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RISK FACTORS FOR DISABILITY SUBTYPES AMONG OLDER PERSONS

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Abstract

Objective—To identify risk factors for five different subtypes of disability.

Design, Setting and Participants—Prospective cohort study of 754 community-living residents of greater New Haven, Connecticut, who were 70 years or older and initially nondisabled in four essential activities of daily living (bathing, dressing, walking, and transferring).

Measurements—Candidate risk factors were measured every 18 months for 90 months during comprehensive home-based assessments. Disability was assessed during monthly telephone interviews for up to 108 months. Among participants who were nondisabled at the start of an 18-month interval, incident episodes of five different disability subtypes were determined during the subsequent 18 months: transient, short-term, long-term, recurrent, and unstable.

Results—The cumulative incidence rates (95% confidence intervals) per 100 person-intervals were 9.8 (8.9–10.6) for transient disability, 3.8 (3.3–4.3) for short-term disability, 7.1 (6.4–7.8) for long-term disability, 4.7 (4.1–5.3) for recurrent disability, and 4.4 (3.9–5.0) for unstable disability. In a multivariate analysis, the Short Physical Performance Battery (SPPB) was associated with each of the five disability subtypes, with adjusted hazard ratios ranging from 1.10 for transient disability to 1.35 for long-term disability. The only other factors associated with short-term, long-term, and recurrent disability were stroke, visual impairment, and poor grip strength, respectively. Transient disability and unstable disability shared the same set of risk factors—depressive symptoms, stroke, and poor grip strength—in addition to the SPPB.

Conclusions—Our results provide mixed evidence to support the distinct nature of the five disability subtypes.

Keywords

aged; cohort studies; risk factors; disability evaluation; activities of daily living

INTRODUCTION

Disability among older persons is viewed increasingly as a complex and highly dynamic process (1). Reflecting the heterogeneity of disability, we have recently characterized and estimated incidence rates for five different disability subtypes: transient, short-term, long-term, recurrent, and unstable (2). As described in the Methods, these subtypes are distinguished on the basis of the number and duration of disability episodes over a discrete period of time. While we found no gender differences in the incidence rates for any of the disability subtypes,

differences in rates were observed for each subtype according to age and slow gait speed, with only one exception; and these differences were especially large for long-term disability (2).

Whether the five disability subtypes are truly distinct is uncertain. One strategy to address this question is to determine whether the risk factors for the disability subtypes differ. While numerous studies have evaluated risk factors for functional decline and disability (3), none has sought to determine whether a different set of risk factors is associated with the different disability subtypes. Identifying a distinct set of risk factors would suggest that the mechanisms underlying the disability subtypes might differ and, in turn, that different interventions might be needed to forestall the development of the different disability subtypes. In the current study, we set out to identify risk factors for the five subtypes of disability, with the goal of providing evidence to support the distinct nature of the disability subtypes.

METHODS

Study Population

Participants were members of the Precipitating Events Project, an ongoing longitudinal study of 754 community-living persons, aged 70 years or older, who were initially nondisabled in four essential activities of daily living—bathing, dressing, walking, and transferring (4). The assembly of the cohort, which took place between March 1998 and October 1999, has been described in detail elsewhere (4).

Data Collection

Data on candidate risk factors were collected during comprehensive, home-based assessments, which were completed at baseline and every 18 months for 90 months. Disability was assessed during monthly telephone interviews for up to 108 months. Three hundred forty four (45.6%) participants died after a median follow-up of 57 months, while 34 (4.5%) dropped out of the study after a median follow-up of 23 months. Data were otherwise available for 99.2% of the 61,631 monthly interviews.

Candidate Risk Factors—We considered potential risk factors from five domains that have been linked to disability in prior studies (Table 1) (3). The demographic factors included age, sex, race, education, and marital status. The cognitive–psychosocial factors included cognitive status (5), depressive symptoms (6), functional self-efficacy (7), and social support (8).

The health-related factors included nine self-reported, physician-diagnosed chronic conditions (hypertension, myocardial infarction, congestive heart failure, stroke, diabetes mellitus, arthritis, hip fracture, chronic lung disease, and cancer), corrected near vision (9), hearing impairment (10), and self-report of a 10-pound weight loss in the past year (11). The habitual factors included smoking status, physical activity (12), and body-mass index.

The physical capacity factors included slow gait speed (13), gait and balance (14), single chair rise (13), three timed chair stands (13), manual dexterity (14), gross motor coordination (14), nondominant upper body (shoulder flexion) and lower body (hip abduction) strength (11), peak expiratory flow (15), and a modified version of the Short Physical Performance Battery (SPPB) (16) that included the standard balance maneuvers but substituted three timed chair stands (instead of five) and timed rapid gait instead of timed usual gait. Quartile cut-points for these latter two tasks were determined from the first 356 enrolled participants, who had been selected randomly from our source population (4). As per convention (16), a composite SPPB score, ranging from 0 (lowest) to 12 (highest), was calculated by adding the scores (0 to 4) for the three component tasks. Prior work has shown that a 1-point change on the SPPB is clinically substantial (17). The amount of missing data for the candidate risk factors was less than 1% in

the baseline assessment and less than 5% in all subsequent assessments. To account for the small amount of missing data, we used multiple imputation with 50 random draws per missing observation. Additional operational details regarding the candidate risk factors are provided in Table 1.

Assessment of disability—Complete details regarding the assessment of disability are provided elsewhere (18). During the monthly telephone interviews and each of the comprehensive assessments, participants were evaluated for disability using standard questions that were identical to those used during the screening telephone interview (18). For each of the four essential activities of daily living, we asked, “At the present time, do you need help from another person to (complete the task)?” Participants who needed help with any of the tasks were considered to be disabled. The reliability of our disability assessment was substantial ($\kappa=0.75$) for reassessments completed within 48 hours and excellent ($\kappa=1.0$) for reassessments performed the same day (18). To address the small amount of missing monthly data on disability, we used multiple imputation with 100 random draws per missing observation, as previously reported (2).

Disability Subtypes—As described in detail elsewhere (2), we defined five mutually exclusive disability subtypes on the basis of the number and duration of disability episodes whose onset occurred within an 18-month interval, i.e. the time between our comprehensive assessments. Transient and short-term disability were defined as a single episode lasting only one month and two to five months, respectively; long-term disability was defined as one or more episodes, with at least one lasting six or more months; and recurrent and unstable disability were defined as two episodes and three or more episodes, respectively, with none lasting six or more months.

For an 18-month interval to be included, participants had to be nondisabled at the start of the interval, as determined during the corresponding comprehensive assessment. This was necessary to identify incident cases, thereby ensuring temporal precedence for evaluating candidate risk factors. We excluded intervals for which there was no comprehensive assessment and those that were shorter than 12 months in duration, i.e. due to death, lost to follow-up, or end of the follow-up period. Of the 3,590 possible intervals, 811 (22.6%) were excluded for the following reasons: disability was present during the comprehensive assessment ($n=642$), duration of interval was shorter than 12 months ($n=147$), and the comprehensive assessment was not completed ($n=22$).

Statistical Analysis

The analytic sample included 722 (95.8%) of the 754 cohort members; the other 32 members were excluded because they contributed no intervals to the analysis, largely because of death within the first 12 months of follow-up (2). We determined the cumulative incidence rates per 100 person-intervals for each of the disability subtypes. For each incidence rate, we calculated 95% confidence intervals by bootstrapping samples with replacement. One thousand samples were created, and the 2.5th and 97.5th percentiles were used to form the confidence intervals.

Because the times to occurrence of the different disability subtypes are likely correlated, we used a marginal multivariate Cox model (19) to evaluate the associations between the candidate risk factors and the times to occurrence of the five subtypes across all of the “at risk” intervals. This analytical strategy adjusts the standard error of the estimated associations for the correlation of subtypes within individual participants and assigns a distinct baseline hazard function for each subtype (20). Because the risk factors, other than sex, race, and education, could change over time, the bivariate and multivariate models used time-dependent variables. To create a parsimonious model, we selected candidate risk factors according to a hierarchical

screening process (21). We first evaluated the bivariate associations between each factor and the five disability subtypes, using the likelihood ratio chi-square statistic. Factors were retained if they were associated with at least one subtype at $P \leq .20$ (22). Next, we sequentially evaluated the non-parametric Spearman's rank-order correlations (23) among the remaining factors, first within each of the previously described domains and then overall. When the correlation coefficient was greater than 0.35, denoting potential collinearity, we chose a single factor based on clinical judgment and the strength of association with the multivariate outcome as determined by the -2 Log Likelihood statistic ($-2LL$). Factors were retained in the final multivariate model if their addition improved the model fit as determined by a decrease in the $-2LL$ at $P < .01$.

All analyses were performed using SAS version 9.1.3 (SAS Institute, Cary, NC).

RESULTS

Information on the candidate risk factors at baseline is provided in Table 1. About one out of eight participants were 85 years or older; the mean age was 78.4 ± 5.2 years. The majority of participants were women and white, about half were not currently married, and a third did not complete high school. The prevalence of the chronic conditions ranged from 4.6% for hip fracture to 54.6% for hypertension.

The cumulative incidence rates (95% confidence intervals) per 100 person-intervals were 9.8 (8.9–10.6) for transient disability, 3.8 (3.3–4.3) for short-term disability, 7.1 (6.4–7.8) for long-term disability, 4.7 (4.1–5.3) for recurrent disability, and 4.4 (3.9–5.0) for unstable disability.

Detailed results for the bivariate analyses, including all 35 candidate risk factors categorized by domain, are provided in Appendix Figure 1 (available at <http://www3.interscience.wiley.com/journal/117995531/home>). Two factors from the health-related domain—chronic lung disease and hip fracture—were not associated with any of the five disability subtypes at $P < .20$ and, hence, were not considered further. To reduce potential collinearity with the SPPB, which was the factor most strongly associated with the disability subtypes in the bivariate analysis, eleven other factors were also omitted, including functional self-efficacy (cognitive–psychosocial domain); low physical activity (habitual domain); and slow gait speed, gait and balance, inability to rise from chair, timed chair stands, manual dexterity, gross motor coordination, lower and upper body strength, and peak expiratory flow (from the physical capacity domain). The remaining 22 candidate risk factors were included in the multivariate analysis.

As shown in Table 2, the final multivariate model included five factors representing three domains: depressive symptoms (cognitive–psychosocial domain), stroke and visual impairment (health-related domain), and SPPB and poor grip strength (physical capacity domain). The SPPB was associated with each of the five disability subtypes, with adjusted hazard ratios ranging from 1.10 for transient disability to 1.35 for long-term disability. In contrast, visual impairment was associated only with long-term disability, with an adjusted hazard ratio of 1.49. No other factor was associated with long-term disability, although the adjusted hazard ratio for poor grip strength was marginally significant ($P = .063$). Stroke was the only other factor associated with short-term disability, with an adjusted hazard ratio of 2.49, while poor grip strength was the only other factor associated with recurrent disability, with an adjusted hazard ratio of 1.80. Transient disability and unstable disability shared the same set of risk factors—depressive symptoms, stroke, and poor grip strength—in addition to the SPPB.

DISCUSSION

In this prospective study of community-living older persons, we set out to identify the risk factors for five mutually exclusive subtypes of disability. We found that the SPPB was independently associated with each of the five disability subtypes, that the only other factors independently associated with short-term, long-term, and recurrent disability were stroke, visual impairment, and poor grip strength, respectively, and that transient disability and unstable disability shared the same set of risk factors—depressive symptoms, stroke, and poor grip strength—in addition to the SPPB. These results provide mixed evidence to support the distinct nature of the five disability subtypes.

The premise underlying this research is that the risk factors should differ if the disability subtypes are truly distinct. According to this premise, transient and long-term disability appear to be the two most distinct subtypes, sharing only a single risk factor, while transient and unstable disability appear to be the most comparable, sharing the same set of risk factors. For two of these risk factors—depressive symptoms and stroke—the magnitude of association, as denoted by the adjusted hazard ratios, was remarkably similar. These similarities are surprising since transient disability, which is characterized by only a single month of disability, and unstable disability, which is characterized by three or more episodes of disability with each lasting up to five months, appear to be clinically distinct. Operationally, transient disability is most similar to short-term disability, which is also characterized by only a single episode of disability (lasting two to five months); while unstable disability is most similar to recurrent disability, which is characterized by two or more episodes of disability with each lasting up to five months. Despite these operational similarities, depressive symptoms was not a risk factor for either short-term or recurrent disability, and stroke was not a risk factor for recurrent disability.

The most robust risk factor was the SPPB, which was independently associated with each of the five disability subtypes. The hazard ratios varied widely, however, from 1.10 for transient disability to 1.35 for long-term disability. This difference in risk elevation was statistically significant and is likely to be clinically meaningful, particularly for changes in SPPB scores of more than 1 point. As an objective measure of lower extremity performance, the SPPB has been shown previously to be highly predictive of new disability in both mobility and activities of daily living among community-living older persons (16). The risk of disability for each of the subtypes was also consistently elevated among participants with poor grip strength, although these elevations in risk did not achieve statistical significance for short-term or long-term disability. As one of the key elements of the frailty phenotype (24), poor grip strength is considered to be a global indicator of muscle weakness. Prior studies have shown strong associations between poor grip strength and an array of adverse outcomes, including disability and mortality (25).

Each of the three other risk factors identified in the current study—visual impairment, stroke, and depressive symptoms—has been strongly linked to disability and functional decline in prior studies (3). No other study, however, has attempted to distinguish between different disability subtypes. While there were some similarities, we found that these three risk factors mapped to a different set of disability subtypes, with visual impairment independently associated with long-term disability, stroke with transient, short-term and unstable disability, and depressive symptoms with transient and unstable disability. The reasons for these differences are not entirely clear, but should be the focus of future research. For example, visual impairment may impede recovery after the initial onset of disability, thereby allowing disability to become long-term. Older persons with depressive symptoms may be susceptible to reporting brief, intermittent episodes of disability, perhaps explaining the elevated risk for transient and unstable disability, albeit not the absence of association with recurrent disability. Finally, newly

disabled older persons with a prior history of stroke may be more likely to be referred for, and to accept, rehabilitative services, thereby reducing the likelihood that disability will become long-term.

Our results must be interpreted carefully in light of several potential limitations. Despite the large sample size and longitudinal design with an extended period of follow-up, our power to detect clinically meaningful elevations in risk was somewhat limited, as evidenced by several of the relatively wide confidence intervals shown in Table 2. For example, although not statistically significant, the adjusted hazard ratio for the association between depressive symptoms and long-term disability was 1.45, with an upper bound in the confidence interval of 2.40. Our analytic strategy included a single multivariate model for the five disability subtypes. Because the model-fitting approach is based on optimizing the model's ability to explain variability in the data across all five outcomes simultaneously, the likelihood of identifying a factor that was strongly associated with only a single disability subtype may have been diminished. A review of the bivariate results (shown in Appendix Figure 1), however, indicates that none of the potential risk factors was strongly associated with only one of the disability subtypes. Although our list of candidate risk factors was comprehensive, it was not exhaustive. For example, only a single global measure of cognition was available, data were collected about the presence, but not the severity of the nine chronic conditions, and the receipt of interventions, such as physical therapy, was not ascertained. Furthermore, although we updated information on the risk factors every 18 months, it is possible that some of the risk factors changed over shorter periods of time, leading to some misclassification of risk. While focusing on 18-month intervals might be considered a limitation, we have previously shown that the distribution of the disability subtypes was not sensitive to modest changes (i.e. three months) in the duration of the time interval (2). The interval approach allowed us to establish temporal precedence between the candidate risk factors and the disability outcomes, while making full use of our longitudinal data, which were collected over the course of nine years. Whether alternative analytic strategies, such as longitudinal latent class analysis, would identify a different set of disability subtypes is uncertain, but should be the focus of future research.

Despite these limitations, the current study provides important new information about the epidemiology of disability in older persons. In an earlier editorial (1), Guralnik and Ferrucci suggested that the risk factors for transient disability might differ from those of permanent (i.e. long-term) disability, a finding that was largely confirmed in the current study, and that additional research was needed to better delineate the nosology of disability. To accomplish this goal, we plan to evaluate the subsequent course and prognosis of the different disability subtypes and to elicit the perspectives of older persons on their disability experiences in subsequent epidemiologic and qualitative studies. Based on the results of an earlier study (4), we also plan to evaluate the role of intervening events, including illnesses and injuries leading to either hospitalization or restricted activity, on the development of the disability subtypes.

From a clinical perspective, the findings from the current study demonstrate that the SPPB and grip strength are robust risk factors for disability, regardless of subtype, and suggest that these two well established, performance-based measures should be used to identify older persons at risk for disability, so that preventive interventions can be suitably targeted (26,27). Given their elevated risk for several disability subtypes, preventive efforts might also be considered for older persons who have high depressive symptoms or history of a prior stroke. Finally, in the setting of disability, attention to visual impairment might be warranted to prevent the progression to long-term disability.

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Author Contributions: Dr. Gill had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Gill, Barry, Allore.

Acquisition of data: Gill.

Analysis and interpretation of data: Gill, Murphy, Allore.

Drafting of the manuscript: Gill, Murphy, Allore.

Critical revision of the manuscript for important intellectual content: Gill, Murphy, Barry, Allore.

Statistical analysis: Murphy, Allore.

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Demographic

Cognitive-Psychosocial

Health-related

Habitual **Physical Capacity**

Appendix Figure 1.

Unadjusted Hazard Ratios and 95% Confidence Intervals for the Disability Subtypes. The candidate risk factors are categorized by domain. To facilitate comparisons with the other factors, scores for the Short Physical Performance Battery (SPPB) were reversed so that 12 was the worst possible score.

Table 1

Baseline Characteristics of Candidate Risk Factors among 722 Community-living Nondisabled Older Persons

Characteristic	Operational Details	N (%) or Mean $\pm$ SD
Demographic		
Age $\geq$ 85 y		93 (12.9)
Women		471 (65.2)
Non-Hispanic white		653 (90.4)
Not currently married		379 (52.5)
Did not complete high school		236 (32.7)
Cognitive–Psychosocial		
Cognitive impairment	score on Folstein MMSE $<$ 24	79 (10.9)
Depressive symptoms	score on CES-D $\geq$ 20 (28)	51 (7.1)
Functional self-efficacy	0 (low) to 40 (high)	9.6 $\pm$ 7.6
Social support	MOS: 0 (low) to 28 (high)	22.3 $\pm$ 5.5
Health-related		
Hypertension		394 (54.6)
Arthritis		222 (30.8)
Diabetes mellitus		127 (17.6)
Myocardial infarction		129 (17.9)
Chronic lung disease		123 (17.0)
Cancer		119 (16.5)
Stroke		60 (8.3)
Congestive heart failure		46 (6.4)
Hip fracture		33 (4.6)
Visual impairment	percentage, assessed with a Jaeger card	
None or mild	$<$ 6%	495 (68.7)
Moderate	6% to 26%	104 (14.4)
Severe	$>$ 26%	122 (16.9)
Hearing impairment	tones missed out of 4 *	
None or mild	0 to 1	308 (42.7)
Moderate	2 to 3	260 (36.1)
Severe	4	153 (21.2)
Weight loss	10 pounds in past year	163 (22.6)
Habitual		
Current smoker		59 (8.2)
Low physical activity	PASE score $<$ 64 for men and $<$ 52 for women ^f	219 (30.3)
Body mass index	self-reported height and weight ^g , kg/m ²	
Normal or underweight	$<$ 25	288 (39.9)
Overweight	25 to 29.9	272 (37.7)
Obese	$\geq$ 30	162 (22.4)
Physical capacity [§]		
Slow gait speed	$>$ 10 seconds on rapid gait test	322 (42.7)
Gait and balance	modified POMA: 0 (good) to 12 (poor)	2.0 $\pm$ 2.0
Inability to rise from chair	in single attempt with arms folded	139 (19.3)
Timed chair stands **, sec	up and down three times	
$<$ 7.6		145 (20.1)
7.6 – 9.0		123 (17.0)
9.1 – 11.9		203 (28.1)
$\geq$ 12.0		251 (34.8)
Short Physical Performance Battery (SPPB)	0 (low) to 12 (high)	6.8 $\pm$ 2.9
Manual dexterity **, sec	9-hole pegboard test	
$<$ 21.8		123 (17.0)
21.8 – 24.3		146 (20.2)
24.4 – 27.5		185 (25.6)
$\geq$ 27.6		268 (37.1)
Gross motor coordination **, sec	10 finger taps (14)	
$<$ 8.8		112 (15.5)
8.8 – 10.3		132 (18.3)
10.4 – 12.4		193 (26.7)
$\geq$ 12.5		285 (39.5)
Lower body strength ^{††}	Non-dominant hip abduction, kg	
$<$ 11.5		119 (16.5)
11.5 – 14.5	[16.1 – 18.0]	160 (22.2)
14.6 – 17.0	[18.1 – 20.4]	188 (26.0)
$\geq$ 17.1	$\geq$ 20.5]	255 (35.3)
Upper body strength ^{††}	Non-dominant shoulder flexion, kg	
$<$ 7.9		158 (21.9)
7.9 – 9.9	[12.6 – 14.2]	167 (23.1)
10.0 – 11.8	[14.3 – 16.4]	188 (26.0)
$\geq$ 11.9	$<$ 16.5]	209 (29.0)

Characteristic	Operational Details	N (%) or Mean $\pm$ SD
Poor grip strength ^{§§}	Hand-held dynamometer	388 (53.7)
Peak expiratory flow	< 10% standardized residual percentile (29)	161 (22.3)

* Based on 1000 and 2000 HZ measurements for the left and right ears, as assessed with a handheld audioscope.

[†] These gender-specific cut-points denote the worst quintile of scores among the first 356 enrolled participants, who had been selected randomly from our source population of health plan members, as previously described (11).

[‡] Body-mass index was categorized into three groups based on published cut-points, as previously described (30).

[§] Participants were asked to perform each of the timed tests as quickly (and safely) as possible.

^{||} Includes 5 gait items—step continuity and symmetry, path deviation, turning, and missed steps—and the three standard tasks of standing balance from the SPPB, as previously described (14). To facilitate comparisons with the other measures of physical capacity, scores were reversed so that 12 was the worst possible score.

^{**} Because standard cut-points have not been established for these timed tests, quartile scores were calculated based on the first 356 enrolled participants and subsequently applied to the entire cohort.

^{††} Because standard cut-points have not been established for these timed tests, gender-specific quartile scores were calculated based on the first 356 enrolled participants and subsequently applied to the entire cohort. The first set of values are for women, while the second set of values [within brackets] are for men.

^{§§} Value less than or equal to the gender- and body mass index-specific cut-points provided by Fried et al. (24). MMSE: Mini-Mental State Examination, CES-D: Center for Epidemiologic Studies Depression scale, MOS: Medical Outcomes Survey Social Support Scale, PASE: Physical Activity Scale for the Elderly; POMA: Performance-Oriented Mobility Assessment.

Factors Associated in Multivariate Analysis with Time to Onset of the Disability Subtypes among 722 Community-living Nondisabled Older Persons

Table 2

Factors*	Disability Subtype			
	Transient	Short-term	Long-term	Unstable
	Hazard Ratio (95 Percent Confidence Interval)			
Depressive symptoms	1.88 (1.35–2.62)	0.66 (0.28–1.54)	1.45 (0.87–2.40)	1.96 (1.10–3.48)
Stroke	1.99 (1.30–3.05)	2.49 (1.30–4.78)	0.90 (0.41–1.98)	2.17 (1.11–4.24)
Visual impairment	0.88 (0.70–1.11)	1.12 (0.81–1.55)	1.49 (1.16–1.92)	1.27 (0.92–1.74)
Short Physical Performance Battery (SPPB)	1.10 (1.04–1.17)	1.20 (1.10–1.31)	1.35 (1.24–1.47)	1.23 (1.09–1.38)
Poor grip strength	1.42 (1.03–1.95)	1.43 (0.88–2.31)	1.53 (0.98–2.38)	1.67 (1.01–2.74)

* Age, sex, race, marital status, education, hypertension, arthritis, diabetes mellitus, myocardial infarction, cancer, congestive heart failure, hearing impairment, weight loss, cognitive impairment, social support, smoking, and body mass index were evaluated in the multivariate analysis but did not meet criteria for inclusion in the final model. To facilitate comparisons with the other factors, scores for the SPPB were reversed so that 12 was the worst possible score.