Research Article

Rate of Cognitive Decline Before and After the Onset of Functional Limitations in Older Persons

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Abstract

Background: Loss in physical function is indicative of deterioration in physiological health that may also be associated with deterioration in neurological health. The objective of this study was to examine whether the onset of functional limitations and their severity is associated with increases in cognitive decline among older adults.

Methods: The study sample consists of 3825 (65% African Americans and 53% females) participants over the age of 65 with no functional limitations. Cognitive function was assessed using a standardized global cognitive score, and functional limitations using a summary measure of 8 Rosow-Breslau and Nagi limitations (ROS-B/Nagi). Cognitive decline before and after the onset of limitations were analyzed using a linear piecewise change point model.

Results: During follow-up, 2682 (70%) participants reported limitations in ROS-B/Nagi measure. The rate of cognitive decline was 0.053-units per year before any limitations, and increased to 0.069-units per year after one or more limitations in ROS-B/Nagi measure. This was about 30% (95% Confidence Interval [CI]: 18 – 42%) increase in the rate of cognitive decline comparing before and after the onset of limitations in ROS-B/Nagi measure. Also, higher number of limitations in ROS-B/Nagi measure at the time of onset was associated with faster cognitive decline.

Conclusions: The rate of cognitive decline was significantly higher following functional limitations. This study suggests that self-reported measures of functional limitations may serve as an important marker of cognitive decline.

Key Words: Neurodegeneration; Functional limitations; Cognitive decline; Cognitive function; Cohort studies

Introduction

Functional limitations and cognitive impairments are fairly common in old age and increase the risk of institutionalization, comorbidities, and mortality (1–4). As the U.S. population ages, the prevalence of functional limitations and cognitive impairments are increasing,

making it necessary to understand the dependency of functional and cognitive measures. Several cross-sectional studies have examined the association of cognitive status and self-reported functional abilities (5–11), primarily based on instrumental activities of daily living (IADL) and basic activities of daily living (ADL) that also capture aspects of cognition (12,13). Longitudinal studies have also

demonstrated that impairments in ADL and IADL are associated with future decline in cognitive functioning (14–17). Even though the interdependence of cognitive function and self-reported functional impairments using ADL and IADL limitations have been investigated, the association of self-reported functional limitations in balance and mobility, and cognitive decline, needs further investigation.

The loss of functionality captured by limitations in Rosow-Breslau and Nagi measures assess the balance and lower-body strength (18), and upper- and lower-body strength, balance and fine dexterity (19), respectively. Within the overall disablement framework, limitations in basic, individual upper- or lower-extremity functions tend to occur earlier in the disability process than limitations in more complex tasks or functions captured by IADL and ADL limitations (20). Given the sequence of development of functional limitations and progression towards more severe disability, the transition in functional limitations can provide a better understanding of the temporal course of cognitive decline. Here, we focus on one transition defined by the onset of any number of functional limitations in combined Rosow-Breslau and Nagi (ROS-B/Nagi) measure, and the total number of functional limitations reported at the time of onset of limitations in ROS-B/Nagi. By examining the rate of change in cognitive function before and after the onset of Rosow-Breslau and Nagi limitations we would be able to provide a better understanding of the cognitive decline process relative to the disablement process in older adults.

This study was performed using data from the Chicago Health and Aging Project (CHAP) (21). The study sample consisted of 3825 older subjects with no functional limitations at the initial assessment from a geographically defined neighborhood in Chicago. During a mean of 9.5 years of follow-up, cognitive function was assessed 2 to 5 times at 3-year intervals and their Rosow-Breslau and Nagi limitations were ascertained at the same time. The objective of this study was to characterize the rate of change in cognitive function before and after the onset of self-reported functional limitations in ROS-B/Nagi measure.

Methods

Participants

The Chicago Health and Aging Project (CHAP) was a, population-based, longitudinal study of Alzheimer's disease and other common health conditions among adults 65 years or older performed from 1993–2012. This study was performed in three adjacent neighborhoods on the south side of Chicago. The interviews were conducted in the participants' homes in approximately three-year cycles. Study participants who provided data for at least two cycles of follow-up data collection were included in this investigation. Of the 7656 study participants with two or more consecutive cognitive assessments, 3825 reported no limitations in ROS-B/Nagi measure at baseline, and formed the analytical sample for this investigation.

Cognitive function

Cognitive function was evaluated using a battery of four tests including two tests of episodic memory (immediate and delayed recall) derived from the East Boston Memory Story (22,23); a test of perceptual speed (the Symbol Digits Modalities Test) (24) and a test of general orientation and global cognition (the Mini-Mental State Examination) (25). The four tests loaded on a single factor that accounted for about 75% of the variance in a factor analysis (26). Thus, we constructed a composite measure of global cognitive

function based on all four tests. This measure combines variables with different ranges and floor-ceiling effects by averaging the four tests together after centering and scaling to the baseline mean and standard deviation. Thus, a participant whose performance matches the average participant at baseline has a composite cognitive score of 0, and a person who performs one SD better than average on every test has a composite cognitive score of +1.

Functional Limitations

This study included two self-report measures that represent complementary aspects of functional limitations. The first measure is based on the work by Rosow and Breslau (18), and focuses on tasks that require a certain degree of strength and basic mobility. The three Rosow-Breslau items include “Are you able to do heavy work around the house, like washing windows, walls, or floors without help?”, “Are you able to walk up and down stairs to the second floor without help?”, and “Are you able to walk half a mile without help?” Each positive report was coded as “1” and added across the items to form a summary score (range, 0–3). The second measure is based on the work by Nagi (19), and evaluates more basic upper- and lower-extremity functions. The Nagi measure of functional limitations is composed of the following questions, “How much difficulty, if any, do you have pulling or pushing large objects like a living room chair?”, “What about stooping, crouching, or kneeling?”, “Lifting or carrying weights over 10 pounds, like a very heavy bag of groceries?”, “Reaching or extending arms above shoulder level?”, and “Either writing or handling or fingering small objects?” Each of the 5 items is scored according to degree of difficulty, with reports of no or a little difficulty coded as 0, and reports of some or a lot of difficulty, or just unable to do, coded as 1. A summary score was created by adding responses to the individual items producing a score that ranged from 0 to 5. We created a combined Rosow-Breslau/Nagi measure based on 3-point Rosow-Breslau and 5-point Nagi measures (range: 0 – 8).

Other covariates

Covariates such as sex (males or females), race (blacks and whites), education (measured in number of years of schooling completed) (27,28), body mass index (kg/m^2) (29,30), the number of co-morbid conditions (heart condition, cancer, hip fracture, diabetes and stroke) (31–36), and depressive symptoms (Center for Epidemiologic Severity of Depression (CES-D)) (37) were selected since they have been shown to be associated with cognitive function and functional limitations.

Statistical Analysis

The descriptive measures were computed using mean and standard deviation for continuous variables and percentages for categorical variables. Linear mixed-effects regression models with a change point were used to study rate of change in cognitive function (38). Each model allowed the rate of change in cognitive function to shift after onset of limitations in ROS-B/Nagi measure. In the first set of analyses, onset measured by any limitation was used to test the differences in rate of cognitive decline. A second set of analyses, we tested differences in rate of cognitive decline as a function of the absolute number of limitations at the time of onset. Random effects were included for the intercept, slope prior to limitations onset, and slope following onset of limitations to study the change in cognitive function before and after functional limitations. Each model also included fixed effects for time before limitations (in years since baseline); time after limitations (in years since reported functional

limitations); and age, sex, race, education, depressive symptoms, number of medical conditions, body mass index and their interactions with time before and after onset of limitations. We retained only the significant interactions in subsequent models. In a sensitivity analysis, we looked at the trajectory of cognitive function among those with incident onset of functional limitations, thereby removing those who reported no functional limitations during follow-up since those who develop functional limitations may be different than those who do not. All models were fitted using SAS software (39).

Results

The study sample consisted of 3825 participants who reported no Rosow-Breslau or Nagi functional limitations at baseline interview. At baseline, the study sample was significantly younger; more educated, had higher income, higher body mass index and higher cognitive function, and were more likely to be European American and male than those excluded due to prevalent Rosow-Breslau or Nagi functional limitations (Table 1). Study participants with no functional limitations at baseline also reported fewer depressive symptoms and fewer chronic health conditions such as hypertension, diabetes mellitus, and stroke compared to those with functional limitations.

During a mean of 9.5 years of observation, 2682 (70%) participants reported onset of a mean of 2.2 (SD=1.5) limitations in ROS-B/Nagi measure. Onset of ROS-B/Nagi limitations occurred at a mean age of 78.1 (SD=6.1) years. The mean follow-up time after the onset of ROS-B/Nagi limitations was 4.2 (SD=2.3) years.

At baseline, the average cognitive function among those with no ROS-B/Nagi limitations was 0.416 (SD=0.592). As shown in Table 2, the composite measure of global cognition declined by a mean of 0.053-units per year prior to any functional limitations. Following any limitations in ROS-B/Nagi measure, the rate of decline in cognitive function increased by 0.016-units per year, which translates to

a 30% increase (95% CI= 18 – 42%) from 0.053-units per year to 0.069-units per year after the onset of ROS-B/Nagi limitations. This effect is shown in Figure 1(a) for a person with an onset of ROS-B/Nagi limitations in year 5 (dashed line) compared to a person with no limitation (solid line).

Table 2. Rate of change in cognitive function before and after onset of functional limitations in 3825 subjects free of limitations at baseline^a

Model Term	Combined Rosow-Breslau/Nagi measure of functional limitations	
	Model-1 ^a Estimate (SE) ¹	Model-2 ^b Estimate (SE) ¹
Annual decline before onset of limitations	0.053 (.003) ***	0.050 (.003) ***
Increase in decline before onset of limitations for each 10 years of older age	0.043 (.004) ***	0.036 (.004) ***
Increase in annual decline after onset of limitations	0.016 (.005) **	--
Increase in annual decline for each additional number of limitation	--	0.012 (.002) ***
Increase in decline for each additional number of limitation and 10 years of older age	--	0.010 (.003) ***

¹ SE, standard error

^a Association between cognitive decline and any limitation

^b Association between cognitive decline and number of limitations

^c Adjusted for age, sex, marital status at baseline, education, body mass index, CES-D score, and number of chronic health conditions

P < **.01, ***.001

Table 1. Baseline characteristics (mean (SD), %) of subjects in a random sample of population aged 65 years and older

Characteristics	No limitations	Any limitations	P
N	3825	3831	
Age (years)	70.7 (5.0)	73.7 (7.0)	<0.0001
Education (years)	12.8 (3.5)	12.0 (3.5)	<0.0001
Body mass index (kg/m ²)	27.5 (4.9)	28.8 (6.7)	<0.0001
Cognitive function (sd units)	0.416 (0.592)	0.149 (0.814)	<0.0001
Females, %	2020, 53%	2762, 72%	<0.0001
African Americans, %	2501, 65%	2410, 63%	0.023
Marital status, %			<0.0001
Never married	147, 4%	217, 6%	
Married	2271, 59%	1654, 43%	
Widowed	1021, 27%	1564, 41%	
Divorced	386, 10%	395, 10%	
Annual income, %			<0.0001
\$0-\$14,999	781, 21%	1387, 38%	
\$15,000-\$29,999	1427, 38%	1293, 35%	
\$30,000+	1546, 41%	1004, 27%	
Depressive Symptoms, %			<0.0001
0-1	3342, 87%	2636, 69%	
2-3	213, 6%	365, 10%	
4+	270, 7%	815, 21%	
Chronic diseases, %			
Heart disease	285, 8%	653, 17%	<0.0001
Diabetes mellitus	170, 5%	351, 9%	<0.0001
Stroke	148, 4%	488, 13%	<0.0001

Figure 1. Rate of change in cognitive function for onset of ROS-B/Nagi functional limitations and absolute number of limitations

A larger number of ROS-B/Nagi limitations at the time of onset were associated with a more rapid decline in cognitive function. At the time of onset of Rosow-Breslau limitations, the rate of cognitive decline increased by 0.012-units per year for each additional limitation (Table 2). This effect is shown in Figure 1(b) for a person with no limitation (solid line), 2 limitations (50th percentile, dashed line), and 5 limitations (90th percentile, dotted line). Also, the number of limitations was associated with higher cognitive decline at older ages than at younger ages.

As a part of our sensitivity analysis, we examined cognitive decline among 2682 participants who reported onset of ROS-B/Nagi limitations. The rate of cognitive decline was 0.053-units per year prior to onset of limitations. Following any limitation in the ROS-B/Nagi measure, the rate of cognitive decline increased by 0.012-units per year for each additional limitation. Older age was still associated with more rapid decline in cognitive function as before. The findings from our sensitivity analysis were similar to our earlier estimates.

Discussion

In this study, we examined the rate of cognitive decline before and after the onset of functional limitations using a combination of two self-reported functional limitations measure. Approximately, 70% of the participants developed limitations in Rosow-Breslau and Nagi measures. The rate of decline in cognitive function increased by 30% after the onset of limitations in Rosow-Breslau and Nagi measures. These findings persisted after controlling for demographic variables, chronic health conditions, and depression.

The relation between self-reported onset of functional limitations in lower and upper-extremity functions and the rate of subsequent cognitive decline has not been extensively investigated. Longitudinal studies have looked at the association between basic and instrumental activities of daily living and cognitive function with Rajan et al (14), and Njegovan et al (15), reporting significant cognitive decline following instrumental and basic activities of daily living, while Chodosh et al. reported no influence of activities of daily living on

future cognitive decline (16). Even though several studies have investigated the association of functional limitations in ADL and IADL measures, few have investigated the association of functional limitations in Rosow-Breslau and Nagi measures. This is of particular interest, since functional limitations in lower and upper-extremity functions might precede limitations in activities of daily living. An increase in cognitive decline after the onset of functional limitations may be due to more restricted activity patterns of activities, which in turn may adversely cognitive function (40). The association of occurrence of Rosow-Breslau and Nagi limitations with cognitive decline also suggests a hierarchical order, which may be helpful in understanding the overall disablement process relative to cognitive decline (20). In other words, limitations in functional tasks may represent a gradual restriction in daily activity, and their occurrence in late life may have a greater adverse impact on cognitive function.

The main limitation of this study is the length of time between cognitive tests. A 3-year interval in cognitive tests limited our ability to track short term changes in cognition around the time of functional limitations. Also, participants had to survive at least 6 years from the first assessment to be included in analyses. In terms of functional limitations, we only looked at two aspects, namely, onset of functional limitations and maximum number of limitations at onset. However, other aspects of functional limitations such as faster progression or recovery from limitations may also impact cognitive decline in older adults. These factors may have led us to underestimate the rate of change in cognitive decline associated with functional limitations. Cognitive decline may also impact the accuracy of self-reported functional limitations as these assessments may have reporting errors that are not dependent on the level of cognitive function. By combining the two functional limitation measures, we might have reduced some of the reporting and misclassification errors.

In conclusion, we found that Rosow-Breslau and Nagi limitations were associated with rate of future cognitive decline. The trajectories of cognitive decline before and after functional limitations showed significant differences in older persons for the two

self-reported functional limitation measures. In essence, the findings of this research suggest that self-reported functional limitations may be an important marker of the future cognitive decline in older adults, similar to limitations in activities of daily living (9,11). Therefore, preventing, detecting, and treating early signs of functional loss might also prove beneficial in reducing future cognitive decline and improving overall health.

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