in the derivation set had experienced functional decline in vigorous activities, and 204 (4.6%) had experienced functional decline in basic activities.

Development of each clinical prediction rule

For the four continuous candidate predictor variables without existing validated clinical cutpoints (grip strength, gait speed, social network score, and exercise level), the bivariable associations between these variables by quintile and functional decline showed a clear linear trend, with those in the lowest quintile being at greatest risk (data not shown). Therefore, we dichotomized these variables into the lowest quintile versus all others.

In multivariable analyses adjusted for the fixed covariables, women with slow gait, short-acting benzodiazepine use, depression, low exercise level or BMI ≥ 29 were more likely to experience functional decline in both vigorous and basic activities (Tables 3 and 4). Along with these five common risk factors, weak grip predicted functional decline in vigorous activities, and long-acting benzodiazepine use and poor visual acuity predicted functional decline in basic activities. Low social network score did not predict either type of functional decline. In the model predicting functional decline in vigorous activities, osteopenia-level BMD was significant at the level of $P = .090$, whereas osteoporosis-level BMD was not significantly associated with functional decline; thus, BMD was not included in the prediction tool. Though not candidates for the prediction tool, the fixed characteristics age, cognitive function, and medical comorbidity were significant predictors of both types of functional decline (Appendices Ia and b).

Table 2. Baseline* Characteristics of the Participants (n = 6632)

Characteristic	
Mean age, years ± SD	73 ± 4.9
Education	
<12 years, n (%)	2598 (39.2)
12 years, n (%)	2674 (40.3)
>12 years, n (%)	1360 (20.5)
Coronary Artery Disease, n (%)	801 (12.1)
Arthritis, n (%)	4091 (61.7)
Previous Stroke, n (%)	235 (3.5)
Congestive Heart Failure, n (%)	133 (2.0)
Smoking Status	
Never, n (%)	4068 (61.3)
Past, n (%)	1965 (29.6)
Current, n (%)	599 (9.0)
Unable to perform 1 or more Vigorous Activities at baseline, n (%)	1411 (21.3)
Unable to perform 1 or more Basic Activities at baseline, n (%)	229 (3.5)
Mean BMI, ± SD†	26.3 ± 4.6
Depressed*, n (%)†‡	365 (5.5)
Using short-acting benzodiazepines, n (%)†	437 (6.6)
Using long-acting benzodiazepines, n (%)†	415 (6.3)
Binocular visual acuity worse than 20/40, n (%)†	443 (6.7)

*All modifiable baseline characteristics except visual acuity and physical activity level (not shown) taken at visit 2 (1988–1990).
†Classified as a modifiable predictor and, therefore, a candidate for the prediction tool. ‡Scoring 6 or greater on 15-item Geriatric Depression Scale (49).

As illustrated in Tables 3 and 4, the prediction tool was derived from the beta-coefficients of the eight independent risk factors: to create a simple integer-based scoring system, beta-coefficients from the model for vigorous activities were multiplied by 4 and rounded to the nearest integer, and the beta-coefficients from the model for basic activities were multiplied by 2 and rounded to the nearest integer. The resulting prediction tool stratified women into groups for each type of functional decline, with probabilities of 12% (0–1 points), 25% (2–3 points), and 39% (≥4 points) of functional decline in vigorous activities and 2% (0–1 points) and 10% (≥2 points) of functional decline in basic activities (Table 5, Figure 1). When the women in the validation set were categorized using the same point system, the probabilities of functional decline in vigorous activities were 14%, 27%, and 39%, and in basic activities they were 2% and 7%.

In models containing the significant predictors in their original continuous state, Somers' D was 0.34 for vigorous activities and 0.52 for basic activities. The areas under the ROC curves were (estimate ± SE) 0.67 ± 0.01 for vigorous activities and 0.76 ± 0.02 for basic activities. In comparison, using the prediction rule cutpoints, the areas under the ROC curves were 0.62 ± 0.01 and 69 ± .02, respectively, indicating that approximately 6% of the predictive power was lost in the conversion to a clinically feasible prediction tool.

Table 3. Significant Multivariable Predictors of Functional Decline in Vigorous Activities*

Risk Factor	β	OR	95% CI	Points†
y intercept	−3.53			
Slow gait (lowest quintile)	.57	1.76	1.44–2.16	2
Short-acting benzodiazepine use	.48	1.62	1.21–2.18	2
Depression (6 or greater on 15-item GDS)	.41	1.51	1.09–2.08	2
Low exercise level (lowest quintile)	.31	1.36	1.12–1.67	1
BMI ≥29	.26	1.30	1.07–1.58	1
Weak grip strength (lowest quintile)	.19	1.21	.99–1.49	1

*Model adjusted for age, level of education, medical comorbidity, cognitive function, presence of spine fracture, smoking status, and enrollment site. OR = odds ratio; CI = confidence interval.
† Calculated by multiplying β-coefficient by 4 and rounding to nearest integer. The point scheme for predicting functional decline is derived from summing the points from the six significant factors.

Table 4. Significant Multivariable Predictors of Functional Decline in Basic Activities*

Risk Factor	β	OR	95% CI	Points†
y intercept	−1.66			
Slow gait (lowest quintile)	.83	2.29	1.66–3.17	2
Depression (6 or greater on 15-item GDS)	.62	1.87	1.17–2.98	1
Long-acting benzodiazepine use	.59	1.80	1.10–2.95	1
Visual acuity worse than 20/40	.51	1.66	1.09–2.55	1
Short-acting benzodiazepine use	.50	1.66	1.02–2.68	1
Low exercise level (lowest quintile)	.39	1.47	1.06–2.05	1
BMI ≥29	.32	1.37	0.98–1.93	1

*Model adjusted for age, education, medical comorbidity, cognitive function, presence of spine fracture, smoking status, and enrollment site. OR = odds ratio; CI = confidence interval.
† Calculated by multiplying β-coefficient by 2 and rounding to nearest integer. The point scheme for predicting functional decline is derived from summing the points from the seven significant factors.

Table 5. Performance of the Prediction Rule for Functional Decline

		Derivation Set		Validation Set	
Risk Group	Points	n/N (95% CI*)	Relative Risk	n/N (95% CI*)	Relative Risk
Vigorous Activities					
Low	0–1	391/3172 (11.2–14.7)†	1.0	220/1614 (12.0–15.3)†	1.0
Moderate	2–3	249/1012 (22.0–27.3)†	2.0	126/474 (22.6–30.6)†	2.0
High	=4	92/238 (32.5–44.9)†	3.1	48/122 (30.7–48.0)†	2.9
Basic Activities					
Low	0–1	74/3151 (1.8–2.9)†	1.0	38/1602 (1.6–3.1)†	1.0
High	=2	130/1271 (8.6–11.9)†	4.4	42/608 (4.5–8.9)†	2.9

*95% confidence intervals of percentage of participants in risk group experiencing functional decline.
†Chi-square trend, $P < .001$.

Sensitivity analyses demonstrated: (1) when we re-derived the models adjusting for the number of vigorous or basic activities participants were unable to perform independently at baseline, all significant modifiable factors remained in the model, and the point system remained unchanged; (2) when dead women were included as "decliners," beta-coefficients and tests of significance remained the same for all significant predictors except BMI ≥ 29, which was no longer a significant risk factor for functional decline in vigorous activities; (3) when 1002 women missing GDS or social network scores were assigned mean values for the cohort overall, the same factors remained in the prediction rule; (4) and (5) neither re-categorizing smoking as a modifiable characteristic nor using a forward-stepwise selection procedure to construct the multivariable models changed the significant predictors or their magnitude; (6) models constructed with indicator variables for each quintile of exercise level and social network score showed a clear dose-response relationship for exercise level and functional decline, but social network was not a significant predictor of either type of

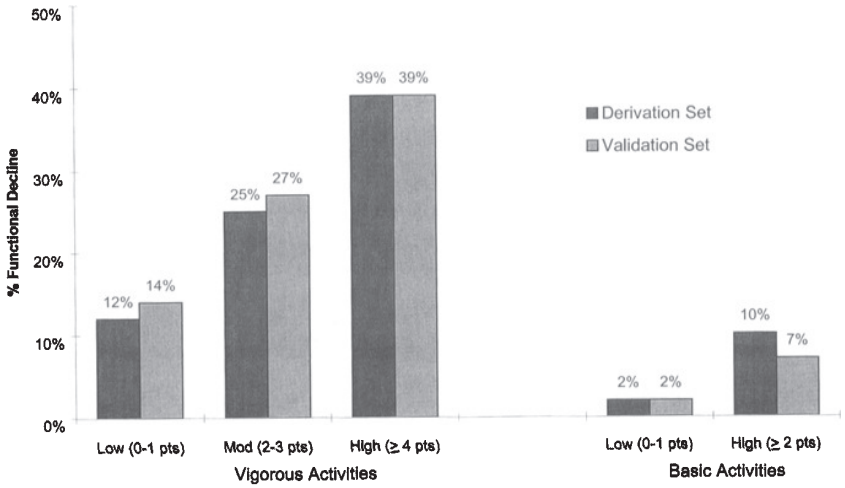

Figure 1. Performance of the prediction tool for functional decline in vigorous and basic activities.

functional decline (data for sensitivity analyses not shown). These sensitivity analyses suggest that decisions regarding inclusion criteria, modeling strategy, and cutpoints for predictor variables did not strongly influence the content of the decision tool.

DISCUSSION

This simple tool, based on eight modifiable predictors, successfully classifies community-residing older women into risk categories for two types of functional decline. We estimated that as much as 34% of the variation of functional decline in vigorous activities and 52% of the variation of functional decline in basic activities can be attributed to these modifiable risk factors; this is encouraging news that carries important clinical, policy, and research implications.

This tool, based only on modifiable risk factors (Appendix II), can be used by clinicians both to identify older women at increased risk for functional decline and to simultaneously suggest ways in which they might be able to modify their risk. For example, a sedentary older woman with a BMI of 29 who uses short-acting benzodiazepines but who has no other modifiable risk factors would generate a score of 4 points by the decision tool for functional decline in vigorous activities and 3 points by the tool for basic activities, conferring a 39% risk of functional decline in vigorous activities (such as walking and stair-climbing) and a 10% risk of functional decline in basic activities (such as getting in and out of a car and dressing oneself) over the next 4 years. The clinician could use this tool to offer ways in which the woman might decrease her risk, i.e., to begin an exercise program and to stop using benzodiazepines. By facilitating patients' understanding of the role of modifiable predictors in the likelihood of functional decline, this tool could allow patients to participate more fully in the decisions that affect their health.

Like previous investigators,[58] we found poor performance on the rapid-gait test to be a powerful predictor of functional decline. The critical question this raises is whether interventions to increase gait speed would lower the probability of functional decline or whether gait speed is a marker for unmeasured comorbidity or other immutable characteristics. Though some randomized trials of strength and/or endurance training in community-residing older adults have succeeded in improving short-term gait speed,[59–60] none to date have demonstrated that modifying this predictor prevents functional decline over time.

Our finding that the 13 functional status items clustered into vigorous and basic activities is consistent with previous findings identifying similar subsets of functional status items.[62,63] These two decision tools are quite similar, suggesting that the five modifiable characteristics included in both — slow gait, short-acting benzodiazepine use, depression, low exercise level, and BMI ≥ 29 — are associated with functional decline in general, a finding that is consistent with the results from several longitudinal studies.[11–28]

Our study differed from these previous studies, however, in that we found that women with weak grip were at increased risk of decline in vigorous, but not basic, activities and that women taking long-acting benzodiazepines or with poor visual acuity were at increased risk of decline in basic, but not vigorous, activities. This extends the work of Fried et al.,[64] who found that risk factors were associated differentially with deficits in subgroups of functional status items. Although preventing both types of functional decline is important, from a research and policy standpoint, this suggests that the disablement processes[65] leading to each type of functional decline differ.

That very obese but not moderately obese women are at increased risk of functional decline is an important finding consistent with recent evidence regarding the level of obesity that puts one at increased risk for mortality.[38] Given the difficulty people have losing weight, it is encouraging that only the most overweight women appear to be at increased risk of functional decline. We did not observe the U-shaped relationship between weight and functional decline that has been observed between weight and mortality[37]; this may be due to the paucity of women with low BMI in our cohort and our decision to group those underweight with those with normal weights.

Several limitations should be considered when interpreting the findings of this study. The major limitation is the lack of ethnic and gender diversity among the participants; whether our findings are generalizable to different populations is unknown. The number of women experiencing functional decline over 4 years in our cohort was smaller than that seen in other population-based studies: 17% compared with 36% in the Established Populations for Epidemiologic Stud-

ies of the Elderly.[21] This may be explained, in large part, by our exclusion of women with missing data; those excluded were more likely both to have had the risk factors in the prediction tool and to have experienced functional decline. Thus, it is likely that the relationship between the modifiable predictors and functional decline is stronger than we report.

It is important to acknowledge that by excluding women who died, some of whom may have experienced functional decline before death, we have identified a relationship between the predictor variables and functional decline of survivors only. Because women who died were more likely to have each of the predictors, it is likely that these exclusions also decreased the magnitude of effect for our significant predictors. Nevertheless, the sensitivity analyses we conducted with imputed variables for the deaths, GDS, and social network scores indicate our models are reasonably robust. It is also important to emphasize that the rigid classification of characteristics as "modifiable" or "fixed" is a simplification of the real-world setting of clinical medicine in which some characteristics classified as fixed will be modifiable in some patients, and other characteristics classified as modifiable may actually be very difficult to change. This tool is not intended to serve as a rigid guideline but rather as a tool to be used in combination with clinical judgement and patient preferences to facilitate discussion between clinicians and patients who are interested in decreasing their risk of functional decline by changing modifiable risk factors.

Because we define functional decline as a binary outcome, this prediction tool is unable to discriminate between women who will decrease by one from those who will decrease by several functional activities. Likewise, in our decision to gain clinical practicality by dichotomizing the continuous predictors, we sacrificed some of the predictive power of the tool. For example, the results of our sensitivity analysis illustrate that women in the second- and third-lowest quintile of exercise level were also at increased risk for functional decline, but the tool does not assign them extra points for this increased level of risk. It is also possible that measurement error may have caused some of the nonsignificant predictors, social network in particular, to be left out of the models. Because of these limitations, this prediction tool should be validated in other populations before general use or before using it to identify persons eligible for a clinical trial designed to decrease functional decline based on modifying these characteristics. It is reassuring, however, that despite categorizing the variables, rounding the beta-coefficients and using a point-stratification system, we lost only 6% of the areas under the ROC curves.

In conclusion, this study encouragingly shows that eight modifiable risk factors could account for a substantial proportion of short-term functional decline in this sample of older women and that a clinical prediction tool based upon these easily identifiable predictors stratifies older women by risk of functional decline. These findings inspire hope that interventions to modify many of these predictors may succeed in decreasing functional decline.

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Appendix Ia: Beta Coefficients and Odds Ratios of Fixed Covariables in Model for Functional Decline in Vigorous Activities*

Risk Factor	β	OR	95% CI
Age (by decade)	.62	1.86	1.61–2.14
Education (less than high school grad)	−.26	.77	.62–.96
Cognitive function†	.48	1.62	1.14–2.32
Medical comorbidity‡	.44	1.56	1.28–1.89
Smoking status (current)	.15	1.16	.87–1.54
Presence of spine fracture	.13	1.14	.93–1.41

*Fixed covariables used as adjusters only, and not candidates for prediction tool. OR = odds ratio; CI = confidence interval.

†Scoring 21 or lower on 26 item modified Folstein Mini-Mental Examination (3.8% of cohort).

‡ Scoring 3 or higher on medical comorbidity adjuster (see text) derived from logistic regression of 8 medical conditions as correlates of functional impairments (19.5% of cohort).

Appendix Ib: Beta Coefficients and Odds Ratios of Fixed Covariables in Model for Functional Decline in Basic Activities*

Risk Factor	β	OR	95% CI
Age (by decade)	.77	2.17	1.70–2.76
Education (less than high school grad)	−.02	.98	.69–1.40
Cognitive function†	.24	1.28	.72–2.25
Medical comorbidity‡	.55	1.73	1.25–2.38
Smoking status (current)	.11	1.12	.67–1.86
Presence of spine fracture	.44	1.55	1.13–2.16

*Fixed covariables used as adjusters only, and not candidates for prediction tool. OR = odds ratio; CI = confidence interval.

†Scoring 21 or lower on 26 item modified Folstein Mini-Mental Examination (3.8% of cohort).

‡Scoring 3 or higher on medical comorbidity adjuster (see text) derived from logistic regression of 8 medical conditions as correlates of functional impairments (19.5% of cohort).

Appendix II: Prediction Tool for Functional Decline

Modifiable Risk Factor	Points: Vigorous Activities	Points: Basic Activities
Slow Gait (≤1 m/sec on 6 m course)	2	2
Short-acting Benzodiazepines	2	1
Depression (GDS ≥6)	2	1
Low Exercise Level (<448 kcal/wk)	1	1
Obesity (BMI ≥29)	1	1
Weak Grip (<15 kg average)	1	
Long-acting Benzodiazepines		1
Visual acuity worse than 20/40		1

Vigorous Activities	Basic Activities
0–1 points: Low Risk (12%)	0–1 points: Low Risk (2%)
2–3 points: Moderate Risk (25%)	≥2 points: High Risk (10%)
≥4 points: High Risk (39%)	