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Life-Space Mobility Change Predicts 6-Month Mortality

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Abstract

Background / Objective—Limited mobility in the community, measured by life-space, is associated with long-term mortality; but little is known about changes in life-space over time predicting short-term mortality. We examined 6-month change in life-space mobility as a predictor of subsequent 6-month mortality for community-dwelling older adults.

Design—Prospective cohort study.

Setting—Community-dwelling older adults from five Alabama counties in the University of Alabama at Birmingham (UAB) Study of Aging.

Participants—A random sample of 1000 Medicare beneficiaries, stratified by gender, race, and rural/urban residence, recruited between November 1999 and February 2001, followed by telephone interview every 6 months for the subsequent 8.5 years.

Interventions—None.

Measures—Mortality data was determined from informant contacts and confirmed by the National Death Index and Social Security Death Index. Life-space was measured at each interview using the UAB Life-Space Assessment, a validated instrument for assessing community mobility. A total of 11,817 6-month life-space change scores were calculated over 8.5 years of follow-up. Generalized linear mixed models were used to test predictors of mortality in subsequent 6-month intervals.

Results—There were 354 deaths that occurred within 6 months of two sequential life-space assessments. Controlling for age, gender, race, rural/urban residence, and comorbidity, life-space score and life-space decline over the preceding 6-month interval predicted mortality. A 10-point decrease in life-space resulted in a 72% increase in odds of dying over the subsequent 6 months (OR = 1.723, $p < 0.001$).

Conclusions—Both life-space score at the beginning of a 6-month interval and life-space decline over 6 months were associated with significant increases in subsequent 6-month mortality. Life-space assessment may assist clinicians to identify older adults at risk for short-term mortality.

Keywords

Life space; mortality; risk assessment; mobility; comorbidity

Introduction

Mobility is an important measure of overall health of the individual. Performance-based measures of mobility, such as gait speed, are predictive of mortality among community-dwelling older adults.^{1, 2} However, performance-based measures can be difficult to incorporate into clinical or public health practice,³ and self-report ratings of performance-based measures can substitute in such circumstances. Self-reported walking difficulty is one of the strongest predictors of mortality among older adults.⁴ Similarly, self-reported ability to walk ¼ mile is associated with increased odds of mortality over the subsequent 12 months.⁵

The University of Alabama at Birmingham (UAB) Study of Aging Life-Space Assessment (LSA) is an alternative self-report measure that assesses mobility in the community, in which persons report distance, frequency, and independence of movement ranging from one's room to beyond one's town.^{6, 7} As a measure of mobility, we would expect life-space to have strong associations with mortality risk. Life-space offers several advantages over self-report measures of walking or activities of daily living (ADLs). The LSA measures the full continuum of mobility among community-dwelling older adults, with very few persons reporting lowest or highest levels,^{6, 7} while other scales based on level of disability often have ceiling effects in this population. Furthermore, the LSA incorporates use of assistive devices in measurement of mobility, which may not be adequately captured by other instruments.⁸

Two studies^{9, 10} have demonstrated associations of life-space with long-term mortality. These associations remained even after adjusting for performance measures and comorbidity, indicating life-space provides additional information beyond physical measurements of mobility and the relationship is not entirely due to comorbid illnesses restricting mobility. However, the effect of life-space on short-term (less than 1 year) mortality remains unclear. Furthermore, studies have focused on the life-space score, and have not examined mortality associated with changes in life-space over time. The purpose of this study was to determine if assessment of life-space mobility and if change in life-space mobility over 6 months of follow-up predicted mortality among community-dwelling older adults during a subsequent 6-month follow-up interval.

Methods

Subjects

The UAB Study of Aging was designed to understand subject-specific factors predisposing older adults to mobility decline. Participants were a stratified random sample of 1000 Medicare beneficiaries, age ≥ 65 years, living in the community in five central Alabama counties. Oversampling was used to achieve balance in terms of race, gender, and rural residence. Baseline in-home interviews were conducted between November 1999 and February 2001 by trained interviewers after obtaining informed consent. Telephone follow-up interviews to assess life-space and vital status (alive or dead) were conducted at six-month intervals. If participants were unable to complete follow-up assessments, designated contact persons were interviewed for this information (2.3% of interviews). The UAB

Institutional Review Board approved the study protocol. Details of study methods have been described elsewhere.¹¹

Measures

Life-Space—The UAB Study of Aging Life-Space Assessment (LSA)^{6, 7} is a validated measure of life-space mobility based on distance through which a person reports moving during the four weeks preceding assessment. The composite measure incorporates life-space level, frequency with which it is attained, and degree of independence, based on reported use of assistive equipment or help from another person. The composite score ranges from 0 to 120, with higher scores indicating greater mobility.^{6, 7} Life-space shows a gradual decline over years due to normal aging, and acute changes over months associated with life events such as hospitalization.^{6, 12} Life-space was assessed at baseline and at each 6-month interval over 8.5 years of follow-up. Thus, participants who were alive and had no missing assessments could contribute up to 16 life-space scores to this analysis.

Mortality—Mortality over 8.5 years was initially determined by report of family or designated contact, as well as review of local obituaries, for dates of death. Dates of death were confirmed through the National Death Index (NDI) and Social Security Death Index (SSDI). Final determination of vital status for all participants was made at the conclusion of the 8.5-year follow-up period.

Sociodemographic Factors—Age, gender and race were self-reported at baseline interview. Marital status was classified as married or not married. Education was categorized as 6th grade or less, 7th through 11th grade, high school graduate, and some college or beyond. Locale was defined as urban or rural based on county of residence.¹³

Comorbidity—A comorbidity score was calculated based on the Charlson Comorbidity Index,¹⁴ without consideration of severity, from data collected during the baseline in-home assessment. Comorbidities were considered verified if the participant reported the condition and took medication for the condition, if the condition was reported on a questionnaire returned from the participant's physician, or if the condition was noted on a hospital discharge summary reviewed by the research team.

Cognition—Cognition was assessed at baseline using the Mini-Mental State Examination (MMSE),¹⁵ which includes items related to orientation, registration, recall, attention, and visuospatial construction. Scores range from 0 to 30, with higher scores representing better cognition.

Depression—Depressive symptoms were assessed at baseline using the short form Geriatric Depression Scale (GDS).¹⁶ Scores range from 0 to 15; a score of 6 or higher suggests possible depression.¹⁷

Function—Function was assessed during baseline in-home assessments using self-reported difficulty in completing ADLs and IADLs.¹⁸ ADL tasks were bathing, dressing, transferring, toileting, and eating; IADL tasks were light and heavy housework, using the telephone,

preparing meals, shopping, and managing money. Scores ranged from 0–15 for ADLs and 0–18 for IADLs, with higher scores representing more difficulty.

Statistical Analyses

Characteristics of participants who died during the study were compared to those alive at the end of the study using chi-squared tests for categorical variables and t-tests for continuous variables. Generalized linear mixed models (GLMMs)¹⁹ with a logistic link function were used to determine significant associations of life-space at the beginning of each 6-month interval and change in life-space over the same 6-month interval with mortality over the subsequent 6-month interval. A 10-point difference in LSA scores was considered clinically meaningful based on prior reports,^{6, 12, 20} although smaller differences may still be clinically significant.²¹ An example of a 10-point difference would be an older person who previously reported no assistance to go into the neighborhood daily and to town 1 to 3 times a week (64 points) but who now requires a cane to go into town less than once a week (54 points). We included age at the time of interview, race, gender, urban/rural residence, cognition, depressive symptoms, baseline ADLs and IADLs, and Charlson comorbidity score as covariates based on previous reports of associations with life-space.^{6, 7} We included interaction terms to examine differences in life-space based on race and gender, and to examine whether the effect of life-space on mortality differed based on level of comorbidity. We also conducted sensitivity analyses using only observations in the first 6 months of the study to minimize changes in covariates from baseline values. Finally, GLMMs were used to estimate probability of death over a 6-month period, using life-space at the beginning and end of the prior 6-month period, adjusting for covariates. All statistical analyses were conducted using the *glmmADMB* package²² version 0.8.3.3 for R²³ version 3.2.2.

Results

Participant Characteristics

Over the 8.5-year follow-up period, 398 participants (39.8%) died, while 602 were alive at the end of the study. Characteristics of participants are shown in Table 1. Participants who died were older, more likely to be male, and had lower education than those who survived. Participants who died also had lower cognitive scores, higher depression scores, more impairments on ADLs and IADLs, and more comorbidities at baseline. Mean baseline life-space for subjects who died was 56.2 in contrast to 69.3 for those who remained alive ($p < 0.001$).

Life-Space and Short-Term Mortality

Of the 1000 participants, 971 completed at least 2 sequential life-space assessments, and contributed data to the logistic GLMM. These participants had similar characteristics to the whole sample. A total of 11,817 life-space change scores were calculated across adjacent 6-month intervals. Subsequent to these changes, 11,349 were followed by a 6-month period during which mortality could be determined; for 354 intervals the participant died in the subsequent 6-month observation period, while for 10,995 intervals the participant survived the subsequent 6-month period. Over 8.5 years of follow-up, 44 participants who died did not have a life-space score at the beginning and end of the previous 6-month interval from

which a change score could be calculated, so their final observation (but not prior observations) were excluded from analysis. These participants differed from other participants who died during follow-up on race and length of follow-up, but not other characteristics. Mean 6-month decrease in life-space among survivors was 1.22 points (SD 16.00); while mean 6-month decrease in life-space among participants who died was 8.00 points (SD 19.13). Mean life-space score at the beginning of the 6-month interval was 59.69 (SD 25.02) for survivors and 38.36 (SD 23.95) for participants who died. Table 2 shows the final logistic GLMM assessing the impact of 6-month change in life-space score on mortality in the subsequent 6-month follow-up interval after adjusting for covariates.

The odds ratio for 6-month change in life-space suggested that, after adjusting for covariates, a 10-point decrease in life-space over a 6-month period increased odds of dying over the subsequent 6-month interval by 72%. Likewise, for every 10 points that a person's life-space score was lower relative to other individuals at the beginning of a 6-month interval, odds of dying over the next 6-month interval (i.e., within the next full year) increased by 92%. The model showed that other significant independent predictors of mortality included age, African American race, male gender, education, and Charlson Comorbidity Index scores. There was significant interaction of comorbidity with life-space, indicating the effect of comorbidity on mortality was attenuated at higher life-space scores. In sensitivity analyses using only observations in the first 6 months of the study, a trend remained for life-space change associated with increased mortality, after adjusting for covariates ($p=0.0515$); life-space score at the beginning of the interval was no longer significant (data not shown).

Table 3 provides subsequent 6-month mortality probability estimates as a function of life-space at the beginning and end of a 6-month interval. The 6-month mortality ranged from less than 1% for those at highest levels of life-space to 19.5% for those at lowest levels of life-space, after adjusting for age, gender, race, education, and comorbidity (other covariates were excluded as they were not significant in the multivariate model). Acute declines in life-space, occurring over 6 months or less, were associated with sizeable increases in mortality, with much smaller increases associated with life-space score at the beginning of the interval. Decline to an LSA of 20 or less carried a 6-month mortality risk of 5.4% or greater, regardless of life-space score prior to decline.

Similarly, recovery of life-space scores from lower levels were associated with sizeable decreases in mortality, with much smaller decreases associated with life-space score at the beginning of the interval. Life-space scores of 70 or greater at the end of the 6-month interval carried a mortality rate of less than 1% over the subsequent 6 months, regardless of life-space score prior to recovery.

Discussion

In this study, we found that life-space mobility scores, measured by the LSA, predicted short-term increases mortality among older, community-dwelling men and women over the subsequent 6-month period. Change in the life-space score over a 6-month follow-up interval also predicted mortality in the subsequent 6-month observation period, even after

adjusting for life-space at the beginning of the 6-month follow-up interval, age, gender, race, marital status, education, rural residence, cognition, depressive symptoms, baseline ADLs and IADLs, and comorbidity. While previous studies have reported association of low life-space with increased mortality after 2.7 to 8 years,^{9, 10} our study is the first to demonstrate effects of life-space on mortality over much shorter intervals. In this analysis, a decrease in life-space score of 10 points resulted in 72% increased odds of mortality over the next 6 months. Thus, the amount of change in life-space mobility in a preceding 6-month interval and the absolute level of life-space mobility at the beginning of a follow-up interval will help identify older adults at risk for subsequent mortality. Participants with persistently low life-space had the highest mortality risk, with 19.5% of those with persistent life-space of 0 dying over the next 6 months. However, declines to low life-space levels carried a high mortality risk even if participants began at the highest life-space levels, although risk was not as great as for participants beginning at low life-space levels. Conversely, recovery to a high life-space level had low mortality risk even if participants began at low life-space levels. These results suggest more intensive evaluations or interventions to address modifiable risk factors for decline in mobility, particularly among individuals with pre-existing low life-space, may help reduce mortality rates. It is notable that effects of change in life-space on mortality remained in sensitivity analyses even after adjusting for comorbidity, suggesting increased risk of mortality with change in life-space was not entirely due to increased comorbidity that limited community mobility.

Several potential mechanisms might explain the relationship between life-space and mortality. The LSA reflects not only physical performance but also socio-economic, cognitive, and emotional factors influencing mobility in the community²⁴ that are related to mortality, and may serve as a broad measure of the overall well-being of the individual. The LSA may also capture effects of disease and symptom severity, which would presumably affect mortality, better than comorbidity measures that classify diseases as present or absent. Finally, LSA scores are influenced by social support,²⁴ which may affect mortality by affecting access to care for individuals with limited mobility. Future studies with concurrent assessment of life-space with each of these factors will be needed to clarify proximate causes of changes in mobility that influence mortality risk.

A particular strength of this study is the examination of short-term effects of life-space on mortality in a large sample of community-dwelling older adults that included both males and females and African Americans and Caucasians, which addresses shortcomings of previous studies.^{9, 10} The focus on short-term mortality in this study is clinically relevant, as it suggests the possibility of interventions to improve life-space that might lead to reductions in mortality and provides prognostic guidance for those with marked mobility decline. Nevertheless, significant limitations do remain. This analysis was limited to changes in life-space mobility scores that occurred over a 6-month period of follow-up, as data were not available at more frequent intervals. Future research should examine the relationship between acuity of life-space change and subsequent adverse outcomes. Comorbidity and ADLs/IADLs were assessed only at baseline, and any interim changes predicting mortality would not be measured.

In summary, we have demonstrated that both life-space scores and change in life-space are associated with significantly increased risk of mortality over the subsequent 6 months. Life-space can serve as a simple yet effective method for risk assessment in older adults and for identifying individuals for interventions to preserve mobility that could reduce mortality in this population.

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Table 1
Participant Characteristics by Mortality Status

Participants (N=1000) were classified based on whether death occurred at any time during the 8.5 years of follow-up, as determined by the National Death Index or the Social Security Death Index. All participant characteristics were obtained at the baseline interview, with one participant missing information on the GDS.

	Alive (N=602)	Dead (N=398)	P Value
Age, Years	74.35+/- 5.98	77.95+/- 7.14	<0.001
Sex, Male	55% (332)	42% (167)	<0.001
Race, African American	50% (304)	49% (196)	0.698
Rural Residence	48% (291)	56% (223)	0.017
Education			<0.001
6 th Grade or Less	20% (118)	22% (86)	
7 th through 12 th	25% (152)	36% (142)	
High School Graduate	24% (147)	22% (88)	
Some College	31% (185)	21% (82)	
Married	53% (320)	48% (193)	0.149
MMSE Score	25.86+/- 4.27	23.70+/- 5.38	<0.001
GDS Score	2.00+/-2.15	2.89+/-2.49	<0.001
Number of ADL Impairments	0.548+/-1.017	1.171+/-1.462	<0.001
Number of IADL Impairments	0.777+/-1.272	1.616+/-1.659	<0.001
Baseline Life-Space	69.3+/-22.5	56.2+/-26.3	<0.001
Charlson Comorbidity Score	1.92+/-1.42	2.74+/-1.71	<0.001
Follow-Up Interval, Years	7.78+/-1.75	4.24+/-2.26	<0.001

ADL = activities of daily living; GDS = Geriatric Depression Scale; IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination

Table 2

Multivariate Model for Mortality

Odds of mortality is shown over a 6-month period, based on life-space scores at the beginning of the previous 6-month period and the change in life-space score over the previous 6-month period. All covariates represent values collected at baseline.

	Unadjusted		Adjusted for Demographics and Comorbidity		Fully Adjusted	
	Odds Ratio	P Value	Odds Ratio	P Value	Odds Ratio	P Value
Intercept	0.277	<0.001	0.019	0.001	0.047	0.011
6-Month Change in Life-Space, per 10 point Decrease	1.700	<0.001	1.686	<0.001	1.723	<0.001
Life-Space at Start of 6-Month Interval, per 10 point Decrease	1.686	<0.001	1.745	<0.001	1.919	<0.001
Age at Baseline, Years			1.038	0.001	1.033	0.004
Race, African American			0.736	0.062	0.535	0.028
Sex, Male			0.332	<0.001	0.479	0.012
Marital Status, Married			1.063	0.704	1.062	0.703
Education						
6 th grade or less			---	---	---	---
7 th through 11 th grade			1.895	0.002	1.850	0.003
High school graduate			1.706	0.033	1.703	0.030
Some college or more			1.783	0.026	1.785	0.022
Rural Residence			1.233	0.153	1.214	0.177
MMSE			0.985	0.388	0.981	0.266
GDS			1.009	0.775	1.007	0.820
ADL Difficulty			0.891	0.090	0.916	0.185
IADL Difficulty			1.011	0.847	1.011	0.840
Charlson Comorbidity Score			1.155	0.001	0.968	0.702
6-Month Change in LS $\times$ Race					1.008	0.922
6-Month Starting LS $\times$ Race					1.079	0.213
6-Month Change in LS $\times$ Sex					0.971	0.722

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	Unadjusted		Adjusted for Demographics and Comorbidity		Fully Adjusted	
	Odds Ratio	P Value	Odds Ratio	P Value	Odds Ratio	P Value
6-Month Starting LS × Sex					0.919	0.204
6-Month Change in LS × Comorbidity					1.014	0.557
6-Month Starting LS × Comorbidity					1.043	0.025

Table 3**Predicted Mortality as a Function of Life-Space**

Percent mortality is shown over a 6-month period, based on a logistic regression model using life-space scores at the beginning and the end of the previous 6-month period. Percent mortality is adjusted for age, gender, race, education, and Charlson comorbidity score. The number of observations in each category are shown in parentheses.

Life Space at End of a 6-Month Interval											
	0	10	20	30	40	50	60	70	80		
Life Space at Beginning of a 6-Month Interval	0	19.5 (200)	12.8 (82)	8.1 (32)	5.1 (18)	3.1 (5)	1.9 (5)	1.2 (3)	<1 (0)	<1 (2)	
	10	18.9 (79)	12.3 (140)	7.8 (87)	4.9 (52)	3.0 (10)	1.8 (6)	1.1 (2)	<1 (0)	<1 (1)	
	20	18.3 (61)	11.9 (91)	7.6 (209)	4.7 (253)	2.9 (53)	1.8 (21)	1.1 (9)	<1 (2)	<1 (2)	
	30	17.7 (42)	11.5 (73)	7.3 (254)	4.5 (761)	2.8 (263)	1.7 (88)	1.0 (33)	<1 (11)	<1 (8)	
	40	17.1 (16)	11.1 (16)	7.0 (85)	4.4 (306)	2.7 (399)	1.6 (237)	1.0 (85)	<1 (32)	<1 (29)	
	50	16.6 (17)	10.7 (8)	6.8 (35)	4.2 (129)	2.6 (256)	1.6 (543)	1.0 (278)	<1 (168)	<1 (173)	
	60	16.0 (9)	10.3 (5)	6.5 (10)	4.0 (59)	2.5 (101)	1.5 (293)	<1 (299)	<1 (250)	<1 (279)	
	70	15.5 (6)	10.0 (5)	6.3 (5)	3.9 (30)	2.4 (49)	1.5 (215)	<1 (222)	<1 (345)	<1 (494)	
	80	15.0 (4)	9.6 (1)	6.0 (6)	3.7 (8)	2.3 (24)	1.4 (94)	<1 (119)	<1 (249)	<1 (604)	
	90	14.5 (1)	9.3 (2)	5.8 (8)	3.6 (13)	2.2 (21)	1.3 (68)	<1 (124)	<1 (198)	<1 (757)	
	100	14.0 (1)	9 (2)	5.6 (1)	3.5 (8)	2.1 (8)	1.3 (22)	<1 (27)	<1 (76)	<1 (321)	
	110	13.5 (1)	8.6 (1)	5.4 (1)	3.3 (0)	2.0 (0)	1.2 (4)	<1 (5)	<1 (12)	<1 (112)	