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Research Article

Hospitalization-Associated Change in Gait Speed and Risk of Functional Limitations for Older Adults

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Abstract

Background: Hospitalization-associated functional decline is a common problem for older adults, but it is unclear how hospitalizations affect physical performance measures such as gait speed. We sought to determine hospitalization-associated change in gait speed and likelihood of new limitations in mobility and activities of daily living (ADLs).

Methods: We used longitudinal data over 5 years from the Health, Aging and Body Composition Study, a prospective cohort of black and white community-dwelling men and women, aged 70–79 years, who had no limitations in mobility (difficulty walking 1/4 mile or climbing 10 steps) or ADLs (transferring, bathing, dressing, and eating) at baseline. Gait speed, and new self-reported limitations in mobility and ADLs were assessed annually. Selected participants (n = 2,963) had no limitations at the beginning of each 1-year interval. Hospitalizations were self-reported every 6 months and verified with medical record data. Generalized estimating equations were used to examine hospitalization-associated change in gait speed and odds of new limitations over each 1-year interval. Fully adjusted models included demographics, hospitalization within the past year, health conditions, symptoms, body mass index, and health-related behaviors.

Results: In fully adjusted models, any hospitalization was associated with decrease in gait speed (–0.04 m/s; 95% confidence interval [CI]: –0.05 to –0.03) and higher odds of new limitations in mobility or ADLs (odds ratio = 1.97, 95% CI: 1.70–2.28), and separately with increased odds of new mobility limitation (odds ratio = 2.22, 95% CI: 1.90–2.60) and new ADL limitations (odds ratio = 1.84, 95% CI: 1.53–2.21). Multiple hospitalizations within a year were associated with gait speed decline (–0.06 m/s; 95% CI: –0.08 to –0.04) and greater odds of new limitations in mobility or ADLs (odds ratio = 2.96, 95% CI: 2.23–3.95).

Conclusions: Functionally independent older adults experienced hospitalization-associated declines in gait speed and new limitations in mobility and ADLs.

Keywords: Mobility, Functional status, Decline

U.S. adults aged 65 and older experience 12.7 million hospitalizations each year, accounting for $262 billion in annual health care costs (1,2). For older adults, hospitalization is associated with substantial risk for new decline in functional status and adverse health outcomes (3–11). There is considerable concern that the hospitalization experience itself may contribute to negative consequences beyond what is directly related to the admitting diagnosis (5,6,12). To prevent functional decline and improve health outcomes, identification of the effects of hospitalization is warranted, particularly with respect to aspects of physical performance that may be modified by focused interventions. Specifically, it remains unclear how hospitalizations affect observed mobility, especially for older adults who were functionally independent before admission.

Most previous studies examining change in functional status after hospitalizations have focused on self-reported mobility and/or difficulty with activities of daily living (ADLs). For example, past work has shown that more than a third of older adults have increased difficulty performing ADLs after hospitalization, and individuals with functional decline have increased mortality risk, compared with those patients without decline at discharge (3,4,7). Furthermore, self-reported hospitalizations are associated with substantially higher odds of developing new, persistent disability in self-reported mobility and ADLs (9–11).

Physical performance provides important information about the health status of older adults, beyond that provided by self-reported function. A range of physical performance has been observed for individuals with no self-reported disability in ADLs or mobility (13,14). Furthermore, slower gait speed is associated with increased mortality risk, even among older individuals who report no difficulty with ADLs and/or mobility (13,15,16). Thus, hospitalization may negatively affect physical performance, even when there are no apparent declines in self-reported functional status, and such changes in physical performance could indicate additional risk for adverse events. Previous studies have only examined performance at the time of hospital discharge and weeks to months post-discharge (17–22). This past work was also limited by the lack of prehospitalization physical performance assessment and small samples focused on patients admitted for a select list of medical conditions.

Our aim was to examine hospitalization-associated annual change in gait speed and odds of new limitations with mobility and ADLs. We used data from the Health, Aging and Body Composition (Health ABC) Study, a prospective cohort of black and white community-dwelling adults, aged 70–79 years and functionally independent at baseline. We hypothesized that hospitalization would be associated with declines in gait speed and higher odds of new limitations in mobility and ADLs.

Methods

Data set and Participants

Health ABC Study enrolled community-dwelling black and white adults, aged 70–79 years (mean of 74 years), who reported no limitations with mobility (walking 1/4 mile and climbing 10 stairs) or performing ADLs (transferring, bathing, dressing, and eating) at baseline in 1997–1998. Participants were recruited from areas around Memphis, TN, and Pittsburgh, PA, and black participants were oversampled to achieve 40% representation. Detailed study protocols and methodology are available at https://healthabc.nia.nih.gov/.

We used longitudinal data over 5 years for 2,963 participants. Of 3,075 participants enrolled at baseline, we selected those with at least a 1-year interval (ie, two consecutive annual assessments) for which they met the following eligibility criteria: (i) no reported limitations (mobility and ADLs) at the beginning of interval; (ii) had gait speed data at the beginning of interval; and (iii) had gait speed and/or functional status data at end of interval (Figure 1). Of 2,963 participants who met these criteria, 2,766 (93%) were included in analyses of both gait speed change and new limitations, 54 (2%) were included only in the gait speed analyses, and 143 (5%) were included only in the analyses for new limitations. Overall, 59% of selected participants contributed data to three or more intervals of analysis.

This work was approved by the University of Minnesota Medical School, Twin Cities Campus, Institutional Review Board.

Measures

Gait speed

We used 6-m usual pace gait speed at baseline and either 20-m usual pace gait speed at annual follow-up clinic visits or 4-m usual gait speed at follow-up home visits (for feasibility, this shorter distance was used at home visits, which occurred for 19–27 participants [1.3–1.8%] across all intervals). We converted 20- and 4-m gait speeds to 6-m gait speed using previously derived formulas (23,24).

Functional status

Limitations with mobility and ADLs were encoded as dichotomous variables, with "yes" being a positive response to any of several questions beginning with "Because of a health or physical problem, do you have any difficulty…" Mobility (walking 1/4 mile and climbing 10 stairs) and ADL (transferring, bathing, dressing, and eating) questions were drawn from established measures of functional status (25,26) and have been used in other large national observational studies of community-dwelling older adults in the United States (27). Self-reported limitations were assessed every 6 months, and we used yearly data to align with timing of gait speed assessments.

Hospitalizations

We examined the effects associated with having any hospitalizations and having multiple hospitalization (two or more admissions) during 1-year intervals. Self-reported hospitalizations were captured every 6 months, with subsequent verification at each site by study staff, including review of medical records to confirm hospitalization events, determine primary and associated diagnoses for admissions, and record lengths of stay.

Deaths

Deaths were adjudicated by the Health ABC Study Diagnosis and Disease Ascertainment Committee, after review of death certificates, medical records, and data from structured interviews of family members, close associates, and/or others who had knowledge of the deaths (eg, health care providers). Detailed protocols and death interview questions are available at https://healthabc.nia.nih.gov/.

Covariates

Fully adjusted models included demographics (age, sex, white or black race, marital status, and education), general health, baseline body mass index (kilogram per square meter), self-reported physician-diagnosed chronic medical conditions (see Table 1), hospitalization within past year, fall within past year, moderate to severe chronic pain reported at baseline, depressive symptoms (10-item Center for Epidemiologic Studies Depression Scale) (28), smoking, heavy alcohol use, physical activity from walking and climbing stairs (29),

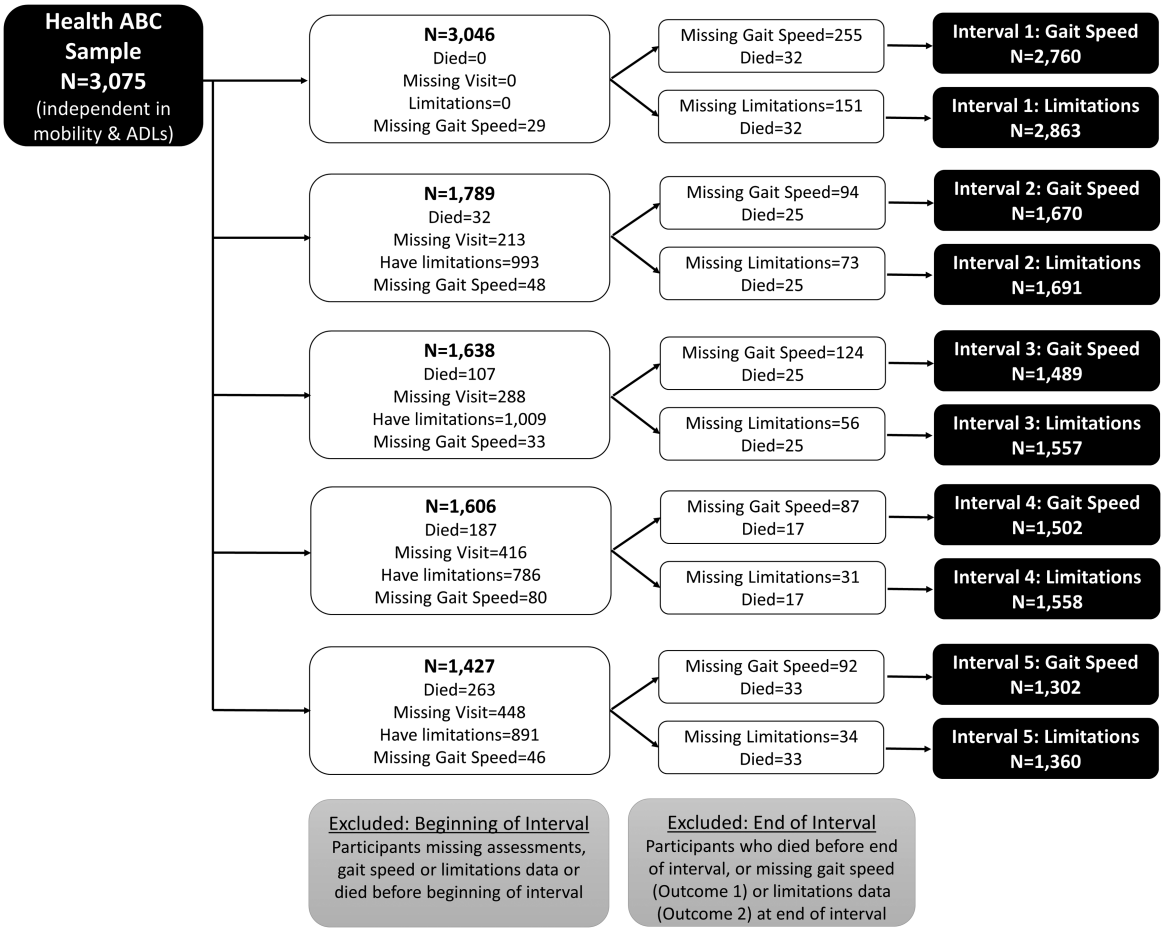

Figure 1. Selection of Health ABC participants for models of hospitalization-associated change in gait speed and risk for new limitations. Selection of participants is shown separately for gait speed and limitations outcomes, for each 1-y interval included in analyses. Limitations included difficulty with mobility (walking 1/4 mile or climbing one flight of stairs) and/or activities of daily living (ADLs; transferring, bathing, dressing, or eating). Final number of included participants for each interval shown in black boxes on the right, separated by outcome.

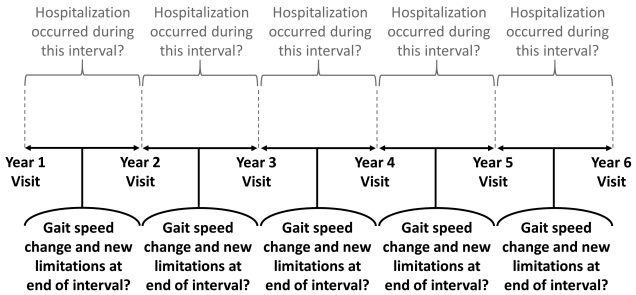

Figure 2. Schematic of longitudinal analytic approach. Figure adapted from ref. (42).

difficulty with shopping or preparing meals, and hearing and visual impairments. We defined heavy alcohol use as positive response to "During the past 12 months, have you had 5 or more drinks almost every day?" We encoded as having visual impairment if vision issues limited work or other activities at least some of the time. For hearing impairment, we used affirmative responses to "Do you feel that any difficulty with your hearing limits or hampers your personal or social life?" Medical conditions were mostly updated on an annual basis or every 6 months, whereas other covariates were updated annually.

Statistical Analyses

Baseline characteristics for participants who experienced any hospitalizations during the 5 years were compared with those who did not, using χ^2 or t tests as appropriate.

To account for having repeated measures (an individual can contribute data to more than one interval), we used separate generalized estimating equations with Toeplitz variance–covariance structure (30) to examine how any hospitalization during a 1-year interval was associated with the following outcomes: (i) annual gait speed change; (ii) odds of new limitation in mobility or ADLs at end of interval; (iii) odds of new mobility limitation at end of interval; and (iv) odds of new ADL limitation at end of interval (Figure 2).

Initial base models adjusted for age, sex, race, and study site. We evaluated interaction effects between sex and hospitalization and between race and hospitalization, which were nonsignificant (p = .73 and .31, respectively), and thus interaction terms were not included in final models. In the fully adjusted models, we included all covariates as noted above. We provide effect estimates and 95% confidence intervals (CI) for gait speed change and odds of new limitations associated with any hospitalization. To further understand the effect of multiple hospitalizations, we then categorized participants into having zero, one, or two or more hospitalizations within a 1-year interval. We used this three-category

Table 1. Baseline Characteristics of Participants (n = 2,963)[a]

Characteristics	Not Hospitalized (n = 1,990)	Hospitalized (n = 973)	p Value[b]
Age, mean (*SD*), y	73.6 (2.9)	73.6 (2.9)	.95
Female, *n* (%)	1,112 (56)	422 (43)	<.001
Race, *n* (%):			.004
White	1,137 (57)	610 (63)	
Black	853 (43)	363 (37)	
Married, *n* (%)	1,025 (55)	560 (62)	.001
Education, *n* (%):			<.001
Less than high school	529 (27)	203 (21)	
High school degree	657 (33)	305 (31)	
More than high school	801 (40)	461 (48)	
General health, *n* (%):			.09
Excellent/very good	898 (45)	420 (43)	
Good	322 (16)	138 (14)	
Fair/poor	767 (39)	414 (43)	
Diabetes mellitus, *n* (%)	287 (14)	146 (15)	.69
Hypertension, *n* (%)	992 (50)	513 (53)	.14
Cardiac condition, *n* (%)[c]	323 (16)	239 (25)	<.001
History of stroke, *n* (%)	125 (6)	84 (9)	.02
Lung disease, *n* (%)	363 (18)	181 (19)	.81
History of cancer, *n* (%)	373 (19)	189 (20)	.64
Arthritis, *n* (%)	1,102 (56)	551 (57)	.44
Depressive symptoms, mean (*SD*), range 0–30[d]	2.77 (3.24)	3.19 (3.43)	.002
Pain, *n* (%)[e]	166 (8)	93 (10)	.27
Hospitalized in past year, *n* (%)	260 (13)	183 (19)	<.001
Fall in past year, *n* (%)	418 (21)	217 (22)	.41
Smoking, *n* (%)			.003
Never	921 (46)	388 (40)	
Current	199 (10)	98 (10)	
Past smoker	869 (44)	487 (50)	
Alcohol, heavy use, *n* (%)[f]	15 (1)	11 (1)	.30
Gait speed, mean (*SD*), m/s	1.13 (0.23)	1.10 (0.23)	.001
Activity (walking and stairs), mean (*SD*), kcal/kg/wk	7.3 (15.9)	8.8 (21.6)	.06
Difficulty with preparing meals or shopping, *n* (%)	158 (8)	104 (11)	.01
Vision impairment, *n* (%)[g]	103 (5)	53 (5)	.76
Hearing impairment, *n* (%)[g]	172 (9)	87 (9)	.76

Notes: [a]Participants who were included for either gait speed change and/or new limitation outcomes. [b]For continuous variables, either *t*-test or nonparametric Wilcoxon rank sum; χ^2 test for categorical variables. [c]Includes heart attack and heart failure. [d]Scores on 10-item Center for Epidemiologic Studies Depression Scale. [e]Includes moderate to severe pain in feet, knees, hips, and back. [f]Having five or more drinks nearly every day over past year. [g]Work or social activities limited by vision or hearing.

predictor in the same base and fully adjusted models as noted earlier.

Finally, we provide descriptive information on the distributions of gait speed change and gait speed after hospitalization for hospitalized participants, comparing those who developed new limitations with those who did not.

Results

Thirty-three percent of participants experienced at least one hospitalization, and 12% (n = 367) died over 5 years of follow-up. Comparing baseline characteristics, hospitalized participants were more likely to be men, have a cardiac condition or history of stroke, have a hospitalization in the past year, have more depressive symptoms, be a past smoker, have slower average baseline gait speed, and have difficulty preparing meals or shopping (Table 1). Majority of participants who experienced any hospitalization had one admission per annual interval (75%–83%, across intervals). Those with multiple hospitalizations most often had two admissions per interval, whereas a few had three or more admissions (<10% across all intervals). Hospitalizations were most frequently due to cardiac conditions (ie, ischemic heart disease and/or heart failure), followed by gastrointestinal problems, cancer, and genitourinary conditions (Supplementary Table 1). Median length of stay was 7 days (interquartile range 3–15 days).

Gait speed change and new functional limitations associated with experiencing hospitalization(s) are given in Table 2. In the base model, any hospitalization was associated with a concurrent annual decline in gait speed (–0.03 m/s; 95% CI: –0.04 to –0.02). Adjustment for multiple potential confounders, including hospitalization in the previous interval, did not attenuate this effect (–0.04 m/s; 95% CI: –0.05 to –0.03). Among covariates, baseline age was associated with a very small decrease in gait speed (–0.003 m/s; 95% CI: –0.005 to –0.001) and black race with a very small increase (0.01 m/s; 95% CI: 0.005–0.02; Supplementary Table 2). In base models, experiencing two or more hospitalizations was associated with greater declines in gait speed (–0.05 m/s; 95% CI: –0.07 to –0.03), compared with having one admission (–0.03 m/s; 95% CI: –0.04 to –0.02). Similar

Table 2. Change in Gait Speed and Odds of New Limitations in Mobility or Activities of Daily Living Associated With Hospitalizations

		Odds Ratio (95% CI) of New Limitation		
	Change in Gait Speed[a], β (95% CI)	Mobility[b] or ADLs[c]	Mobility[b]	ADLs[c]
Any hospitalization[d]				
Base models[e]	−0.03 (−0.04 to −0.02)	2.16 (1.90 to 2.46)	2.48 (2.17 to 2.84)	2.09 (1.78 to 2.46)
Adjusted models[f]	−0.04 (−0.05 to −0.03)	1.99 (1.72 to 2.31)	2.26 (1.93 to 2.65)	1.86 (1.55 to 2.23)
Number of hospitalization(s)[g]				
Base models[e]				
1	−0.03 (−0.04 to −0.02)	1.88 (1.63 to 2.17)	2.11 (1.81 to 2.46)	1.84 (1.52 to 2.21)
≥2	−0.05 (−0.07 to −0.03)	3.48 (2.72 to 4.46)	4.23 (3.28 to 5.47)	3.12 (2.35 to 4.13)
Adjusted models[f]				
1	−0.03 (−0.04 to −0.02)	1.76 (1.49 to 2.08)	1.96 (1.65 to 2.34)	1.64 (1.33 to 2.03)
≥2	−0.06 (−0.08 to −0.04)	3.04 (2.28 to 4.05)	3.60 (2.67 to 4.87)	2.69 (1.95 to 3.72)

Notes: ADLs = activities of daily living; CI = confidence interval.

[a]Change in 6-m usual gait speed (m/s). [b]Any self-reported difficulty with walking 1/4 mile, and/or climbing one flight of stairs. [c]Any self-reported difficulty with transferring, bathing, dressing, and/or eating. [d]Any hospitalization vs. none in a 1-y interval. [e]Included age, study site, race, and sex. [f]Covariates as in base model plus following: marital status, education, health status, diabetes, hypertension, stroke, cardiac conditions, lung disease, history of cancer, arthritis, depressive symptoms, baseline pain, hospitalization in past year, fall in past year, body mass index, smoking status, alcohol, activity (walking and stairs), difficulty with preparing meals or shopping, vision impairment, and hearing impairment. [g]Categories: none (reference), 1, or ≥2 hospitalizations during a 1-y interval.

to models with any hospitalization, adjusting for all covariates did not attenuate the association between multiple hospitalizations and gait speed change; only age and black race were significantly associated with gait speed change (Supplementary Table 3).

Among hospitalized participants, 50% developed new limitations in mobility or ADLs at the end of the first interval, whereas smaller proportions (25%–34%) during subsequent intervals developed new limitations. For nonhospitalized participants, 36% developed new limitations during the first interval, and 14%–21% did so during following intervals. In the base model, experiencing any hospitalization within an interval was associated with increased odds of new limitations in mobility or ADLs at the end of that interval (odds ratio [OR] = 2.16, 95% CI: 1.90–2.46). Adjusting for all covariates led to a small attenuation in the association (adjusted OR [AOR]: 1.99, 95% CI: 1.72–2.31). Effects were similar for new mobility and ADL limitations when examined separately. Several covariates were independently associated with higher odds of new limitations, including older age, female sex, body mass index, various health conditions, depressive symptoms, baseline pain, and hospitalization or fall in the past year, among others (Supplementary Table 2). Higher physical activity at baseline and more education were associated with lower odds of new limitations (Supplementary Table 2). Experiencing multiple hospitalizations was associated with a threefold higher odds of new limitations in mobility or ADLs (AOR = 3.04, 95% CI: 2.28–4.05), whereas having only one admission was associated with a nearly twofold higher odds of new limitations (AOR = 1.76, 95% CI: 1.49–2.08). Multiple hospitalizations were also separately associated with new mobility limitation (AOR = 3.60, 95% CI: 2.67–4.87) and new ADL limitations (AOR = 2.69, 95% CI: 1.95–3.72). Similar to models with any hospitalization as the main predictor, multiple covariates were significantly associated with higher or lower odds of new limitations (Supplementary Table 3).

Finally, to better understand the relationship between gait speed and new self-reported limitations after hospitalizations, we examined the distributions of gait speed change during the interval, and gait speed at the end of the interval, for participants who were hospitalized during those intervals. In comparing participants with and without new limitations at the end of these intervals, we found largely overlapping distributions in gait speed change and gait speed for every interval (see Figure 3 for first interval data).

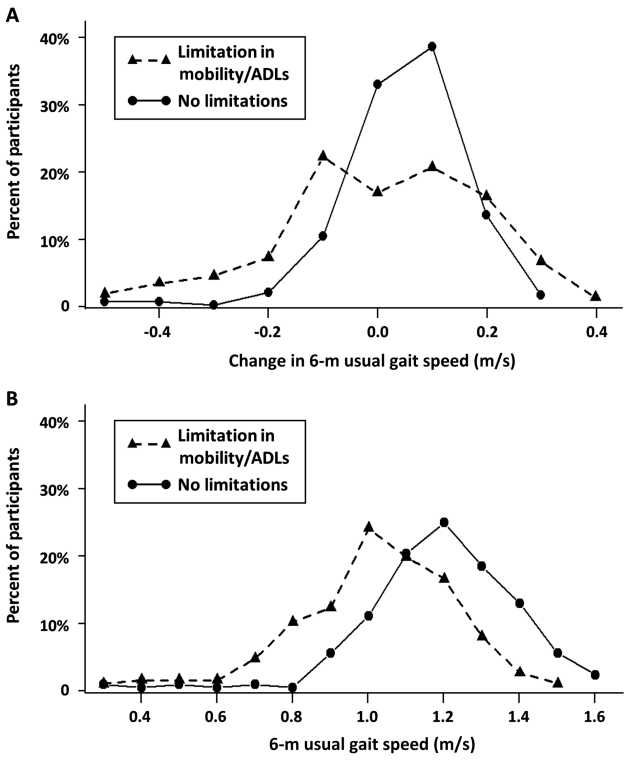

Figure 3. Gait speed for participants hospitalized during first year (n = 398). Distributions of (A) change in gait speed over the first year and (B) gait speed at the end of first year for participants with (n = 184) and without (n = 214) new limitations in mobility or activities of daily living (ADLs) at the end of the interval.

Discussion

In this longitudinal study of community-dwelling adults aged 70–79 years and independent in mobility and ADLs at baseline, we found that experiencing hospitalizations during 1-year intervals were associated with small concurrent declines in annually assessed gait speed. Hospitalizations were also associated with increased odds of developing new limitations in mobility and ADLs by the end of that

interval. For all outcomes, experiencing two or more hospitalizations within an interval was associated with larger effects, compared with having only one hospitalization. Adjustment for a comprehensive set of covariates, most of which were updated annually, did not substantially change the effects associated with hospitalization.

To our knowledge, this is the first study to examine the association of hospitalizations with changes in gait speed or other measures of lower extremity performance (31). Past studies evaluated performance of older adults during or after hospitalizations and lacked prehospitalization data. For example, a small study of older Italian patients showed that 50% had improved lower extremity performance at 1 month post-discharge, compared with the day of discharge (17). Much of this work also examined physical performance for patients admitted for specific medical conditions, such as stroke (19) or hip fracture (21,22). We found that hospitalization due to a variety of medical reasons was associated with concurrent decreases in gait speed that are likely to be clinically relevant in magnitude. Past work has shown that a change of 0.03 m/s in gait speed is associated with small declines in self-reported mobility, and decrease of 0.06 m/s with substantial decline (32,33). For community-dwelling older adults, slower gait speed predicts increased risk for death, hospitalization, and the need for long-term nursing care (15,23,31,34). In a cohort of older patients recruited from primary care clinics, slower baseline 4-m gait speed and 1-year decline of greater than or equal to 0.1 m/s were associated with higher mortality risk (35,36), whereas improvement of greater than or equal to 0.1 m/s was associated with lower mortality risk (37). Thus, interventions that aim to prevent hospitalization-associated decreases in gait speed may be important components of future programs to improve posthospitalization outcomes. For example, early mobilization during hospitalization may prevent deconditioning (38,39), and postdischarge geriatric case management (40) may identify patients with decreased physical performance who would benefit from more intensive rehabilitation.

Our study also confirms that hospitalizations are common for older community-dwelling adults, and all-cause hospitalizations are associated with substantially increased risk of decline in self-reported functional status. One third of our participants experienced one or more hospitalizations over 5 years, somewhat less than the 49% reported in a previous study of older community-dwelling adults over a similar length of follow-up (11). In our study, hospitalization events were confirmed by Health ABC Study staff (via review of medical records), whereas past studies used self-reported hospitalizations (12). We also observed that half of participants hospitalized during the first interval developed new limitations, while a quarter to a third of individuals hospitalized in the subsequent four intervals developed new limitations. Except for the first interval, our results are similar to past work showing a third of older adults develop increased difficulty with ADLs after hospitalization (4). It is unclear why a larger proportion of participants hospitalized during the first year developed new limitations. Overall, our results add to concerns that hospitalization-associated declines in function affect a substantial number of older adults.

In describing the health status of older adults, our findings also suggest that measured gait speed provides distinct information above and beyond that provided by assessment of self-reported functional limitations. Past studies have described variation in summary scores of physical performance for individuals with no self-reported difficulty in mobility or ADLs, showing that these performance scores predict mortality risk and nursing home admission (13,34,41). We similarly found a range of gait speed change and gait speed for hospitalized participants, even among individuals reporting no functional limitations. Thus, assessment of both gait speed and self-reported limitations at hospital discharge may help identify individuals at risk for future adverse outcomes.

Our study has several strengths including its comprehensive repeated assessment of participant characteristics, high follow-up rate, and confirmation of self-reported hospitalization with medical records. However, several limitations exist. Participants with more substantial declines in physical performance (eg, due to more severe illness during hospitalizations) would have been more likely to miss gait speed assessments after hospitalization. Thus, missing outcome data probably contributed to biased estimation of the impact of hospitalization toward the null. We used correction factors to compare gait speeds assessed using walks of varying distances (6 m at baseline, 20 m at annual follow-up clinic visits, and for less than 2% of participants, 4 m at follow-up home visits). We relied on self-reported medical conditions, health behaviors, and physical activity. Finally, black participants were oversampled, and participants were recruited from only two sites; therefore, the study sample is not representative of the general U.S. population.

Despite the abovementioned limitations, our results indicate that for well-functioning community-dwelling older adults, hospitalizations were associated with small to moderate declines in gait speed and higher odds of new limitations in mobility and ADLs. Thus, assessment of gait speed and limitations in mobility and ADLs at discharge may identify individuals who will benefit from interventions to promote recovery and mitigate risks. Future efforts should focus on design and evaluation of interventions during acute and postacute care to prevent declines in physical performance and enhance posthospitalization recovery of performance and function.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of Interest

None reported.

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