Improvement in Usual Gait Speed Predicts Better Survival in Older Adults

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OBJECTIVES: To estimate the relationship between 1-year improvement in measures of health and physical function and 8-year survival.

DESIGN: Prospective cohort study.

SETTING: Medicare health maintenance organization and Veterans Affairs primary care programs.

PARTICIPANTS: Persons aged 65 and older (N = 439).

MEASUREMENTS: Six measures of health and function assessed at baseline and quarterly over 1 year. Participants were classified as improved at 1 year, transiently improved, or never improved for each measure using a priori definitions of meaningful change: gait speed (usual walking pace over 4 m), 0.1 m/s; Short Physical Performance Battery, 1 point; Medical Outcomes Study 36-item Short Form Health Survey physical function, 10 points; EuroQol, 0.1 point; National Health Interview activity of daily living scale, 2 points; and global health change, two levels or reaching the ceiling. Mortality was ascertained from the National Death Index. Covariates included demographics, comorbidity, cognitive function, and hospitalization.

RESULTS: Of the six measures, only improved gait speed was associated with survival. Mortality after 8 years was 31.6%, 41.2%, and 49.3% for those with improved, transiently improved, and never improved gait speed, respectively. The survival benefit for improvement at 1 year persisted after adjustment for covariates (hazard ratio = 0.42, 95% confidence interval = 0.29–0.61, $P < .001$) and was consistent across subgroups based on age, sex, ethnicity, initial gait speed, healthcare system, and hospitalization.

CONCLUSION: Improvement in usual gait speed predicts a substantial reduction in mortality. Because gait speed is easily measured, clinically interpretable, and potentially modifiable, it may be a useful "vital sign" for older adults. Further research is needed to determine whether interventions to improve gait speed affect survival. **J Am Geriatr Soc 55:1727–1734, 2007.**

Key words: functional status; health status; gait speed; improvement; mortality

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Simple measures of health and function have repeatedly been shown to be powerful discriminators of future mortality in older adults.[1–4] Moreover, decline in health and function over time, whether measured according to self-report or performance, reduces survival independent of baseline measurements.[5–9] Although on average, health and function decline with age, individual trajectories are dynamic.[5,10,11] Many older adults can experience episodes of improved physical function and health due to positive lifestyle changes, recovery from an illness, or medical interventions. The association between improvements in function and health and subsequent survival in community-dwelling adults is not known.

The objective of this study was to determine whether improvement over 1 year in six self-reported and physical performance measures of health and function is associated with subsequent mortality; whether these associations are independent of other predictors of mortality, including baseline function; and whether these associations are consistent across important subgroups of older adults. Data from a prospective cohort study of the usefulness of physical performance measures to predict health and functional outcomes over 1 year were used.

METHODS

Overview

Subjects for this prospective cohort study were recruited from two primary care clinics (a Medicare health maintenance organization and a Veterans Affairs clinic) during April to October of 1996 and followed for 36 months. The purpose of the original study was to determine the feasibility and effectiveness of physical performance measures as predictors of health and functional outcomes in the primary

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care setting. The present study used data from the first 12 months of follow-up and mortality data from the National Death Index,[12] ascertained up to January 1, 2007. The institutional review boards of the relevant institutions approved the study. Study methods, described in detail elsewhere,[5,13] are summarized below.

Subjects

Eligible community-dwelling adults aged 65 and older from two primary care clinics serving a common geographic region in a major U.S. metropolitan area were recruited. Patients were eligible if they were either cognitively intact (Mini-Mental State Examination (MMSE)[14] score $\geq$24) or were mildly impaired (MMSE score 16–23) and had a caregiver, were able to walk 4 m, and had a gait speed between 0.2 and 1.3 m/s. Participants who used assistive devices were included.

Measures

Participants had baseline assessments of demographic characteristics, cognition,[14] and self-reported comorbid conditions.[15] Physical performance, health status, and self-reported functional status were assessed in home visits at baseline and 3, 6, 9, and 12 months. Physical performance was measured using the 12-point Short Physical Performance Battery (SPPB),[1,16] and usual gait speed was assessed over a 4-m course. Health status was assessed using the EuroQol, which ranges from 0 to 1,[17] and the five-level ordinal global health item from the Medical Outcomes Study 36-item Short Form Health Survey (SF-36).[18] Functional status was assessed using a 16-item, 32-point basic and instrumental activity of daily living (ADL) scale from the National Health Interview Survey[19] and the 100-point physical function index (PFI) of the SF-36.[18] Hospitalization during the initial year was ascertained from diaries and hospital records. Interrater and test–retest reliability for the measures used in this study were found to be excellent, with intraclass correlations generally greater than 0.9.[13] Date of death was determined using the Social Security National Death Index,[12] which confirms all deaths through a family member or death certificate.

Meaningful Change

A consensus panel defined criteria a priori for meaningful change in the six main measures of health and function based on literature review and clinical experience, as follows: 4-m usual-pace gait speed, 0.1 m/s;[20] SPPB, 1 point;[20] SF-36 PFI, 10 points;[5] EuroQol, 0.1 points;[5] National Health Interview Survey ADLs, 2 points;[5] and global health change, two levels or reaching the ceiling.[5] Participants were grouped into three improvement categories based on an increase of at least the prespecified magnitude from baseline at different follow-up time points: improved at 1 year (1-year improvers); improved at 3, 6, or 9 months, but not at 1 year (transient improvers); and never improved (never improvers). The 1-year point was selected for analysis a priori, because the original study was designed to examine changes over 1 year and because many health maintenance examinations are recommended annually.

Statistical Analysis

Mortality rates in those who did and did not show an improvement in the six main measures of function and health were compared. Treating the 12-month follow-up visit as zero time for subsequent survival, Kaplan-Meier product-limit survival curves were used to depict survival graphically, and Cox proportional hazards models were used to estimate hazard ratios (HRs), their 95% confidence intervals (CIs), and *P*-values to compare the rates of death across groups. The proportional hazards assumption was checked by including the interaction between time and change groups in the model; these interaction terms were not significant. All six initial models were adjusted for age, sex, race, education, baseline status, comorbid burden, and any hospitalization within the first year of follow-up. Analyses using alternate criteria for meaningful change in the SPPB and self-report measures (SPPB, 2 points; SF-36 PFI, 5 points; EuroQol, 0.05 points; NIHS ADLs, 1 point; and global health, 1 level) were also performed.

After detecting the association between gait speed gain and survival, additional post hoc analyses were performed to better assess this phenomenon. Because gait speed is a component of the SPPB, the association between improvement in SPPB and survival was assessed after adjustment for improvement in gait speed. The association between gait speed gain and survival was reassessed using different definitions of the magnitude of gain; potential additional confounders (cognition, baseline global health, functional status, and physical function from the SF-36); a sensitivity analysis for participants with missing data; and within important subgroups, formed by stratifying according to clinically meaningful cutpoints. The consequences of the choice of a 1-year point for analysis were examined by repeating the analysis using other time points. Further analyses adjusted for gait speed at 1 year instead of at baseline were performed to evaluate whether faster gait speeds at 1 year, rather than improvements over the prior year, explained the association with survival. To confirm that the results were due to less mortality in improvers rather than greater mortality in decliners, the analysis was repeated using participants with no change in gait speed as the control group. For these analyses, no change was defined as gait speed change from baseline to 1 year of less than an absolute value of 0.1 m/s. SAS version 8.2 (SAS Institute, Inc., Cary, NC) was used for all analyses, with PHREG and LIFETEST procedures for main analyses.

RESULTS

Of the 572 individuals screened, 492 (86.0%) entered the study, and 439 (92.6% of survivors) were followed over the year. The study population had a mean age of 74, and 44.4% were female (Table 1, first column). Men were overrepresented in this study, because one of the recruitment sites was a Veterans Affairs clinic. Persons who scored at or near the ceiling for a measure at baseline had no room for detectable improvement and could not be categorized for the purposes of this study. Ceiling effects eliminated 22 participants for the SPPB analyses, 91 for the SF-36 physical function score, 49 for global health, 146 for the EuroQol, and 245 for functional status. As of July 2006, 188 participants (43%) had died. As expected, each of the six baseline

Measure	1-Year Improvers N	1-Year Improvers Deaths	Transient Improvers N	Transient Improvers Deaths	Never Improvers N	Never Improvers Deaths
Gait Speed	136	47	68	28	211	105
SPPB	167	78	104	45	126	57
SF-36 PFI	133	58	79	44	119	58
Global Health	13	7	20	12	334	145
EuroQol	107	48	69	43	94	42
NHIS ADL	86	44	43	28	57	29

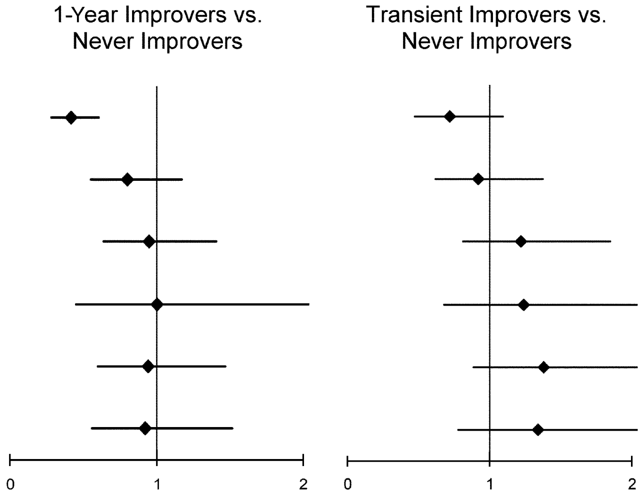

Figure 1. Adjusted effects of 1-year improvement in six measures of health and function on 8-year survival in older adults. Hazard ratios from Cox models are presented, with the diamonds representing the point estimates and the lines the 95% confidence intervals. Each model was adjusted for the baseline value of the measure, age, sex, race, education, comorbid disease burden, and hospitalization. SPPB = Short Physical Performance Battery; SF-36 PFI = Medical Outcomes Study 36-item Short-Form Health Survey Physical Function Index; NHIS ADL = National Health Interview Survey basic and instrumental activities of daily living.

measures, baseline age, comorbid burden, and hospitalization during the index year significantly predicted survival as individual variables (all $P < .05$).

Of the six commonly used measures of health and function, only improvement in gait speed at 1 year was significantly associated with subsequent mortality (Figure 1). Analyses using alternate criteria for meaningful change in self-report measures also failed to show a significant association with survival. For gait speed improvement, the unadjusted mortality rate was 31.6% in 1-year improvers, 41.2% in transient improvers, and 49.3% in never improvers ($P = .005$). Characteristics of the three gait speed improvement groups are compared in Table 1. The only significant difference between the groups at baseline was in

Table 1. Characteristics of the Study Population According to Ability to Increase Gait Speed 0.1 m/s over 1 Year

Characteristic	Total (N = 439)	1-Year Improvers (n = 136)	Transient Improvers (n = 68)	Never Improvers (n = 211)	P-Value*
Baseline					
Age, mean ± SD	73.9 ± 5.6	73.8 ± 5.7	73.3 ± 6.1	73.9 ± 5.4	.79
Female, n (%)	195 (44.4)	63 (46)	29 (43)	94 (45)	.88
White, n (%)	346 (78.8)	101 (74)	58 (85)	168 (80)	.41
High school education, n (%)	290 (66.0)	87 (64)	47 (69)	141 (67)	.74
Number of comorbid conditions (of 8)	2.4 ± 1.3	2.2 ± 1.3	2.3 ± 1.5	2.5 ± 1.3	.07
ADL/IADL					
No difficulty in ADLs or IADLs, n (%)	137 (33.7)	46 (38)	21 (33)	61 (31)	.76
Difficulty in IADLs only	183 (45.1)	51 (42)	30 (47)	95 (48)	
Difficulty in ADLs	86 (21.2)	24 (20)	13 (20)	43 (22)	
Recruitment site: Medicare health maintenance organization	315 (71.8)	157 (74.4)	43 (63.2)	101 (74.3)	.17
Gait speed (m/s)	0.88 ± 0.24	0.81 ± 0.24	0.91 ± 0.23	0.91 ± 0.24	<.001
Short Physical Performance Battery score (range 0–12)	8.5 ± 2.6	8.4 ± 2.6	9.0 ± 2.3	8.5 ± 2.7	.23
Mini-Mental State Examination score (range 0–30)	27.5 ± 2.4	27.2 ± 2.7	27.7 ± 2.4	27.7 ± 2.1	.12
EuroQol score (range 0–1)	0.76 ± 0.18	0.78 ± 0.15	0.76 ± 0.19	0.76 ± 0.19	.43
Excellent, very good, or good health	347 (79.0)	112 (82)	53 (77)	161 (76)	.40
Medical Outcomes Study 36-item Short Form Survey Physical function score (range 0–100)	65.0 ± 29.0	67.9 ± 28.9	68.7 ± 28.5	62.4 ± 28.8	.12
One year					
Hospitalized during prior year	96 (21.9)	25 (18)	13 (19)	46 (22)	.72
Gait speed (m/s)	0.91 ± 0.29	1.01 ± 0.24	0.86 ± 0.33	0.87 ± 0.29	<.001
Change in gait speed from baseline	0.03 ± 0.19	0.20 ± 0.09	− 0.06 ± 0.21	− 0.05 ± 0.15	<.001

* *P*-values are for the comparison across groups, using chi-square for categorical variables and *t*-tests for continuous variables.
ADL = basic activities of daily living; IADL = instrumental activities of daily living.

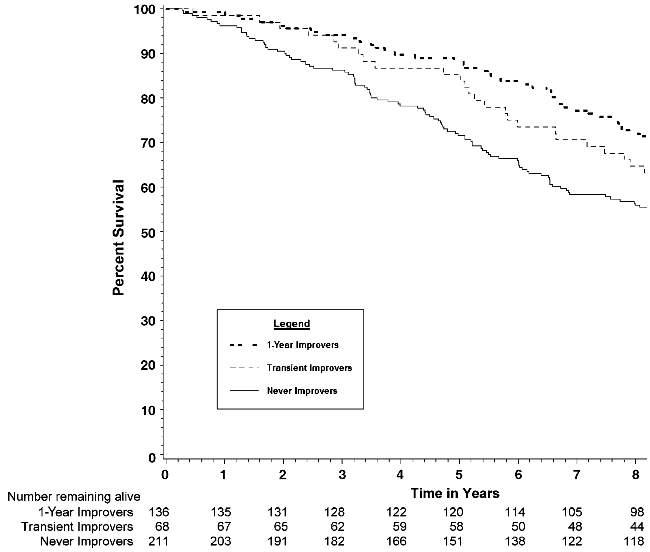

Figure 2. Eight-year survival based on Kaplan-Meier survival curves in older adults who improved, improved transiently, or never improved in gait speed over the course of 1 year. $P<.001$ for comparison across groups.

gait speed, with the improvers having slightly slower gait speeds than those with transient or no improvement.

The adjusted mortality HR for gait speed 1-year improvers versus never improvers was 0.42 (95% CI = 0.29–0.61, $P<.001$), whereas the HR for transient gait speed improvers versus never improvers was favorable but not statistically significant (0.72, 95% CI = 0.47–1.10, $P=.12$). The 1-year improvers had significantly better survival than the transient improvers (adjusted HR = 0.58, 95% CI = 0.36–0.95). Exclusion of the 25 participants who used an assistive device at baseline did not alter these results (data not shown). Survival curves for the three gait speed improvement groups are shown in Figure 2. Despite slightly slower baseline gait speed, improvers had the best survival, whereas never improvers had the worst survival, and transient improvers formed an intermediate category. Improvement over the baseline year resulted in a separation of survival curves that persisted out to 8 years.

Estimates for the association between improvement in SPPB score over 1 year (HR = 0.80, 95% CI = 0.55–1.17, $P=.25$) and transiently (HR = 0.92, 95% CI = 0.62–1.37, $P=.70$) and survival were modest and not significant (Figure 1). Using an increase of 2 points as the definition of meaningful change, the adjusted association between 1-year improvement and survival was significant (HR = 0.56, 95% CI = 0.36–0.88). Because gait speed is a component of the SPPB, the association between 2-point improvement in SPPB and survival was examined after adjustment for improvement in gait speed, and it was found that the HR became nonsignificant (HR = 0.81, 95% CI = 0.50–1.30), indicating that gait speed improvement accounted for much of the association between SPPB improvement and survival.

One-year improvement in the four self-report measures of health and function demonstrated no statistically significant effect on survival, but power was limited because of the small sample size caused by exclusion of subjects who were at the ceiling at baseline and thus unable to improve. However, the HRs were all close to 1 for improvers compared with never improvers, and the CIs excluded moderate to strong associations with mortality (Figure 1), suggesting that low power did not obscure a clinically meaningful association. Transient improvement in self-reported health and function also had no association with survival; CIs are wide, and point estimates are on the opposite side of 1.

The strong association between gait speed improvement and survival was assessed in further post hoc analyses (Table 2) in which HRs and CIs are presented for models testing various assumptions. Models 1 and 2 present the HRs for gait speed improvement in models that are unadjusted and adjusted for baseline gait speed. This strong association between improvement in gait speed and survival persists in models adjusted for the main covariates (Model 3) and in a model that adjusted for the initial set plus baseline cognitive function, global health, physical function from the SF36, and functional status (Model 4). In Model 5, these associations were reassessed using a gain in gait speed of 0.05 m/s, previously shown to represent a small mean-

Table 2. Tests of Assumptions on the Effect of Gait Speed Improvement on 8-Year Survival

Model	Assumptions	1-Year Improvers Versus Never Improvers	Transient Improvers Versus Never Improvers
		Hazard Ratio (95% Confidence Interval) *P*-Value	
1	Unadjusted gain of 0.1 m/s	0.54 (0.37–0.76) <.001	0.74 (0.49–1.13) .16
2	Model 1 adjusted for baseline gait speed	0.39 (0.27–0.56) <.001	0.73 (0.48–1.11) .14
3	Model 1 adjusted for baseline gait speed, age, sex, race, education, comorbidity, and hospitalization	0.42 (0.29–0.61) <.001	0.72 (0.47–1.10) .12
4	Model 3 plus cognition, baseline health, Medical Outcomes Study 36-item Short Form Survey physical function, and activities of daily living	0.44 (0.30–0.64) .001	0.73 (0.48–1.21) .15
5	Gait speed improvement ≥0.05 m/s and covariates in Model 3	0.51 (0.35–0.73) <.001	0.81 (0.55–1.21) .31
6	Two levels of gait speed improvement and covariates in Model 3, m/s*		
	0.1–0.19	0.44 (0.25–0.78) .005	N/A
	≥0.2	0.47 (0.26–0.86) .013	
7	All persons with missing gait speed conservatively assigned to the 1-year improver category (adjusted for covariates as in Model 3)	0.51 (0.36–0.71) <.001	0.72 (0.47–1.09) .12

* One-year improvers only.

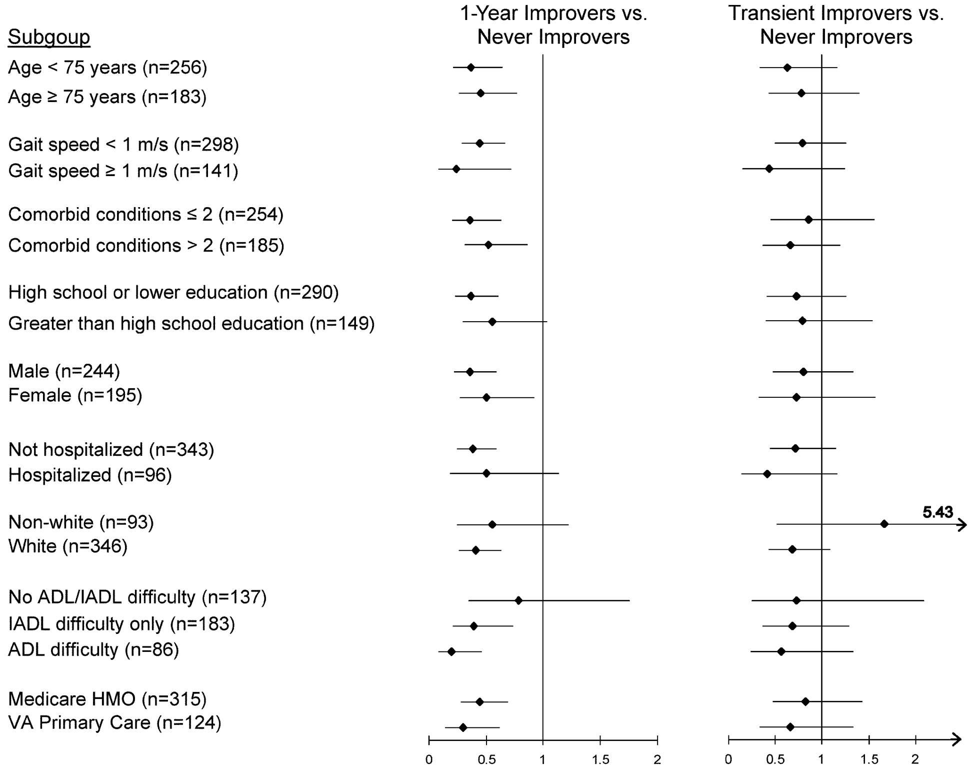

Figure 3. Adjusted effects of 1-year improvement in gait speed on 8-year survival in subgroups of older adults. Hazard ratios from Cox models are presented, with the diamonds representing the point estimates and the lines the 95% confidence intervals (CIs). When the upper CI extends beyond a hazard ratio of 2.5, the line ends in an arrow, and the upper CI is printed above the line. Each model was adjusted for baseline gait speed, age, sex, race, education, comorbid disease burden, and hospitalization. IADL = instrumental activity of daily living; ADL = basic activity of daily living; HMO = health maintenance organization; VA = Veterans Affairs.

ingful change.[20] In Model 6, the association with survival of a gait speed gain of more than 0.2 m/s was similar to the association with a gain of 0.1 to 0.19 m/s. Model 7 is a sensitivity analysis to assess the effect of missing gait speed data on the relationship between gait speed improvement and survival. Twenty-four participants did not have gait speed data at follow-up assessments. They could not be assigned to an improvement category and were excluded from the gait speed analyses described in Models 1 to 6 and in the figures. Mortality in subjects with missing gait speed was higher (54%, 13/24) than in those included in the above analyses (42%, 175/415). In a conservative test of the relationship between improvement and survival, all persons with missing data were assigned to the group with the lowest mortality; the 1-year improvers. The HR for mortality remained significant and of similar magnitude to other estimates.

To examine the role of assessment interval in the association between gait speed improvement and survival, the gait speed were repeated analyses using improvement at 3, 6, and 9 months as the main predictor. The adjusted HRs comparing improvers with never improvers at each time point were 3 months, 0.69 (95% CI = 0.46–1.03, $P = .07$); 6 months 0.74 (95% CI = 0.51–1.07, $P = .11$); and 9 months, 0.62 (95% CI = 0.43–0.90, $P = .01$). The association between improvement and survival was consistently in the expected direction, although it was only statistically significant for the 9-month time point.

To assess whether faster gait speeds at 1 year, rather than improvements over the prior year, explained the better survival, the analyses were repeated adjusting for gait speed at 1 year instead of at baseline. The significant decrease in mortality in the improvers at 1 year persisted (covariates as in Model 4 above, HR = 0.63, 95% CI = 0.44–0.91, $P = .01$). To confirm that the findings were due to less mortality in the improvers rather than less survival in the decliners, survival in the improvers at 1 year was compared with that of those with no change at 1 year; it was found that improvers had significantly better survival in unadjusted (HR = 0.59, $P = .003$) and adjusted (HR = 0.45, $P < .001$) analyses.

In another set of post hoc analyses, the association between improvement in gait speed and survival was assessed in potentially clinically important subgroups (Figure 3), including sex, ethnicity, age, education, initial gait speed, hospitalization, healthcare system, and level of function in daily activities. HRs for gait speed improvement were consistent, favorable, and statistically significant for subgroups within categories of age, sex, initial gait speed, healthcare system, and comorbid burden. Associations were consistently favorable but not always statistically significant within all subcategories for education, ethnicity, functional status, and hospitalization. In the subgroup analyses, transient improvement in gait speed compared with no improvement produced consistently favorable but diluted HRs that did not reach statistical significance (Figure 3).

DISCUSSION

An increase in usual gait speed over a 1-year period strongly predicts survival through the subsequent 8 years, with a 58% reduction in relative risk and a 17.7% reduction in absolute risk of death. This survival benefit persists after adjustment for numerous medical, functional, and psychosocial factors that are known to affect survival and is highly consistent across a variety of important subgroups. Although survival of transient improvers was not significantly better than that of never improvers, the small sample size in this group limits power to detect an association. Improvement in usual gait speed, perhaps even transiently, could be a useful clinical indicator of well-being in older adults and is a potential target for interventions.

Why would short-term improvement in usual gait speed affect survival? Perhaps improved gait speed is a subclinical indicator of "physiological reserve."[21] It may indicate a kind of resilience, or an ability to improve or recover from a prior stressful event.[22,23] Improved gait speed over time might also indicate improved physiological health due to medical interventions or change in health behaviors such as physical exercise. Why would self-reported improvement not affect survival? Many of the self-report measures used in this study, although widely accepted indicators of status in older adults, have substantial ceiling effects, so that improvements may be difficult to detect. It is possible that self-report measures that probe higher levels of health and function might perform better as detectors of improvement,[24] although there was no association between improvement in self-reported health and function in persons well below the ceiling and survival, whereas there was a strong association between improvement in gait speed in slow walkers and survival.

The prognostic implications of improved gait speed have rarely been evaluated. In a geriatric rehabilitation setting, increasing gait speed predicted subsequent independence in mobility.[25] Older veterans whose gait speed increased over a 1-year period also experienced improved health status and physical function, fewer disabilities, and lower healthcare utilization and costs.[26] In patients with severe congestive heart failure, the 6-minute walk distance predicted survival and hospitalization over the next year, but change in distance over the first month had no independent contribution to either outcome.[27] No other studies of the association between improved gait speed and survival could be found.

This study has several strengths. It focuses on older adults recruited from primary care offices, making results relevant to primary care providers and their patient populations. African Americans were well represented, which further enhances the generalizability of the results. Participants were assessed in their homes every 3 months, allowing for frequent monitoring and minimizing missing data due to inability to travel. This frequent assessment schedule allowed short-term improvements that might otherwise go unnoticed to be detected.[28] Participant retention was excellent, with more than 92% of survivors still in the study at 1 year. The sensitivity of the findings to adjustment for important covariates, alternative criteria for improvement, and the effect of missing data was examined. Consistent strong associations with survival were found, increasing the validity of the results.

The study also has several limitations. Limited clinical information was available to explain the relationship between change in gait speed and survival. Improved gait speed was associated with better survival when adjusted for hospitalization between the baseline and 1-year assessments, but information about the reason for these hospitalizations was unavailable. There may have been specific acute illnesses, such as cancer or hip fracture, that prevented gait speed improvement and increased risk of mortality. A self-report measure of comorbid conditions was used. Although this is a real constraint, it is also common in studies of aging[1,10] and has been demonstrated to be a valid alternative to chart review.[29] Direct assessment of subclinical physiological impairments could provide important insights into the potential mechanisms of the association between gait speed improvement and survival.[30] Finally, although older adults with a wide range of health and function were included in this study, power to detect the consequences of improvement in self-report measures was limited because of ceiling effects. Nonetheless, the point estimates for mortality risk of the self-reported improvements were close to 1.0, and CIs excluded moderate to strong associations, suggesting that lack of power alone is unlikely to explain the lack of association.

Gait speed has been recommended as a possible "vital sign" in older adults.[31] The results of the current study add to the increasingly robust evidence in support of routine clinical measurement of gait speed. Gait speed measurement requires 2 to 3 minutes in the outpatient clinical setting, and clinical staff and patients find it acceptable.[13] Clinical cutpoints for single measurements and meaningful changes in gait speed have been defined. Older adults can be categorized as slow, intermediate, or fast walkers using cutpoints of 0.6 and 1.0 m/s.[13] Those with slower gait are at higher risk for functional decline, morbidity, and mortality.[13,16,25] Older persons who walk faster than 1.0 m/s generally have good functional status, lower risk of health events, and better survival.[4,13] Gait speed has known relationships with overall aerobic capacity and functional status, so it can be linked to cardiovascular health and capacity to perform daily activities. Although usually reported as velocity in m/s, gait speed can be converted to miles/h, perhaps a more familiar metric for the American public. An increase in gait speed of 0.1 m/s is equivalent to a gain of about 0.2 miles/h,[32] which is subtle but detectable.

Evaluation strategies and interventions for gait speed have been proposed, and further development is possible. Organized clinical assessments of contributors to walking speed target the cardiopulmonary, musculoskeletal, and neurological systems.[33,34] Gait speed can be a target for intervention through medical, rehabilitative, and health-promoting behavioral strategies. Therapeutic exercise can improve habitual gait speed in older adults,[35] and interventions on conditions such as congestive heart failure, arthritis, and chronic obstructive pulmonary disease have shown some effects on walking speed.[36–40] Medical, surgical, rehabilitative, and behavioral interventions to improve gait speed should be formally assessed, individually and in combination, for their ability to improve not only function and quality of life but also possibly survival.

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Author Contributions: Susan E. Hardy: study concept and design, analysis and interpretation of data, drafting of manuscript. Subashan Perera: conception and design, analysis and interpretation of data, drafting of manuscript. Yazan Roumani: analysis and interpretation of data, critical revision of manuscript. Julie M. Chandler: conception and design, critical revision of manuscript. Stephanie A. Studenski: study concept and design, collection and assembly of data, analysis and interpretation of data, drafting of manuscript.

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