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Research Article

Association of Physical Function With Driving Space and Crashes Among Older Adults

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Abstract

Background and Objectives: Balancing both driver mobility and safety is important for the well-being of older adults. However, research on the association of physical function with these 2 driving outcomes has yielded inconsistent findings. This study examined whether physical functioning of older drivers, as measured by the Short Physical Performance Battery (SPPB), is associated with either driving space or crash involvement.
Methods: Using cross-sectional data of active drivers aged 65–79 years from the AAA Longitudinal Research on Aging Drivers (LongROAD) study (n = 2,990), we used multivariate log-binomial and logistic regressions to estimate the associations of the SPPB with either self-reported restricted driving space in the prior 3 months or any crashes in the past year. Interaction with gender was assessed using likelihood ratio tests.
Results: After adjustment, older drivers with higher SPPB scores (higher physical functioning) had lower prevalence of restricted driving space (8–10 vs. 0–7, prevalence ratio [PR] = 0.88, 95% confidence interval [CI]: 0.78–0.99; 11–12 vs. 0–7, PR = 0.78, 95% CI: 0.61–0.99). Fair (8–10), but not good (11–12), scores were significantly associated with reduced crash involvement (8–10 vs. 0–7, odds ratio [OR] = 0.71, 95% CI: 0.60–0.84). Gender was not a significant effect modifier.
Discussion and Implications: This study provides evidence that higher physical functioning is associated with better driving mobility and safety and that the SPPB may be useful for identifying at-risk drivers. Further research is needed to understand physical functioning's longitudinal effects and the SPPB's role in older driver intervention programs.

Keywords: Driving, Function/mobility and balance

In 2016, about 19% (41 million) of all drivers were 65 years of age and older (hereafter referred to as older drivers), and recent trends in aging suggest that this number will increase to 25% by 2050 (Federal Highway Administration, 2017; National Highway Traffic Safety Administration, 2015). Age-related sensory, cognitive, and physical impairments among older drivers are associated with increased risk of crashes and decreased driving performance (Anstey, Wood, Lord, & Walker, 2005; Desapriya et al., 2011; Lacherez, Wood, Anstey, & Lord, 2014). To compensate for these impairments, many older drivers may reduce their mobility by reducing their driving frequency, restricting their driving space (the typical distance driven away from their home), or increasing avoidance of difficult driving situations (O'Connor, Edwards, Small, & Andel, 2012; O'Connor, Edwards, Wadley, & Crowe, 2010; Papa et al., 2014; Ross et al., 2009). However, driving reduction or cessation increases an older driver's risk of depressive symptoms, long-term care entry, and mortality (Chihuri et al., 2016; Fonda, Wallace, & Herzog, 2001). Maintaining independent mobility while balancing driving safety is challenging and complex (Albert, Lotan, Weiss, & Shiftan, 2018); therefore, it is important to understand the specific risk factors for those who actually restrict their driving mobility and for those who engage in unsafe driving.

Previous research on older adults has investigated whether physical function is associated with driving space (a measure of driving mobility) and crashes, but findings so far have been inconsistent. For example, in a longitudinal study, self-reported driving space across 5 years was not associated with either the Turn 360 Test (a measure of lower limb strength and balance), or self-reported physical functioning, but was associated with grip strength (Phillips, Sprague, Freed, & Ross, 2016). However, Vance et al. (2006) demonstrated that among individuals 55 years of age and older, lower extremity function, as measured by a composite of the Rapid Pace Walk (a measure of lower limb mobility through walking and turning) and the Foot Tap test did not predict a composite variable of driving space within the last year, number of days driven per driven, miles driven per week and miles driven per year. Ross et al. (2009) also found in a longitudinal study of the same cohort that the Rapid Pace Walk was not a significant predictor of restricted driving space over 5 years. Similarly, Anstey et al. (2005) reported that studies using various measures of physical function provided little support for the association between physical function and poor driving performance or crash risk. In another systematic review, the Timed Up-and-Go test (an assessment of basic mobility through transfers, walking, and turning) and the Rapid Pace Walk were not associated with increased risk of crashes in the four studies reviewed (Mielenz, Durbin, Cisewski, Guralnik, & Li, 2017). However, a case-control study by Sims et al. (2001) found that the odds of at-fault police-investigated crashes increased with increasing numbers of self-reported functional impairments among older drivers. While these studies differed in many ways including characteristics of the study populations and outcome measurements, the inconsistent findings of the association between physical function and driving space and crash risk may also be due in part to the range and reliability of different performance measures or reliance on self-report rather than a standardized performance-based test or battery.

The systematic review by Mielenz et al. (2017) proposed that the Short Physical Performance Battery (SPPB) may be a good standardized performance-based test for studying associations of physical functioning and driving outcomes. The SPPB is a measure of lower extremity functioning and has been established as a predictor of adverse health outcomes including nursing home admission, disability, and mortality (Guralnik et al., 1994; Guralnik et al., 2000; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995; Pavasini et al., 2016; Penninx et al., 2000; Stenholm, Guralnik, Bandinelli, & Ferrucci, 2014). Gill et al. (2012) found that older adults with low SPPB scores (<7, indicating poorer performance) had a 120% higher hazard of driving cessation in the past 6 months compared to scores of 10 or higher (adjusted hazard ratio [HR] = 2.20, 95% confidence interval [CI]: 1.32, 3.68). Sims et al. (2007) found higher SPPB scores were associated with decreased odds of driving cessation in the past 2 years (adjusted odds ratio [OR] = 0.86, 95% CI: 0.78, 0.95). Davis et al. (2011) reported that lower SPPB scores were associated with reduced driving exposure as measured by number of car trips per week. In a nationally representative sample, SPPB scores were also associated with current driver status, with persons with poor (<6) and fair (6–9) SPPB scores having 2.01 times (95% CI: 1.78, 2.26) and 1.31 times (95% CI: 1.19, 1.45) the adjusted rate of non-driving status compared to those with good scores (10–12), respectively (Durbin et al., 2017). The consistent results of these studies suggest that the SPPB may be useful for identifying older drivers at risk for other negative driving outcomes, including confirming the associations between physical function and driving space and crashes inconsistently found in previous research. However, to date, studies have only investigated the SPPB's association with the outcomes of driving cessation and driving exposure.

This study examined the association between lower extremity function (as measured by the standardized SPPB) and self-reported driving space and crash involvement, using baseline data from a large multi-site cohort study. We hypothesized that lower SPPB scores (poorer physical function) would be associated with restricted driving space and recent crashes after adjustment for demographics and other characteristics known to be associated with these driving outcomes.

Methods

Study Population

Data were from the baseline of the AAA Longitudinal Research on Aging Drivers (LongROAD) Study, a prospective cohort study aimed at examining risk factors for driving behavior and safety in aging drivers. Study population and data collection methods have been described elsewhere and are summarized here (Li et al., 2017). Potentially eligible participants were active drivers aged 65 to 79 identified from the electronic medical records of health systems or primary care clinics affiliated with the 5 study sites (located in Ann Arbor, Michigan; Baltimore, Maryland; Cooperstown, New York; Denver, Colorado; and San Diego, California). The study sites contacted 40,806 potentially eligible participants by mail or email and conducted eligibility screening with those individuals who did not opt out and who were reachable by telephone. Eligibility criteria included: (a) holding a valid driver license; (b) driving on average at least once a week; (c) residing in study site area for at least 10 months a year; (d) having no plans to move outside the study area within the next 5 years; (e) driving a recent (model year 1996 or newer) vehicle for 80% or more of the time; (f) being fluent in English; and (g) having no significant cognitive impairment or, at some sites, a diagnosis of degenerative medical condition. A total of 2,990 participants enrolled between July 2015 and March 2017. The LongROAD study includes a baseline assessment and annual follow-ups are ongoing. This study uses the cross-sectional data collected at baseline by questionnaires on driving, health and behaviors, and in-person assessments of physical function.

Measures

Driving Space

The Driving Habits Questionnaire (DHQ) assessed participants' self-reported driving space using 6 dichotomous questions about distances driven in the past 3 months (i.e., immediate neighborhood, beyond neighborhood, neighboring towns, distant towns, outside the state, outside the country) (Owsley, Stalvey, Wells, & Sloane, 1999). The LongROAD summed "yes" responses to create a composite driving space variable ranging from 0 to 6, corresponding to the farthest area driven to in the past 3 months. We defined restricted driving space as a score between 0 and 3, indicating the participant did not drive beyond neighboring towns, and unrestricted driving space greater than 3 as originally reported by Owsley et al. (1999).

Crashes

Participants' crash involvement was assessed by the following DHQ item: "How many accidents have you been involved in over the past year when you were the driver." Because of small sample sizes associated with responses of 2 or more crashes, we dichotomized the outcome of self-reported crashes as none versus 1 or more. As a dichotomized variable, self-report of crashes has moderate agreement with state records of any motor vehicle collisions (McGwin, Owsley, & Ball, 1998; Singletary et al., 2017).

Physical Function

The LongROAD study measured lower extremity physical performance using the original SPPB timed components of standing balance (side-by-side, semi-tandem, tandem), walking speed, and repeated chair stands as well as the National Health and Aging Trends Study (NHATS) Expanded SPPB (Guralnik et al., 1995; National Health and Aging Trends Study (NHATS), 2016; Pahor et al., 2014). The NHATS Expanded SPPB includes an additional difficult balance test of standing on 1 leg with eyes open (Kasper, Freedman, & Niefeld, 2012). For increased sensitivity at the higher scores, we selected the NHATS Expanded SPPB as the measure of physical function instead of the original SPPB given that 80.3% of the LongROAD cohort had scores corresponding to a high level of performance (10–12) using the original scoring. Using cut points for walking speed and repeated chair stands that reflect quartiles of the NHATS sample population and scoring criteria for the balance tests established by NHATS, the LongROAD study assigned a score from 0 to 4 for each of the 3 components, with 0 corresponding to not completed or not attempted and 4 the highest level of performance. The scores of all three components were added to create a summary SPPB score ranging from 0 to 12. We categorized total SPPB scores as poor (0–7), fair (8–10), and good (11–12), rather than the more common categorizations of 0–6, 7–9, and 10–12, to account for the high physical functioning of the LongROAD cohort. Of the 2,990 LongROAD participants, 2,948 participants had baseline NHATS Expanded SPPB scores.

Covariates

We selected covariates as potential confounders a priori, including gender, age, education, marital status, self-reported vision, driving importance, depression, anger, cognitive health, miles driven per week, and days driven per week. Based on previous study findings of gender differences in SPPB scores, driving mobility and driving exposure, we selected gender as a potential effect modifier of the association between physical functioning and both outcomes (Guralnik et al., 1994; Phillips et al., 2016; Ross et al., 2009).

The LongROAD study measured depression using standardized T-scores from the Patient-Reported Outcomes Measurement Information System (PROMIS) Short Form v1.0-Depression 4a and anger using the PROMIS Short Form v.1.1-Anger 5a (HealthMeasures, 2017). Cognitive health, specifically episodic and working memory, was measured using a sum of immediate and delayed word recall of 10 nouns during in-person assessments (Wallace & Herzog, 1995). Due to the limited number of drivers in some categories, we collapsed self-reported eyesight from 5 categories to 3 (excellent, very good, poor to good); marital status from 6 categories to 3 (married or living with a partner, separated or divorced or never married, widowed); and education from 9 categories to 4 (high school or less, some college, bachelor's degree, advanced degree). The LongROAD study also asked participants "How important is driving to you" with a response of "not at all" corresponding to 1 and "completely" to 7. We collapsed this driving importance variable into 3 levels (1 to 5, 6, and 7), due to small sizes in categories 1 to 5. Similarly, we combined the categories of 1 to 3 days driven per week due to a small number of drivers with this low driving frequency.

Of the entire cohort, 85.5% of the participants were White Non-Hispanic; therefore, we did not include race and ethnicity in the analysis due to small variation. We also did not include comorbidities in the analyses because baseline data only included lifetime prevalence of self-reported medical conditions.

Statistical Analyses

Descriptive statistics were used to explore the distribution of demographics, health and driving characteristics among the study population. We tested differences between NHATS Expanded SPPB (hereafter referred to as SPPB) groups and bivariate associations between covariates and outcomes using Pearson's Chi-square tests.

Separate multivariate logistic regression was performed to generate ORs and CIs for the association between SPPB scores and either restricted driving space or crash involvement. We assessed for collinearity of independent variables and found anger and depression were moderately correlated. Based on bivariate associations, we only considered depression in the models. We assessed the linearity between independent variables and each outcome to determine if SPPB score category and covariates should be entered into the models as continuous, nominal or ordinal variables. Continuous variables that violated the linearity assumption were categorized using the variables' distributions as cut points and then we reassessed the linearly of the categorized variables with each outcome. We found that SPPB score category was linearly related to the log odds of restricted driving space but not crashes. We entered miles driven per week as an ordinal variable for the outcome of driving space and as a nominal variable for crashes using quartiles as cut points. We dichotomized word recall at the median (with higher scores indicating better recall) and depression at 50, corresponding to the U.S. general population average (with lower scores indicating less depression; HealthMeasures, 2018). We entered the remaining covariates into the models as nominal variables, except for education, which we entered into the driving space model as an ordinal variable.

A priori confounders known to affect driving outcomes (gender, age, depression, cognitive health, and miles driven per week) were kept in the models as confounders and the remaining covariates were evaluated for evidence of confounding using a change-in-estimate method (Anstey et al., 2005; Greenland, 1989; Hill et al., 2017; Owsley et al., 1999; Phillips et al., 2016; Rolison & Moutari, 2018; Turano et al., 2009). We deleted each variable individually from an initial model that included all covariates and included in the final model only covariates that changed the SPPB parameter estimate by at least 10%. We tested for interactions on the multiplicative scale using a cross product term in the logistic regression models and likelihood ratio tests to assess significance of the interaction term for gender. Standard errors for all models were adjusted for any potential intraclass correlation due to the cluster sampling design by study site.

Any crash in the past year was a rare outcome; therefore, the ORs generated from logistic regression are a good approximation of the prevalence ratios. To investigate if the ORs generated from multivariate logistic regression overestimated the prevalence ratios for the common outcome of restricted driving space, we used a log-binomial regression model that included the same covariates in the final logistic regression model and adjusted standard errors for study site (Richardson, Kinlaw, MacLehose, & Cole, 2015).

Statistical significance level was set at 0.05 for all analyses. We recognize that interaction tests have low power; however, we used a stringent criterion ($p < .05$) instead of a higher significance level to test for the hypothesized interaction between gender and SPPB scores (Frongillo, 2004; Greenland, 1983). STATA version 15 was used for assessing linearity, estimating prevalence ratios, and adjusting standard errors in the final model. All other analyses were performed using SAS version 9.4.

Results

Table 1 describes baseline demographics, physical and mental health measures, and driving characteristics of the LongROAD cohort. The study population was 53.0% female and 41.6% were between 65 and 69 years of age. Of those participants with available data, most participants were married or living with a partner (66.7%), and highly educated, with 64.4% of participants reporting college degrees or higher. A high percentage (67.1%) of the participants that provided self-rated vision reported very good or excellent vision. For the measure of depression, 86.0% of those participants with PROMIS T-scores had scores that were at the U.S. general population average or better. Of those participants with NHATS Expanded SPPB scores, about four fifths (80.6%) had SPPB scores of 8 or higher and 15.9% had the highest score of 12, indicating an overall high physical functioning of the LongROAD cohort.

Of the 2,990 participants with data, 2,334 (78.1%) reported that driving is completely important to them and 2,215 (74.1%) reported that they drive 5 or more days per week. The mean and median miles driven per week for the entire cohort were 120 and 100 miles, respectively (range: 1 to 800). Restricted driving space (score ≤3 corresponding to not driving beyond neighboring town) was not uncommon among the LongROAD participants (22.6%). Of the 11.2% participants who reported crash involvement in the past year as the driver, 93.1% were involved in only 1 crash.

Table 1. Baseline Characteristics of the AAA Longitudinal Research on Aging Drivers (LongROAD) Study Participants

Characteristic	*n*	%
Female gender	1,586	53.04
Age		
65–69	1,243	41.57
70–74	1,037	34.68
75–79	710	23.75
Education (*n* = 2,981)		
High school or less	336	11.27
Some college	726	24.35
Bachelor's degree	698	23.41
Advanced degree	1,221	40.96
Marital status (*n* = 2,960)		
Married/Living with Partner	1,974	66.69
Separated/Divorced/Never Married	608	20.54
Widowed	378	12.77
Self-reported vision (*n* = 2,988)		
Excellent	750	25.10
Very good	1,255	42.00
Poor to good	983	32.90
Average or better depression PROMIS T-score (≤50) (*n* = 2,986)	2,568	86.00
Worse immediate and delayed correct word recall (0–10) (*n* = 2,906)	1,505	51.79
NHATS Expanded Short Physical Performance Battery score (*n* = 2,948)		
0–7 (poor)	572	19.40
8–10 (fair)	1,350	45.79
11–12 (good)	1,026	34.80
Miles driven per week (*n* = 2,919)		
1–49	696	23.84
50–99	701	24.02
100–150	795	27.24
151–800	727	24.91
Days driven per week (*n* = 2,989)		
1–3	425	14.22
4	349	11.68
5	449	15.02
6	457	15.29
7	1,309	43.79
Driving importance (*n* = 2,988)		
1–5	198	6.63
6	456	15.26
7—Completely	2,334	78.11
Restricted driving space in past 3 months (0–3)	676	22.61
At least 1 crash in past year (*n* = 2,981)	335	11.24

Notes: PROMIS = Patient-Reported Outcomes Measurement Information System; NHATS = National Health and Aging Trends Study. Total *n* = 2,990 unless otherwise noted.

Except for driving importance (p = .533), all covariates were significantly associated with SPPB score category (p < .001, results not shown).

Driving Space

Table 2 shows the bivariate analysis of driving space. Gender, 5-year age group, education level, marital status, self-reported vision, depression, level of driving importance, and quartile of miles driven per week were significantly associated with restricted driving space in the prior 3 months (p < .05). However, in multivariate logistic regression, education level, marital status, vision, and driving importance did not change the parameter estimates by more than 10% and only a priori confounders were included in the final model.

The ORs generated by logistic regression (results not shown) overestimated the prevalence ratios; therefore, the results of the log-binomial regression model that accounted for the same confounders and cluster sampling are reported. Compared to older drivers with poor SPPB scores (0–7), older drivers with fair scores (8–10) had 12% (OR = 0.88;

Table 2. Baseline Characteristics of the AAA Longitudinal Research on Aging Driver (LongROAD) Study Participants by Driving Space in Past 3 Months

Characteristic	Restricted (*n* = 676)	Unrestricted (*n* = 2,314)	*p* value[a]
Female gender	444 (65.68)	1,142 (49.35)	<.001
Age			
65–69	262 (38.76)	981 (42.39)	.007
70–74	223 (32.99)	814 (35.18)	
75–79	191 (28.25)	519 (22.43)	
Education (*n* = 2,981)			
High school or less	93 (13.78)	243 (10.54)	.023
Some college	171 (25.33)	555 (24.07)	
Bachelor's degree	164 (24.30)	534 (23.16)	
Advanced degree	247 (36.59)	974 (42.24)	
Marital status (*n* = 2,960)			
Married/Living with partner	405 (60.72)	1,569 (68.43)	<.001
Separated/Divorced/Never married	164 (24.59)	444 (19.36)	
Widowed	98 (14.69)	280 (12.21)	
Self-reported vision (*n* = 2,988)			
Excellent	165 (24.48)	585 (25.28)	<.001
Very good	241 (35.76)	1,014 (43.82)	
Poor to good	268 (39.76)	715 (30.90)	
Average or better depression PROMIS T-score (≤50) (*n* = 2,986)	543 (80.44)	2,025 (87.62)	<.001
Worse immediate and delayed correct word recall (0–10) (*n* = 2,906)	351 (53.67)	1,154 (51.24)	.274
Driving importance (*n* = 2,988)			
1–5	50 (7.40)	148 (6.40)	.020
6	124 (18.34)	332 (14.36)	
7—Completely	502 (74.26)	1,832 (79.24)	
Miles driven per week (*n* = 2,919)			
1–49	266 (40.43)	430 (19.02)	<.001
50–99	182 (27.66)	519 (22.95)	
100–150	123 (18.69)	672 (29.72)	
151–800	87 (13.22)	640 (28.31)	
NHATS Expanded SPPB score (*n* = 2,948)			
0–7 (poor)	177 (26.70)	395 (17.29)	<.001
8–10 (fair)	304 (45.85)	1,046 (45.78)	
11–12 (good)	182 (27.45)	844 (36.94)	

Notes: PROMIS = Patient-Reported Outcomes Measurement Information System; NHATS = National Health and Aging Trends Study; SPPB = Short Physical Performance Battery. Total *n* = 2,990 unless otherwise noted. Values are number and percent.
[a]*p* values for chi-squared tests.

95% CI: 0.78–0.99) lower prevalence and older drivers with good scores (11–12) had 22% (OR = 0.78; 95% CI: 0.61–0.99) lower prevalence of restricted driving space in the past 3 months (Table 3). The addition of the interaction term between SPPB score category and gender did not significantly improve the model (X^2 = 2.106, p = .147).

Crashes

Of all covariates included in bivariate analysis of crashes, only marital status was significantly associated with 1 or more crashes in the past year as the driver (p = .010, Table 4), with those who had crashes being less likely to be married or living with a partner. Marital status, education level, and days driven per week were confounders in the multivariate model and were included with a priori confounders in the final model.

In the final model adjusted for all confounders and cluster sampling design, drivers with fair scores (8–10) had 0.71 (95% CI: 0.60–0.84) times the odds of a crash in the past year compared to those with poor scores (0–7) (Table 3). Although not statistically significant (p = .278), older drivers with good SPPB scores (11–12) had 17% (OR = 0.83; 95% CI: 0.62–1.10) lower odds of a crash in the past year compared to those with poor scores. Interaction terms between SPPB score category and gender did not significantly improve the model (X^2 = 1.073, p = .585), indicating that gender did not modify the association between SPPB score category and crashes on the multiplicative scale.

Table 3. Association of Lower Limb Functioning with Restricted Driving Space in Past 3 Months and Crashes in Past Year Among AAA Longitudinal Research on Aging Drivers (LongROAD) Study Participants

	Restricted driving space[a]		At least 1 crash[b]	
	Unadjusted (*n* = 2,948)	Adjusted[c] (*n* = 2,801)	Unadjusted (*n* = 2,939)	Adjusted[d] (*n* = 2,757)
	PR (95% CI)	PR (95% CI)	OR (95% CI)	OR (95% CI)
NHATS Expanded SPPB				
0–7 (poor)	Ref	Ref	Ref	Ref
8–10 (fair)	0.76 (0.71, 0.80)	0.88 (0.78, 0.99)	0.71 (0.61, 0.81)	0.71 (0.60, 0.84)
11–12 (good)	0.57 (0.51, 0.64)	0.78 (0.61, 0.99)	0.82 (0.64, 1.05)	0.83 (0.62, 1.10)

Notes: PR = prevalence ratio; OR = odds ratio; CI = confidence interval; NHATS = National Health and Aging Trends Study; SPPB = Short Physical Performance Battery. All models adjusted errors for site.

[a]Results of log-binomial regression. [b]Results of logistic regression. [c]Adjusted for gender, age category, depression, word recall correct, and miles driven per week. [d]Adjusted for gender, age category, education, marital status, depression, word recall correct, miles driven per week, and days driven per week.

Discussion and Implications

This study of a large multi-site cohort supports the conclusion that SPPB may be a useful objective and standardized measure for identifying older drivers with diminished driving mobility and increased risk of crashes. Specifically, we found that SPPB scores were inversely associated with the prevalence of restricted driving space in the past 3 months and that participants with fair scores (8–10) had decreased odds of any crash in the past year compared to those with poor scores (0–7). Gender did not modify these associations.

To our knowledge, this is the first study to examine the association of SPPB scores and these 2 driving outcomes. The discordance of our findings with prior studies may be due to our use of a different physical functioning measure, large sample size or other differences in study design. As Mielenz et al. (2017) summarized, previous research examining physical functioning and crashes had smaller sample sizes for studying a rare outcome and had methodological differences in crash assessment. In addition to sample size, differences in study population age and length of time over which driving space was measured may also explain the discrepant findings from prior studies that found no significant association between physical function and driving mobility (Ross et al., 2009; Vance et al., 2006).

We did not find a significant association between the highest category of SPPB scores and crashes or an inverse dose-response pattern between SPPB scores and crashes as found with the restricted driving space analysis. One reason could be that this study did not have sufficient power given the low prevalence of the outcome. Additionally, those participants with lower SPPB scores may self-regulate in ways not captured by the variables in this analysis, leading to unaccounted-for confounding. For example, this study adjusted for driving exposure measured by days and miles driven per week; however, Rolison et al. (2018) has proposed that risk exposure for crashes should also include travel duration, not captured in this current study. On the other hand, this relationship may be the true association and those with different levels of physical functioning may avoid difficult driving situations differently. Molnar et al. (2014) found that both poorer physical functioning and higher ratings of self-perceived functioning were associated with greater strategic self-regulation. It may be that there is a large mismatch between objective and self-perceived physical functioning among SPPB groups, resulting in inappropriate self-regulation. Those with high SPPB scores may be more likely to drive in challenging situations, exposing these drivers to greater crash hazards, whereas those with middle range SPPB scores are more likely to avoid these situations and those with the lowest SPPB scores self-regulating the least. This relationship and the role of self-perceived functioning and abilities warrant further investigation.

This study has several additional limitations. Due to the cross-sectional design of this study, we are unable to determine the causal effects of SPPB on these 2 driving outcomes studied. This study is also limited by variable measurements. There is potential for residual confounding since vision and measures of driving exposure were based on self-report. Additionally, both driving space and crashes were self-reported. The domains of the DHQ have been found to have good test-retest reliability, and there is support that self-reported crashes moderately agree with state records of any motor vehicle collisions (McGwin et al., 1998; Singletary et al., 2017; Song, Chun, & Chung, 2015). Nonetheless, this study's use of self-reported outcomes is subject to recall bias, with participants potentially failing to recall if crashes occurred within the 1-year time frame or recalling only major crashes. If participants with lower SPPB scores were less likely to recall or less likely to report a crash, the measures of association in this study would be biased towards the null. Additionally, this study was unable to assess at-fault crashes separately from not-at-fault crashes, potentially biasing any associations towards the null. We were also unable to include comorbidities as

Table 4. Baseline Characteristics of the AAA Longitudinal Research on Aging Drivers (LongROAD) Study Participants by Crashes in the Past Year

Characteristic	None (n = 2,646)	At least 1 crash (n = 335)	p value[a]
Female gender	1,391 (52.57)	189 (56.42)	.184
Age			
65–69	1,093 (41.31)	144 (42.99)	.436
70–74	916 (34.62)	121 (36.12)	
75–79	637 (24.07)	70 (20.90)	
Education (n = 2,972)			
High school or less	301 (11.41)	34 (10.18)	.141
Some college	639 (24.22)	83 (24.85)	
Bachelor's degree	632 (23.96)	64 (19.16)	
Advanced degree	1,066 (40.41)	153 (45.81)	
Marital status (n = 2,951)			
Married/Living with Partner	1,769 (67.54)	199 (59.94)	.010
Separated/Divorced/Never Married	519 (19.82)	88 (26.51)	
Widowed	331 (12.64)	45 (13.55)	
Self-reported vision (n = 2,979)			
Excellent	659 (24.92)	90 (26.87)	.696
Very good	1,110 (41.98)	140 (41.79)	
Poor to good	875 (33.09)	105 (31.34)	
Average or better depression PROMIS T-score (≤50) (n = 2,977)	2,284 (86.42)	277 (82.93)	.084
Worse immediate and delayed correct word recall (0–10) (n = 2,897)	1,330 (51.75)	169 (51.68)	.981
Driving importance (n = 2,979)			
1–5	173 (6.54)	24 (7.19)	.685
6	408 (15.43)	46 (13.77)	
7—Completely	2,064 (78.03)	264 (79.04)	
Miles driven per week (n = 2,910)			
1–49	620 (24.06)	75 (22.52)	.678
50–99	622 (24.14)	75 (22.52)	
100–150	692 (26.85)	99 (29.73)	
151–800	643 (24.95)	84 (25.23)	
Days driven per week (n = 2,980)			
1–3	390 (14.74)	35 (10.45)	.262
4	305 (11.53)	42 (12.54)	
5	397 (15.01)	51 (15.22)	
6	408 (15.43)	49 (14.63)	
7	1,145 (43.29)	158 (47.16)	
NHATS Expanded SPPB score (n = 2,939)			
0–7 (poor)	491 (18.83)	78 (23.49)	.071
8–10 (fair)	1,211 (46.45)	136 (40.96)	
11–12 (good)	905 (34.71)	118 (35.54)	

Notes: PROMIS = Patient-Reported Outcomes Measurement Information System; NHATS = National Health and Aging Trends Study; SPPB = Short Physical Performance Battery. Total n = 2,981 unless otherwise noted. Values are number and percent.
[a]p-values for chi-squared tests.

a potential confounder as in other studies given that the baseline LongROAD data only captures lifetime prevalence of self-reported medical conditions (Durbin et al., 2017; Gill et al., 2012; Sims et al., 2001; Vance et al., 2006). The study also did not evaluate the participants' use or access to other modes of transportation as a potential confounder or effect modifier of the association between driving space and physical functioning (Jones et al., 2018).

Another limitation is that the findings may not be generalizable to the entire U.S. population of older drivers. As pointed out by Li et al. (2017), the distributions of race and education level indicate that the LongROAD cohort is overrepresented by Non-Hispanic Whites and higher socioeconomic status. Additionally, participants who volunteered for this study are likely mentally and physically healthier than the general population of older drivers as evidenced by a large proportion of the cohort with excellent or very good vision, depression scores that are average or better than average for the U.S. general population, and high SPPB scores.

In conclusion, poorer lower limb functioning as measured by the SPPB was associated with restricted driving mobility, as measured by driving space in the prior 3 months, and only fair SPPB scores with any self-reported crash in the past year. These associations warrant further investigation. This study also supports the SPPB as an objective measure for examining the effects of physical functioning on other driving outcomes. The LongROAD study is collecting objective data such as global positioning system (GPS) information, police reports, driving records, visual perception functioning assessments, and medical records, which can be used in further analysis to confirm this study's findings. Additionally, future analysis of the longitudinal data collected by the LongROAD study can establish the causal effects of lower SPPB on driving mobility and safety and examine potential time-varying associations (Phillips et al., 2016).

If future research confirms the findings of this study, implications include the use of exercise and physical activity interventions to improve driving mobility and safety. Physical functioning is modifiable and older adults can have significant gains in strength (Fiatarone et al., 1994). Previous research has found that aerobic, strength, balance, and flexibility exercises can improve SPPB scores among older adults and a change of only 1 point is a meaningful and achievable change (Kwon et al., 2009; Mielenz et al., 2017; Pahor et al., 2006; Perera, Mody, Woodman, & Studenski, 2006; Perera et al., 2014). Programs that focus on improving SPPB scores may keep older drivers mobile and safe.

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Conflict of Interest

None reported.

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