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BRIEF REPORT

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Life-space mobility and cognition in community-dwelling late-life women: A cross-sectional analysis

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Abstract

Background: Life-space mobility captures the daily, enacted mobility of older adults. We determined cross-sectional associations between life-space mobility and cognitive impairment (CI) among community-dwelling women in the 9th and 10th decades of life.

Methods: A total of 1375 (mean age 88 years; 88% White) community-dwelling women enrolled in a prospective cohort of older women. Life-space score was calculated with range 0 (daily restriction to one's bedroom) to 120 (daily trips leaving town without assistance) and categorized (0–20, 21–40, 41–60, 61–80, 81–120). The primary outcome was adjudicated CI defined as mild cognitive impairment or dementia; scores on a 6-test cognitive battery were secondary outcomes.

Results: Compared to women with life-space scores of 81–120 and after adjustment for demographics and depressive symptoms, the odds of CI was 1.4-fold (OR 1.36, 95% CI 0.91–2.03) higher for women with life-space scores of 61–80, twofold (OR 1.98, 95% CI 1.33–2.94) higher for women with life-space scores of 41–60, 2.6-fold (OR 2.62, 95% CI 1.71–4.01) higher for women with life-space scores of 21–40, and 2.7-fold (OR 2.71, 95% CI 1.27–5.79) higher for women with life-space scores of 0–20. The association of life-space scores with

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adjudicated CI was primarily due to higher odds of dementia; the odds of dementia versus normal cognition was eightfold (OR 8.63, 95% CI 3.20–23.26) higher among women with life-space scores of 0–20 compared to women with life-space scores of 81–120. Lower life-space scores were associated in a graded manner with lower mean scores on tests of delayed recall (California Verbal Learning Test-II delayed recall) and language and executive function (phonemic fluency, category fluency, and Trails B). Life-space score was not associated with scores on tests of attention and working memory (forward and backward digit span).

Conclusions: Lower life-space mobility is associated in a graded manner with CI among community-dwelling White women in the 9th and 10th decades of life.

KEYWORDS

cognitive impairment, dementia, life-space mobility

INTRODUCTION

Changes in mobility and physical function are common with aging.[1] Traditional assessments of mobility and physical function focus on self-reported physical function and physical performance, but these measures fail to capture the typical everyday movements of older adults. In response, life-space mobility (LSM) measures were developed to assess the daily, enacted mobility of older adults.[2] Lower life-space scores are associated with poor outcomes in older adults, including frailty,[3] nursing home admission,[4] higher subsequent healthcare utilization,[5] and mortality.[3,6,7]

Constricted LSM is associated with global cognitive impairment (CI) and impairment in specific domains of cognitive function including executive function, memory, and processing speed.[8,9] However, most previous studies have focused on adults with normal cognition in the 8th decade of life. Women aged 85 years and older are among the fastest growing segments of the US population,[10] and are at high risk for incident and prevalent CI[11] and impairment in activities of daily living (ADLs) and instrumental ADLs (such as handling money for shopping).[12] LSM is dependent on a complex set of determinants, including cognitive, psychosocial, physical, environmental, and financial resources.[13] It is unknown whether LSM is associated with cognition among late-life, community-dwelling, US women with a wide range of cognitive function. To determine the cross-sectional association of life-space score and cognition in a cohort of predominantly community-dwelling women in the 9th and 10th decades of life, we used data from the 2007-2008 examination of the Study of Osteoporotic Fractures (SOF). We hypothesized that constricted LSM among late-life women is associated with a higher likelihood of CI (adjudicated mild cognitive impairment or dementia).

Key points

- Among late-life community-dwelling White women, lower life-space mobility scores were associated in a graded manner with higher odds of adjudicated cognitive impairment (mild cognitive impairment or dementia).
- The association of life-space scores with adjudicated CI was due predominantly to markedly higher odds of dementia in women with constricted life-space mobility.

Why does this paper matter?

Life-space scores may be an important risk assessment tool among late-life women.

METHODS

Study population

We studied participants enrolled in SOF, a prospective observational cohort study of community-dwelling women aged 65 years and older enrolled at four sites in the United States. Protocol and consent forms were

approved by the institutional review boards at all participating institutions. All participants provided written informed consent. Further details of the SOF study design and recruitment are described elsewhere.[14,15] From the original cohort of 10,336 women enrolled in SOF, 2368 active surviving women provided at least minimum information at the Year 20 (Y20) examination between 2006 and 2008. Among these women, 1375 community-dwelling women with adjudicated cognitive status and completed life-space score assessment at the Y20 examination formed our analytic cohort (Figure S1).

Life-space mobility score

Trained clinic staff administered the University of Alabama at Birmingham Life-Space Assessment tool[16] via interview at the Y20 examination. This assessment quantifies movement in five life-space levels (Table S1, from life-space level 1, movement in rooms in the home besides the bedroom, to life-space level 5, movement in places outside town/city of residence). For each of these levels, movement is further quantified by frequency of these movements and need for assistance with these movements during the prior 4 weeks. The life-space score is the sum of the score for each of the five levels. Individual level scores were obtained by multiplying the level number (1–5) by a value for the frequency (1 = <1 time/week, 2 = 1–3 times/week, 3 = 4–6 times/week, 4 = daily) and by a value for independence (2 = no assistance, 1.5 = use of equipment only, 1 = assistance from another person). The range of life-space scores is 0 (never leaves one's bedroom) to 120 (daily unassisted movement outside of one's town).

Outcome measures

At Y20, SOF participants completed a battery of neuropsychological tests which evaluated global cognition and performance in specific cognitive domains. Overall cognitive status was adjudicated by a panel of experts and our primary outcome was adjudicated CI[17] (presence of either MCI or dementia; MCI by Petersen criteria[17,18] [IADLs generally intact] or dementia by DSM-IV criteria[19] [IADLs impaired]). We also considered MCI and dementia as separate outcomes in secondary analyses (MCI vs. normal with dementia set to missing and dementia vs. normal with MCI set to missing). Additional secondary cognitive outcomes were scores on a 6-test cognitive battery—the delayed recall California Verbal Learning Test II (CVLT-II) (verbal memory),[20] forward and backward digit span (attention and working memory),[21] phonemic and category fluency (language and executive function),[22] and the Trails B test (executive function).[23] Consistent with previous SOF analyses,[17] all Trails B scores >420 s and scores for participants unable to complete the test were set to 421 s.

Other measures

Demographics, living situation, and history of cardiovascular disease (CVD) were obtained from standardized questionnaires administered at the Y20 examination. Depressive symptoms were evaluated using the Geriatric Depression Scale (GDS, range 0–15).[24]

Statistical analysis

Life-space score was analyzed as a categorial variable based on the distribution of life-space scores in our analytic cohort (0–20, 21–40, 41–60, 61–80, 81–120 [referent group]).[5–7] Characteristics at Y20 were compared according to the category of life-space score using chi-square tests for categorical variables, ANOVA for continuous variables with normal distributions, and nonparametric Kruskal–Wallis tests for continuous variables with skewed distributions. Logistic regression models were used to estimate the association, using odds ratios, of life-space score with adjudicated CI. Multiple linear regression was used to estimate the association of life-space score with scores on specific cognitive tests (CVLT-II, forward and backward digit span, phonemic and category fluency, and Trails B). Trails B scores were log-transformed for analysis due to right-skewed distribution and back-transformed for ease of interpretation.

Initial models were adjusted for age, race, and study enrollment site. Potential confounders were screened for inclusion in multivariable models. Candidate confounding variables were included in multivariable models if they were associated with life-space score and were independently related to CI after adjustment for age, race, and study enrollment site. Gait speed may mediate the association between cognition and life space[25] and was therefore not considered for inclusion in the model. Only years of education and GDS score met criteria for being potential confounders and were included in the multivariable model.

RESULTS

Our analytic cohort consisted of 1375 women with a mean age of 88 years (standard deviation [SD] 3 years)

TABLE 1 Participant characteristics.

	All ($N = 1375$)	Life-space score					*p*-value
		0–20 ($N = 44$)	21–40 ($N = 328$)	41–60 ($N = 406$)	61–80 ($N = 371$)	81–120 ($N = 226$)	
Age, mean (SD)	87.5 (3.3)	88.7 (3.5)	88.9 (3.4)	87.7 (3.3)	86.5 (3.0)	86.5 (2.7)	<0.001
African American, *n* (%)	166 (12.1)	7 (15.9)	28 (8.5)	50 (12.3)	55 (14.8)	26 (11.5)	0.1251
Education, years, mean (SD)	12.8 (2.6)	11.9 (2.7)	12.6 (2.5)	12.8 (2.4)	12.9 (2.7)	13.2 (2.7)	0.0041
GDS score (0–15), mean (SD)	2.4 (2.4)	6.0 (2.8)	3.6 (2.6)	2.5 (2.1)	1.7 (1.8)	1.2 (1.7)	<0.001
Composite CVD variable[a,b], *n* (%)	459 (33.5)	17 (39.5)	143 (43.7)	144 (35.6)	97 (26.1)	58 (25.7)	<0.001
Cognitive function							
3MS (0–100), mean (SD)	88.0 (9.4)	80.0 (14.0)	84.9 (10.5)	87.2 (9.5)	90.4 (6.8)	91.6 (6.9)	<0.001
CVLT-II delayed recall score[a,c], mean (SD)	5.2 (2.7)	3.8 (3.0)	4.4 (2.7)	5.0 (2.7)	5.6 (2.4)	6.0 (2.5)	<0.001
Forward Digit Span score[a,d], mean (SD)	7.4 (2.2)	7.9 (2.7)	7.3 (2.2)	7.3 (2.2)	7.5 (2.1)	7.4 (2.1)	0.1848
Backward Digit Span score[a,e], mean (SD)	5.5 (2.0)	4.7 (2.1)	5.2 (2.0)	5.6 (2.1)	5.6 (2.0)	6.0 (2.0)	<0.001
Phonemic fluency score[a,f], mean (SD)	10.6 (4.2)	7.7 (4.1)	9.6 (3.9)	10.6 (4.2)	11.0 (4.0)	12.0 (4.2)	<0.001
Category fluency score[a,f], mean (SD)	10.6 (3.5)	8.4 (3.3)	9.6 (3.5)	10.2 (3.7)	11.3 (3.0)	11.8 (3.3)	<0.001
Trails B time to complete in seconds[a,g], mean (SD)	216 (122)	311 (128)	264 (126)	231 (125)	178 (99)	163 (96)	<0.001
Primary Cognitive Adjudication, *n* (%)							<0.001
Normal	845 (61.5)	16 (36.4)	151 (46.0)	237 (58.4)	263 (70.9)	178 (78.8)	
MCI	325 (23.6)	9 (20.5)	95 (29.0)	98 (24.1)	86 (23.2)	37 (16.4)	
Dementia	205 (14.9)	19 (43.2)	82 (25.0)	71 (17.5)	22 (5.9)	11 (4.9)	

Abbreviations: 3MS, Modified Mini-Metal State exam; CVD, cardiovascular disease; CVLT-II, California Verbal Learning Test Second Edition; GDS, Geriatric Depression scale; SD, standard deviation.

[a]Due to missing data, denominators are as follows: 1371 for CVD; 1354 women for CVLT-II delayed recall; 1367 for forward digit span; 1356 for backward digit span and category fluency; 1357 for phonemic fluency; and 1153 for Trails B.

[b]History of at least one of myocardial infarction, peripheral vascular disease, congestive heart failure, or stroke.

[c]Recall of nine words after a delay of 20 min. Score range 0–9, higher scores indicate better performance.

[d]Repetition of successively longer strings of numbers. Score range 0–14, higher scores indicate better performance.

[e]Repetition in backwards order of successively longer strings of numbers. Score range 0–14, higher scores indicate better performance.

[f]Number of words that begin with the letter "F" (phonemic fluency) and number of vegetables (category fluency) listed in 1 min. Higher scores indicate better performance.

[g]Time to connect a series of alternating numbers and letters in ascending order. Trails B time is truncated at 421 s. Shorter times indicate better performance.

(Table 1). One quarter (325, 24%) of women met criteria for mild cognitive impairment (MCI); 205 (15%) met criteria for dementia. Lower levels of life space were associated with older age, fewer years of education, a history of CVD, a greater likelihood of adjudicated MCI and adjudicated dementia, and cognitive test scores indicating greater impairment on all tests except forward digit span.

After adjustment for age, race, and enrollment site, odds of adjudicated CI (adjudicated MCI or dementia) was higher in a graded fashion for each level of decreasing life-space scores. Those with the lowest life-space scores (0–20) had fivefold higher odds of adjudicated CI compared to those with the highest life-space scores (81–120; Figure 1 and Table S2; odds ratio [OR] 5.23, 95% confidence interval [95% CI] 2.58–10.59).

The association of life-space score with adjudicated CI was attenuated, but remained significant, following additional adjustment for education and GDS score (Figure 1 and Table S2). Compared to women with life-space scores of 81–120, odds of CI was 1.4-fold (OR 1.36, 95% CI 0.91–2.03) higher for women with life-space scores of 61–80, twofold (OR 1.98, 95% CI 1.33–2.94) higher for women with life-space scores of 41–60, 2.6-fold (OR 2.62, 95% CI 1.71–4.01) higher for women with life-space scores of 21–40, and 2.7-fold (OR 2.71, 95% CI 1.27–5.79) higher for women with life-space scores of 0–20.

The association of life-space scores with adjudicated CI was primarily due to a markedly higher odds of dementia in women with lower life-space scores. LSM was associated with MCI versus normal cognition in the

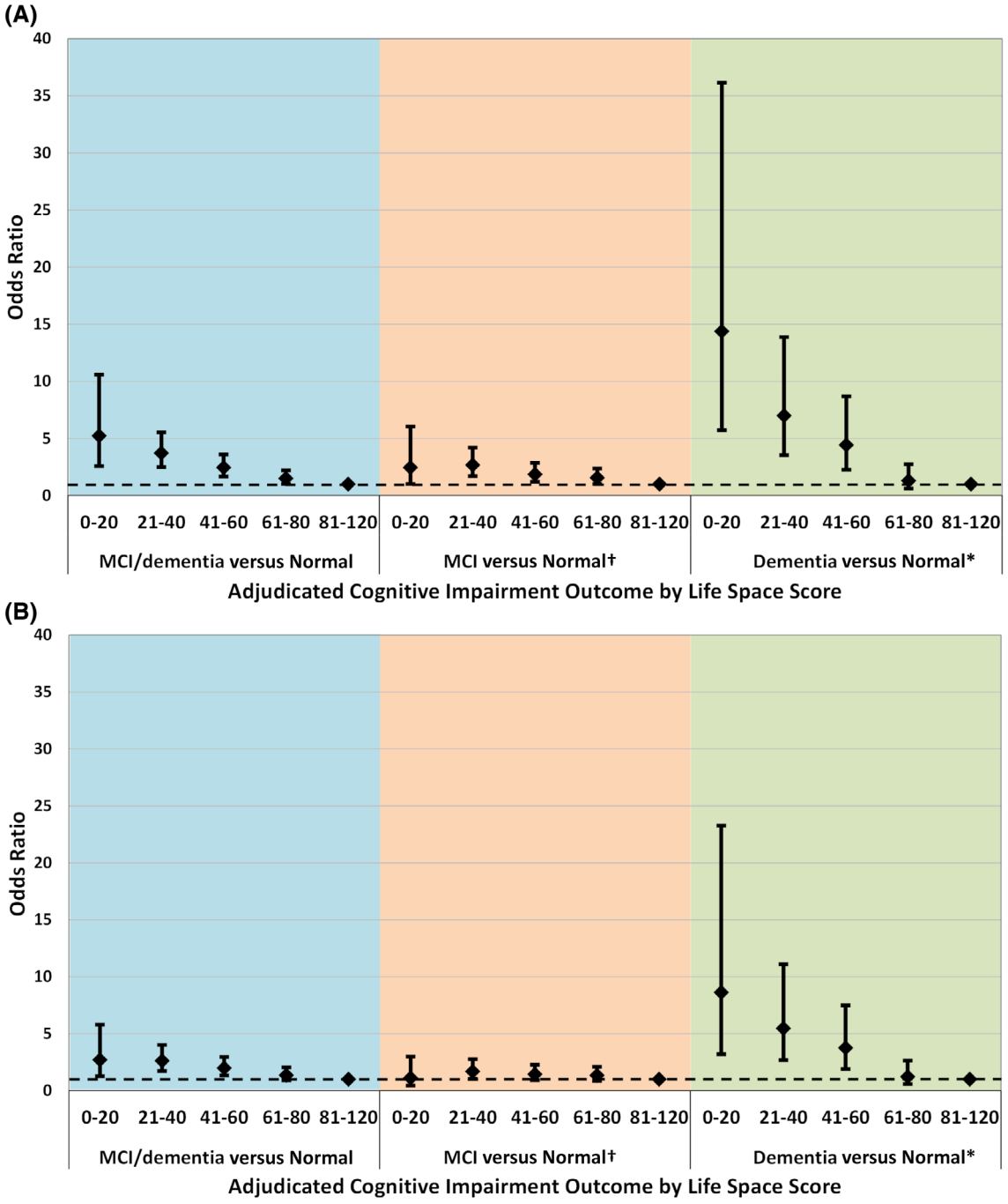

FIGURE 1 Association of life-space score with adjudicated cognitive impairment. Referent group is life-space score 81–120. (A) Base model adjusted for age, race, and study enrollment site; (B) Multivariable model further adjusted for education and Geriatric Depression Scale score. †Participants with adjudicated dementia were excluded from this analysis ($n = 1209$). *Participants with MCI were excluded from this analysis ($n = 1106$).

minimally-adjusted model (Table S2; OR 2.46 for life-space scores 0–20 vs. 81–120, 95% CI 1.00–6.04 and OR 2.67 for life-space scores 21–40 vs. 81–120, 95% CI 1.70–4.20). However, the association was largely attenuated in the fully adjusted model. In contrast, the fully adjusted odds of dementia versus normal cognition was over eight-fold (OR 8.63, 95% CI 3.20–23.26) higher among women with life-space scores of 0–20 compared to those with life-space scores of 81–120.

In fully adjusted models, lower life-space scores were associated in a graded manner with lower mean scores on tests of delayed recall (CVLT-II) and language and executive function (phonemic fluency, category fluency, and Trails B; Table 2). For example, women with life-

TABLE 2 Mean cognitive test score (95% CI) by category of life-space score[a,b].

Life-space mobility score	Verbal memory CVLT-II delayed recall mean (95% CI)	Attention and working memory		Executive function and language		Executive function and attention
		Forward digit span mean (95% CI)	Backward digit span mean (95% CI)	Phonemic fluency mean (95% CI)	Category fluency mean (95% CI)	Trails B time, sec[c] mean (95% CI)
0–20	3.9 (3.1–4.8)	7.9 (7.2–8.6)	4.8 (4.1–5.4)	8.4 (7.1–9.7)	9.1 (8.0–10.2)	261 (221–308)
21–40	4.4 (4.0–4.7)	7.2 (6.9–7.5)	5.0 (4.8–5.3)	9.7 (9.2–10.3)	9.9 (9.4–10.4)	244 (228–262)
41–60	4.7 (4.4–5.0)	7.2 (7.0–7.5)	5.2 (5.0–5.5)	10.4 (10.0–10.9)	10.1 (9.7–10.5)	225 (211–239)
61–80	5.0 (4.7–5.4)	7.5 (7.2–7.7)	5.1 (4.9–5.4)	10.7 (10.2–11.2)	11.0 (10.5–11.4)	189 (177–202)
81–120	5.3 (4.9–5.7)	7.3 (6.9–7.6)	5.4 (5.0–5.7)	11.5 (10.8–12.1)	11.3 (10.8–11.8)	179 (165–194)
Overall *p*-value for life-space mobility score	<0.001	0.20	0.30	<0.001	<0.001	<0.001

Abbreviation: CVLT-II, California Verbal Learning Test Second Edition.

[a]Results include data from 1354 women for CVLT-II delayed recall; 1367 for forward digit span; 1356 for backward digit span and category fluency; 1357 for phonemic fluency; and 1153 for Trails B.

[b]Results adjusted for age, race, study enrollment site, education, and Geriatric Depression Scale score.

[c]Trails B time is truncated at 421 s.

space scores of 81–120 recalled a mean of 5.3 (95% CI 4.9–5.7) of nine words after a 10 min delay, compared to a mean of 3.9 (95% CI 3.1–4.8) words among women with life-space scores of 0–20. Associations between life-space score and forward and backward digit span were not statistically significant.

DISCUSSION

In this cohort of late-life community-dwelling women, lower life-space scores were associated in a graded manner with higher odds of adjudicated CI and lower average scores on tests of memory, verbal fluency, and executive function. The association of life-space scores with adjudicated CI was in large part due to a markedly higher odds of dementia (CI with impairment in IADLs) in women with lower life-space scores; we found only a limited independent association between life-space score and odds of MCI (CI without significant IADL impairment).

Our results are consistent with prior research reporting an association between restricted life-space and CI in cohorts of older adults in their 60s and 70s and extends these findings to include late-life community-dwelling women. A 2019 systematic review found evidence of a moderate relationship between CI and restricted LSM.[8] Of the few studies that have compared LSM in older adults with and without MCI, most found no evidence of a cross-sectional association between low LSM and MCI[8] which is consistent with our results. A cross-sectional analysis of 2381 community-dwelling older adults with and without MCI found an association between lower LSM and non-amnestic and multidomain MCI,[26] but only unadjusted results were reported. We similarly found evidence of an association between low LSM and MCI in minimally adjusted models. Prior cross-sectional studies have found differences in life-space scores between older adults with and without Alzheimer's disease (mean life-space score difference of 21),[27] and reported a greater prevalence of dementia among men with low versus high life-space scores.[6] Our results highlight the magnitude of the cross-sectional association between low LSM and dementia; among our cohort of older community-dwelling women, those with life-space scores of 0–20 (limited movement outside of house) versus 81–120 (wide movement within own community) had over eight times greater odds of dementia. Our results are consistent with prior studies reporting an association between low LSM and reduced executive function.[8,28]

Low LSM and CI are thought to have a bidirectional relationship[2,7,29,30] not explained by reverse causation.[29] We found evidence of a graded association between lower LSM and both greater odds of dementia and worse performance on tests of delayed recall, language, and executive function. Cognitive function, performance-based physical function (e.g., gait speed), and LSM are hypothesized to be connected through complex biologic, behavioral, and environmental pathways[29]; we hypothesize that pathways connecting cognitive function, IADL function, and LSM may be similarly complex. For example, CI may lead to IADL impairment and constricted life space, which in turn may result in reduced opportunities

for cognitive stimulation to promote cognitive function. These hypothesized complex associations, in addition to the observed graded cross-sectional associations between CI and LSM, highlight the potential clinical utility of life space as a risk assessment tool among late-life women. Future studies are warranted to test the utility of life-space assessments in clinical settings; better elucidate the hypothesized complex biologic, behavioral, and environmental pathways that connect LSM and cognition; and to determine whether interventions to increase life space are also associated with improvements (or decreased decline) in cognition and IADL function.

This study is limited by a cross-sectional design, which limits causal and temporal inference, and utilization of a cohort composed predominantly of White women. This study also has strengths including consideration of participants with a wide range of cognitive status, adjudicated cognitive status, and a focus on community-dwelling women in late life. In conclusion, low LSM is associated with cognitive impairment, and especially dementia, among community-dwelling White women in the 9th and 10th decades of life.

AUTHOR CONTRIBUTIONS

Conceptualization: Kerry M. Sheets, Howard A. Fink, Kristine Yaffe, Kristine Ensrud; Data analysis: Allyson M. Kats, Lisa Langsetmo; Manuscript drafting: Kerry M. Sheets; Writing group, critical editing, and approval: All authors.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts.

SPONSOR'S ROLE

The funding agencies had no direct role in the conduct of the study; the collection, management, analyses, and interpretation of the data; or preparation or approval of the manuscript.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1. Participant flow diagram.
Table S1. Life-space levels from the University of Alabama at Birmingham Study of Aging Life-Space Assessment.
Table S2. Association of life-space score with adjudicated cognitive impairment (MCI or dementia).

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