Longitudinal Association Between Self-rated Health and Timed Gait Among Older Persons

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Objective. We evaluated the longitudinal association between self-rated health (SRH) and timed gait, an indicator of lower extremity dysfunction, in a community-based sample of older persons.

Methods. Participants ($N = 754$) were evaluated at 18-month intervals for 72 months. SRH was categorized as Excellent/Very Good/Good and Fair/Poor. Participants were asked to walk a 10-foot course "as fast as it feels safe and comfortable," turn around, and walk back, with timed gait defined as normal (≤ 10 s) or slow (>10 s). Generalized multinomial logit models, adjusted for demographic features, biomedical and psychosocial factors, and activities of daily living, evaluated the association between SRH and the likelihood of 6 possible transitions (from normal or slow timed gait to normal timed gait, slow timed gait, or death) over time. We also ran a repeated measures linear mixed model with change in timed gait as the outcome.

Results. Compared with participants reporting Excellent/Very Good/Good SRH, those reporting Fair/Poor SRH were more likely to transition from normal to slow timed gait or to death. SRH was not associated with transitions from slow timed gait to normal timed gait or to death. In addition, time to complete the gait task increased (i.e., slowed) over time among participants reporting Fair/Poor SRH compared with those reporting Excellent/Very Good/Good SRH.

Discussion. Among older persons, SRH is associated with the development of lower extremity dysfunction but not with recovery from lower extremity dysfunction. This relationship may indicate an intermediate step in the pathway from SRH to mortality.

Key Words: Gait—Longitudinal study—Objective measures—Older people—Self-rated health.

T HE association between self-rated health (SRH), perception of one's own health status, and mortality has been firmly established, even after controlling for an array of health indicators, including comorbidity and cognitive function (DeSalvo, Bloser, Reynolds, He, & Munter, 2006; Idler & Benyamini, 1997). Furthermore, as SRH is a dynamic construct (Idler & Benyamini, 1997), a decline in SRH over time is more highly associated with mortality risk than is a single self-rating of health (Ferraro & Kelley-Moore, 2001; Lyyra, Leskinen, Jylha, & Heikkinen, 2009). Despite substantial research evaluating the relationship between SRH and mortality, however, potential mechanisms influencing the association between SRH, or a decline in SRH, and mortality remain poorly defined.

Because functional decline is associated with mortality in older persons (Ponzetto et al., 2003), the relationship between SRH and functional status may be indicative of an antecedent pathway to mortality in this population. Positive ratings of SRH have been found to be protective of a decline in self-reported functional ability over time, even after adjusting for baseline functional status (Idler, Russell, & Davis, 2000). Thus, maintenance of functioning may operate as the intermediate step in the well-established association between SRH and mortality. Use of self-reported assessments of functional status in these studies, however, does not address whether worse ratings of SRH are independently associated with objective measures of lower extremity dysfunction. Lower extremity dysfunction may represent an early stage in the disablement process that precedes disability in basic activities of daily living (ADLs; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995; Verbrugge & Jette, 1994) and is associated with increased mortality risk in older persons (Guralnik, Ferrucci, Balfour, Volpato, & Di Iorio, 2001). Consequently, it is plausible that an association between SRH and lower extremity dysfunction may be indicative of a pathway that precedes later disability and mortality among older persons.

Slow timed gait, an objective measure of lower extremity dysfunction, is a strong predictor of onset of disability in basic ADLs (Onder et al., 2005). Furthermore, studies have reported an association between timed gait and subsequent SRH (Jylha, Guralnik, Balfour, & Fried, 2001; Leinonen, Heikkinen, & Jylha, 2002). To date, however, no longitudinal study has evaluated the association between SRH and change in timed gait in older persons.

We sought to determine the longitudinal association between SRH and timed gait among older persons. To achieve our objective, we evaluated (a) possible transitions among three states—normal timed gait, slow timed gait, and death, and (b) change in timed gait, at 18-month intervals for 6 years, among a large community-based cohort of older persons.

METHODS

Study Population

Participants included 754 community-living persons aged 70 years and older enrolled in the Precipitating Events Project (PEP; Gill, Desai, Gahbauer, Holford, & Williams, 2001). Potential participants were identified from a list of 3,157 age-eligible members of a large health plan in New Haven, CT. Plan members were eligible if they were community living, English speaking, and nondisabled (requiring no personal assistance) in four key ADLs: bathing, walking, dressing, and transferring from a chair. Exclusion criteria included terminal illness with life expectancy less than 12 months, plans to move out of the New Haven area during the next 12 months, and significant cognitive impairment with no available proxy. In addition, persons who required more than 10 s to walk back-and-forth over a 10-foot course at a rapid pace were oversampled to ensure a sufficient number of participants at increased risk for ADL disability. The participation rate was 75.2%. During the 6-year follow-up between March 23, 1998, and August 31, 2005, 232 participants died after a median of 48 months, 27 dropped out of the study after a median of 24 months, and 18 were excluded because they required a proxy respondent after a median of 32 months. The Human Investigation Committee at the Yale University approved the study.

Data Collection

Data were collected during in-home assessments conducted by trained research nurses at baseline and every 18 months for up to 72 months. Demographic data included age, sex, race, total years of education, and whether the participant lived alone. Biomedical factors included medical comorbidity and cognitive status. Psychosocial variables included depressive symptoms, self-efficacy, social support, and social activity. Data were also collected on ADLs. Further description of the measures used to assess these variables is provided in Table 1. Deaths were ascertained by review of local obituaries and/or from an informant.

Assessment of SRH

The independent variable of interest, SRH, was assessed at each of the five time points (i.e., baseline, 18, 36, 54, and 72 months) by asking the participants, "Would you say your health is Excellent, Very Good, Good, Fair, or Poor?"

Table 1. Participant Characteristics According to Timed Gait at Baseline

Characteristics	Slow timed gait ($n = 322$)	Normal timed gait ($n = 432$)	p Value
SRH[a]			
Excellent/Very Good/Good	184 (57.1)	359 (83.1)	<.001
Fair/Poor	138 (42.9)	73 (16.9)	
Demographics			
Age (years)	80.4 ± 5.4	77.0 ± 4.7	<.001
Female	227 (70.5)	260 (60.2)	.003
White race	283 (87.9)	399 (92.4)	.04
Education (years)	11.6 ± 2.9	12.8 ± 2.8	<.001
Living alone	150 (46.6)	148 (34.3)	<.001
Biomedical			
Number of chronic conditions[b]	2.2 ± 1.3	1.6 ± 1.1	<.001
MMSE score[c]	26.3 ± 2.6	27.1 ± 2.3	<.001
Psychosocial			
Depressive symptoms[d]	95 (29.5)	61 (14.1)	<.001
Self-efficacy[e]	25.1 ± 7.1	34.0 ± 5.6	<.001
Social support[f]	21.9 ± 5.7	22.7 ± 5.3	.05
Social activity[g]	7.2 ± 3.2	9.5 ± 2.9	<.001
ADLs			
ADL score[h]	20.6 ± 3.3	23.1 ± 1.7	<.001

Notes: *p* Values were determined using SAS statistical software, version 9.1. Data are given as $M \pm SD$ unless otherwise indicated. Data are given as *n* (%) of participants. SRH = self-rated health; ADLs = activities of daily living; MMSE = Mini-Mental State Examination.

[a] Mean timed gait at baseline for those with Fair/Poor SRH was 13.03 ± 7.14 s compared with 9.81 ± 5.73 among those with Excellent/Very Good/Good SRH ($p < .001$).

[b] Number of chronic conditions was ascertained based on the presence of nine self-reported, physician-diagnosed chronic conditions, including hypertension, myocardial infarction, congestive heart failure, stroke, diabetes mellitus, arthritis, hip fracture, chronic lung disease, and cancer (other than minor skin cancer).

[c] Cognitive status was assessed by the *Folstein MMSE*, with lower scores indicating worse cognitive status (range 0–30).

[d] Depressive symptoms were determined by the 11-item version of the *Center for Epidemiologic Studies Depression scale*, with a score of 16 and more indicating clinically significant depression.

[e] Self-efficacy was determined by a modified version of the *Falls Efficacy Scale*, with higher scores indicating higher self-efficacy (range 0–40).

[f] Social support was determined by the *Medical Outcomes Study Social Support Survey*, with higher scores indicating higher self-efficacy (range 0–28).

[g] Social activity levels were determined by the *Established Populations for Epidemiologic Studies in the Elderly Social Activity Instrument*, with higher scores indicating higher social support (range 0–20).

[h] Participants were asked if they needed help from another person to perform the following 12 ADLs: bathing, dressing, transferring, walking around house or apartment, eating, grooming, toileting, shopping, housework, meal preparation, taking medications, and paying bills. Responses were scored as 0 (*needs help/unable to do*), 1 (*no help needed but difficulty*), or 2 (*no help needed, no difficulty*), with an overall ADL scale ranging from 0 to 24.

The five responses were collapsed into a dichotomous variable to form the following categories: Excellent/Very Good/Good and Fair/Poor.

Assessment of Timed Gait

To assess timed gait, participants were asked to walk a 10-foot (3.048-m) course "as fast as it feels safe and comfortable," turn around, and walk back. This rapid gait task

Table 2. Longitudinal Association Between Self-rated Health and Transitions in Timed Gait[a]

Transitions	Unadjusted Odds ratio (95% CI)	Adjusted Model 1 Odds ratio[b] (95% CI)	Adjusted Model 2 Odds ratio[c] (95% CI)	Adjusted Model 3 Odds ratio[d,e] (95% CI)
Normal timed gait to[f]				
Normal timed gait	1.00	1.00	1.00	1.00
Slow timed gait	2.22 (1.61–3.06)	2.00 (1.44–2.79)	1.78 (1.24–2.57)	1.63 (1.13–2.37)
Death	3.18 (1.81–5.56)	3.19 (1.84–5.54)	2.44 (1.36–4.38)	2.22 (1.24–3.96)
Slow timed gait to[g]				
Slow timed gait	1.00	1.00	1.00	1.00
Normal timed gait	0.80 (0.56–1.14)	0.76 (0.52–1.12)	0.86 (0.56–1.31)	1.04 (0.68–1.60)
Death	1.40 (0.98–1.99)	1.60 (1.10–2.33)	1.38 (0.90–2.10)	1.32 (0.85–2.04)

Notes: Longitudinal models utilized an exchangeable correlation structure and were performed using SUDAAN survey data analysis software, version 9.0. CI = confidence interval; MMSE = Mini-Mental State Examination.

[a] Fair/Poor self-rated health compared with Excellent/Very Good/Good self-rated health (referent category).

[b] Adjusted for demographic characteristics (age, gender, race, and education).

[c] Adjusted for demographic characteristics, number of chronic conditions, MMSE score, and depression.

[d] Adjusted for demographic characteristics, number of chronic conditions, MMSE score, depression, and activity of daily living score.

[e] The adjusted Wald F-test statistic for the fully adjusted model in which normal timed gait to normal timed gait is the reference category is 7.90 (18 *df*; model minus intercept), $p < .001$. The adjusted Wald F-test statistic for the fully adjusted model in which slow timed gait to slow timed gait is the reference category is 8.47 (18 *df*; model minus intercept), $p < .001$.

[f] Model includes participants who had normal timed gait at the beginning of an 18-month interval, with participants who had normal timed gait during the entire interval (i.e., at two consecutive 18-month time points) serving as the comparison group.

[g] Model includes participants who had slow timed gait at the beginning of an 18-month interval, with participants who had slow timed gait during the entire interval (i.e., at two consecutive 18-month time points) serving as the comparison group.

was demonstrated to each participant by a nurse interviewer, and the time to complete this task (in seconds) was determined using a handheld stopwatch, with interrater reliability determined to be .86 by intraclass correlation coefficients. Participants who completed the task in more than 10 s were considered to have "slow" timed gait, whereas those who completed the task in 10 s or less were classified as having "normal" timed gait. The 10-s cutoff point has previously identified a threshold response between timed gait and the development of disability in a population-based cohort of older persons (Gill, Williams, & Tinetti, 1995). In addition, change in timed gait during an 18-month interval was calculated as the difference in timed gait between the two relevant time points. A negative change score denoted an improvement in timed gait, whereas a positive change score denoted a slowing of timed gait. Data on timed gait were complete for 100% of the participants at baseline and 95.5%, 94.5%, 92.5%, and 90.8% of the nondecedents at 18, 36, 54, and 72 months, respectively.

Statistical Analysis

Cross-sectional bivariate associations between participants' characteristics and level of SRH and timed gait (normal vs. slow) were determined using χ^2 or *t*-test statistics at each of the five time points (i.e., baseline, 18, 36, 54, and 72 months). To assess the associations between SRH and the likelihood of the six possible transitions over time, we used repeated measures generalized multinomial logit models run using generalized estimating equations. The magnitude of association was denoted by odds ratios (ORs). In addition, we ran a repeated measures linear mixed model with

change in timed gait as the outcome. Potential covariates were selected from an a priori list of variables previously determined in the literature to be associated with SRH or timed gait. Covariates were selected for inclusion in the models if they were associated with both SRH and timed gait (normal vs. slow) in bivariate analyses at the $p < .10$ level. The models were sequentially adjusted for demographic characteristics; then for demographic characteristics and the number of chronic conditions, Mini-Mental State Examination (MMSE) score, and depression; and finally for each of the aforementioned factors and ADL score. All statistical tests were two-tailed, and $p < .05$ was considered statistically significant.

RESULTS

At baseline, 543 (72.0%) of the participants reported Excellent/Very Good/Good SRH and 211 (28.0%) reported Fair/Poor SRH. Slow timed gait was documented in 322 (42.7%) of the participants. Table 1 presents the participant characteristics according to timed gait (slow vs. normal) at baseline. Compared with those with normal timed gait at baseline, those with slow timed gait were more likely to report Fair/Poor SRH, to be females and non-White, to live alone, and to be depressed. They were also older; had fewer years of education; had more chronic conditions; and had lower MMSE, self-efficacy, social support, social activity, and ADL scores. Comparable differences were observed at each of the four follow-up time points (data not shown).

Table 2 provides the results from the longitudinal models evaluating the association between SRH and transitions in timed gait. In the unadjusted analysis, the likelihood of

transitioning from normal to slow timed gait was increased more than twofold for participants having Fair/Poor SRH compared with those having Excellent/Very Good/Good SRH, whereas the likelihood of transitioning from normal timed gait to death was increased more than threefold. The addition of demographic characteristics to the model (Adjusted Model 1) reduced the OR for the transition from normal to slow timed gait by approximately 10%. Further adjustment for the biomedical variables and depressive symptoms attenuated the ORs for the transition from normal to slow timed gait by about 11% and attenuated the ORs for the transition from normal timed gait to death by about 24% (Adjusted Model 2). The addition of ADL score to the model further attenuated the ORs, and participants who reported having Fair/Poor SRH had a higher likelihood of transitioning from normal to slow timed gait (OR 1.63, 95% confidence interval [CI] 1.13–2.37) and death (OR 2.22, 95% CI 1.24–3.96) compared with those reporting Excellent/Very Good/Good SRH (Adjusted Model 3). In contrast, Fair/Poor SRH was not associated with the transition from slow to normal timed gait or from slow timed gait to death in either the unadjusted or the adjusted models, with the exception of the model adjusting for demographic characteristics only.

The fully adjusted results from the repeated measures linear mixed model indicated that time to complete the gait task increased (i.e., slowed) over time among participants reporting Fair/Poor SRH compared with those reporting Excellent/Very Good/Good SRH ($b = 2.97$; $p = .02$; Akaike's information criterion = 16,091.8 based on an autoregressive heterogeneous correlation structure).

Discussion

This prospective study provided the opportunity to evaluate the longitudinal relationship between SRH and change in timed gait, an objective measure of lower extremity dysfunction, among a large community-based sample of older persons. We found that the likelihood of transitioning from normal to slow timed gait, and to death, was higher among participants reporting low SRH (i.e., Fair/Poor SRH) compared with those reporting Excellent/Very Good/Good SRH. These findings remained significant even after adjusting for demographic characteristics, biomedical and psychosocial factors, and ADLs. We also found that time to complete the gait task slowed over time among participants reporting low SRH compared with those reporting Excellent/Very Good/Good SRH. Together, these results support the supposition that the pathway from SRH to mortality may include an intermediate step that precedes disability. SRH was not significantly associated with improvement from slow to normal timed gait.

Prior research suggests that an association between SRH and functional status serves as an intermediate step in the well-established relationship between SRH and death (Idler &

Kasl, 1995; Idler et al., 2000). Although these studies are valuable in moving beyond the general appreciation of the association between SRH and mortality, they do not discriminate between domains of functioning. Rather, our findings show that SRH is associated with lower extremity dysfunction, a type of dysfunction that may represent an early stage in the disablement process preceding overall loss of independence (Guralnik et al., 1995; Verbrugge & Jette, 1994). Consequently, our findings suggest another potential step in the pathway between SRH and mortality, with low SRH associated with lower extremity dysfunction, which increases the risk for ADL disability, which, in turn, may lead to death. Furthermore, we found that Fair/Poor SRH was associated with an increased likelihood of transitioning from normal timed gait to death. These results suggest that SRH is associated with mortality directly, as well as indirectly through its relationship with the development of lower extremity dysfunction.

We found, however, that SRH was not associated with improvement from slow to normal timed gait. This finding is consistent with prior research that has found that poor SRH is associated with decline in functional status but not with recovery of functioning (Idler & Kasl, 1995). However, the reason for this finding is uncertain. Prior research indicates that older persons may attribute decreasing physical capabilities, such as lower extremity dysfunction, to old age as a coping mechanism when faced with what they consider to be intractable functional decline (Sarkisian, Liu, Ensrud, Stone, & Mangione, 2001). They then may rate their health more positively as a result of reducing their standards of good health. Participants with slow timed gait who reported positive ratings of health may still have been able to conduct their ADLs, yet may not have regained normal timed gait over time, thereby contributing to the lack of an association between SRH and improvement in timed gait. Nor did we find that SRH was associated with the transition from slow timed gait to death. Despite the strong association between Fair/Poor SRH and subsequent mortality (DeSalvo et al., 2006; Idler & Benyamini, 1997), our findings suggest that once lower extremity dysfunction is present, Fair/Poor SRH is not associated with a progression toward death. Additional research is needed to determine the mechanism(s) responsible for the association between low SRH and mortality in the setting of normal, but not slow, timed gait.

Our use of repeated measures of SRH and timed gait is a significant strength. Prior studies evaluating the association between SRH and functional status have included only a single baseline assessment of SRH (Idler & Kasl, 1995) or assessed change in functional status based on only a single follow-up assessment (Idler et al., 2000). Furthermore, in contrast to prior studies (Idler & Kasl, 1995; Idler et al., 2000), we evaluated an objective, performance-based measure of functional status rather than a self-reported measure. Performance-based functional assessments are less sensitive

to potential confounding effects of factors such as self-efficacy and depressive symptoms than are self-reported assessments. In addition, unlike prior studies, our findings draw attention to slow timed gait as a potential precursor to ADL disabilities. Because timed gait is increasingly recognized as a geriatric "vital sign," and assessments of timed gait are easily administered and relatively straightforward to interpret (Hardy, Perera, Roumani, Chandler, & Studenski, 2007), our findings also encourage future research that utilizes timed gait to understand the mechanisms that relate low SRH to mortality.

Although dichotomizing timed gait might be considered a limitation, our results did not change appreciably when we analyzed timed gait as a continuous measure. Because the PEP cohort comprised members of one health plan in a small urban area, the generalizability of our results may be questioned.

In summary, the longitudinal association between SRH and changes in timed gait may serve as an intermediate step in the pathway from SRH to mortality that precedes later disability. Ultimately, identifying persons with lower ratings of SRH may help clinicians appropriately target older persons who would benefit most from interventions to reduce the likelihood of developing lower extremity physical dysfunction and potentially delay onset of ADL disability and mortality. Future research should focus on formally evaluating lower extremity dysfunction as a mediator of the relationship between SRH and mortality so that the mechanisms driving this relationship can be more fully elucidated.

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