

Life Space Mobility and Social Frailty for Middle-Aged and Older Adults with Different Levels of Hearing Impairment

Jhen Yang You^{1,2}, Ching-Ju Chiu¹ 

¹Institute of Gerontology, College of Medicine, National Cheng Kung University, Tainan, Taiwan; ²Department of Otolaryngology Head and Neck Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan

Correspondence: Ching-Ju Chiu, Institute of Gerontology, College of Medicine, National Cheng Kung University, No. 1 University Road, Tainan, 701, Taiwan, Tel +886-62353535 ext. 5739, Fax +886-63028175, Email cjchiu@mail.ncku.edu.tw

Objective: Life-space mobility reflects daily and social movement, crucial for active aging and independence in older adults. Good mobility is associated with greater vitality and the ability to live independently. This study examines the relationship between hearing loss and life-space mobility using pure tone average (PTA) hearing levels.

Methods: This cross-sectional study recruited participants aged 50–79 from January 2023 to May 2024 through community in southern Taiwan. Participants were recruited via electronic bulletin boards and word-of-mouth. Hearing was assessed using pure tone audiometry, and data on socioeconomic status, life-space mobility, cognition, depression, social frailty, and health status were collected via questionnaires. Logistic regression was used to identify predictors of life-space mobility.

Results: Ninety participants (mean age 64.21 years) with good cognition completed the study. Pure tone audiometry showed 60% had bilateral hearing loss (better ear hearing level >20 dB), and 15.6% had bilateral hearing disability (bilateral hearing level >50 dB). Low life-space mobility was observed in 5.6%, and social frailty in 13.3%. Bilateral hearing disabilities predicted low life-space mobility (OR = 48.34, CI = 2.06–1136.35). Each decibel increase in worse ear hearing level increased the likelihood of low life-space mobility by 6% (OR = 1.06, CI = 1.0–1.1).

Conclusion: Hearing loss is an independent predictor of life-space mobility. Increased worse ear hearing levels are associated with reduced life-space. Routine hearing assessment may support timely identification and intervention to preserve mobility in aging populations.

Keywords: Hearing Loss, Life-Space Mobility, Social Frailty, Environmental Health, Geriatric Function

Introduction

Life-space mobility (LSA) is a multidimensional indicator of physical autonomy and social participation, reflecting how far and how often individuals move within their environment—from within their home to the broader community—and whether such movement is done independently.¹ Declines in LSA have been associated with increased frailty, functional limitations, and mortality.^{2–7} As a marker of healthy aging, maintaining life-space mobility is essential for ensuring autonomy, social engagement, and quality of life in later years.

Hearing loss is one of the most common sensory impairments affecting older adults, and has been increasingly recognized as a contributor to reduced mobility and functional decline. Epidemiological studies have found that age-related hearing loss is linked to slower gait speed, impaired balance, cognitive decline, and even increased risk of disability.^{8–11} For instance, Polku et al demonstrated that mild and severe hearing loss were associated with 1.8 and 2.0 times higher odds of restricted life-space mobility, respectively.¹² Mikkola et al⁵ similarly observed that severe hearing problems affected short-distance walking, stair climbing, and even walking 500 meters. These findings suggest that hearing loss may contribute to spatial restriction and social withdrawal, potentially accelerating frailty and dependence.

Despite this growing body of evidence, few studies have examined the relationship between hearing loss and LSA using objective hearing assessments, particularly among middle-aged adults, whose hearing loss is often underdiagnosed and still modifiable. Most prior studies have relied on self-reported hearing, or used only better-ear pure-tone averages (BPTA) in accordance with WHO definitions.¹³ While the WHO recommends using BPTA to classify hearing impairment (>20 dB as any loss, >35 dB as disabling loss),^{13,14} this may overlook the functional consequences of unilateral or asymmetrical hearing loss.

Emerging research also highlights the role of social frailty—a condition characterized by diminished social interactions and support—in mediating the impact of hearing loss on mobility. For instance, a Korean cohort study found that older adults with moderate-to-severe hearing loss had over twice the odds of being socially frail compared to those with normal hearing, even after adjusting for age, economic status, and physical frailty. This suggests that hearing impairment may contribute to social disengagement, which in turn could exacerbate mobility limitations and accelerate functional decline.

To address these limitations, our study applied clinical pure-tone audiometry to measure both better-ear (BPTA) and worse-ear (WPTA) hearing thresholds. This approach enables a more nuanced understanding of how even partial or single-ear hearing loss may be associated with mobility limitations. It also reflects real-world listening conditions, where binaural hearing is essential for sound localization and effective communication in noisy environments.¹⁵

Furthermore, while the impact of hearing loss on older adults has been widely discussed, little is known about how it affects middle-aged populations (aged 50–64)—a group in which moderate hearing loss is already prevalent.^{16,17} In Taiwan, studies report that 21% of adults aged 50–59 have bilateral hearing loss, a figure that rises to 65% by ages 70–79.¹⁶ Nonetheless, life-space mobility has rarely been included in hearing research in Taiwan, and its associations with hearing aid or cochlear implant use remain unclear.

This study responds to these gaps by examining the relationship between hearing loss and life-space mobility in a community-based of adults aged 50–79 in Taiwan. It also evaluates the potential role of hearing aids/cochlear implants and social frailty status in mobility outcomes. By using objective, ear-specific hearing data and integrating psychosocial variables, we aim to explore the complex mechanisms linking auditory decline to functional aging.

Objectives

This study aims to investigate the multifactorial relationship between hearing impairment and life-space mobility among middle-aged and older adults. Specifically, it seeks to: (1) examine differences in demographic (eg, age, sex, marital status, education, residence), psychological (eg, depressive symptoms), and social characteristics (eg, social frailty, living arrangements, and community participation) between individuals with and without objectively defined hearing loss; (2) determine whether hearing loss—measured by better-ear and worse-ear pure-tone averages (BPTA and WPTA)—serves as an independent predictor of restricted life-space mobility after controlling for key covariates including age, gender, marital status, depressive symptoms, and use of assistive devices; (3) evaluate whether the use of hearing aids or cochlear implants, as well as device usage patterns, is associated with improved life-space mobility outcomes among individuals with hearing loss; and (4) assess whether hearing impairment interacts with other risk factors—such as social frailty and psychological status—to predict restricted mobility, thereby clarifying the broader pathways through which auditory decline contributes to functional limitation and loss of autonomy in aging populations.

Materials and Methods

Study Population

The study began in February 2023 and concluded in May 2024. The Institutional Review Board of the National Cheng Kung University Hospital approved this study. All participants provided written informed consent before the study commenced. Ninety community-dwelling adults aged 50–79 were recruited, excluding those who could not see the questionnaire items even with vision correction. Inclusion criteria included the ability to live independently and intact cognitive function (orientation, attention, memory, language, comprehension, behavior, construction). Participants were selected using simple random sampling and were from southern Taiwan's community-dwelling population.

Data Collection Procedures

Participants completed face-to-face interviews and structured questionnaires to provide demographic, socioeconomic, and health-related information. Variables collected included hearing characteristics (pure-tone average thresholds for better and worse ear, self-perceived hearing impairment, tinnitus, ear fullness, sound intolerance), life-space mobility (Life-Space Assessment, LSA), depression (Center for Epidemiological Studies Depression Scale, CES-D), social frailty (Questionnaire to define Social Frailty Status, QSFS), hearing aid/cochlear implant usage and perceived benefit, fall history and fear of falling, assistive device usage, and medical history and medication use. Although 12 participants reported using hearing aids or cochlear implants, they were not excluded from the analysis. This decision was based on the assumption that such devices may have minimal impact on social frailty, and their usage was statistically adjusted for in the regression models.

Measures

Life-Space Mobility Assessment

Life-space mobility was measured using the University of Alabama at Birmingham (UAB) Study of Aging Life-Space Assessment (LSA) questionnaire,¹ which recorded participants' movement scores over the past four weeks through five questions. The questionnaire assessed life-space levels (bedroom, home, outside home, neighborhood, town, distant locations), frequency (average number of movements/week), and (equipment or assistance) during the past four weeks. Participants filled out their responses in response boxes. Scores were calculated by multiplying life-space levels, frequency, and independence values, resulting in interval and overall life-space scores. Participants were grouped into low life-space mobility (LSA < 40) and high life-space mobility (> 40). The assessment took approximately 15 minutes.

Hearing Assessment

Trained and certified audiologists conducted hearing assessments using pure-tone audiometry. Tests were performed in soundproof rooms equipped with calibrated audiometers at the medical center. Equipment included audiometers (Grason-Stadler [GSI-61], MADSEN [Itera II], or Interacoustics [AD629]). Quality control was established through daily and annual calibration and environmental noise monitoring using sound level meters. Testing rooms met or fell below maximum allowable environmental noise levels. Air conduction stimuli were presented via headphone earphones (TDH 39P, Telephonics Corp, Farmingdale, NY), and insert earphones (ER3A, Etymotic Research, Inc., Elk Grove Village, IL) were used if ear canal collapse was suspected.

During the hearing test, participants sat in a single-door soundproof room, listening to sounds through headphones and pressing a button each time a sound was heard, regardless of volume. Best practice threshold-seeking methods determined hearing levels (HL) in decibels for each ear at different frequencies (0.5, 1.0, 2.0, and 4.0 kHz) using air and bone conduction thresholds.¹⁸ The four-frequency pure-tone averages for each ear were calculated, and the better-ear pure-tone average (BPTA) was used for analysis. In line with previous literature, the worse-ear pure-tone average (WPTA) was also included.

In addition to the modified classification based on WHO criteria (normal: BPTA <20 dB HL; mild to moderate: 20–50 dB HL; moderate to severe: >50 dB HL), participants were also dichotomized into: No hearing impairment: BPTA <50 dB HL, Hearing impairment: BPTA ≥50 dB HL. This binary classification was used in subsequent regression models to examine the impact of hearing disability. Higher values indicated greater hearing loss. All hearing thresholds were reported in dB HL.¹⁸ Daily device (hearing aids or cochlear implants) usage duration (>5 hours), years with hearing loss, and perceived device benefit were also recorded. The hearing test took approximately 15–20 minutes.

Social Frailty

Social frailty was measured using the QSFS developed by Makizako et al,¹⁹ operationally defined based on empirical evidence using five questions to explore frailty issues among older adults (frequency of going out, visiting friends, social roles, living alone, conversations). QSFS scores ranged from 0 to 5. Questions 1, 4, and 5 answered with “yes” and questions 2 and 3 answered with “no” were considered negative responses. Non-frailty = 0, pre-frailty = 1, and frailty ≥ 2. The cut-off score for social frailty was 2, with higher scores indicating greater frailty.²⁰ The questionnaire took about 5 minutes to complete.

Depression

Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item self-report instrument designed to measure depressive symptomatology in the general population. The scale includes questions on depressive mood, reduced positive affect, somatic complaints, and interpersonal difficulties. Participants rated each item based on their experience over the past week using a 4-point Likert scale, with scores ranging from 0 to 60. Higher scores indicate more severe depressive symptoms. A cut-off of 16 was used to indicate probable clinical depression. The CES-D has been widely validated in aging and population health studies.

Covariates

Sociodemographic variables were self-reported, including age (continuous), gender (male, female), and marital status (married, unmarried). Functional status was evaluated based on self-reported need for walking assistance (requiring assistance or not). Self-reported hearing symptoms included hearing difficulties, tinnitus, ear congestion, or sound sensitivity. Hearing history data included the duration of hearing loss (<1 year, 1–5 years, >5 years) and daily exposure to loud noise or music.

Participants using hearing aids or cochlear implants provided usage duration, perceived benefit (none/partial/substantial), and self-reported hearing difficulties. They also reported whether they declined device use despite hearing difficulties. Fall-related variables included number of falls in the past year, time, cause, location, injury, and avoidance of going out due to fear of falling. Use of assistive devices (eg, cane, walker) was recorded. Chronic illness diagnoses and number of prescription medications were reported as continuous variables.

Statistical Analysis

Descriptive statistics were performed to compare sample characteristics across hearing loss categories. One-way analysis of variance (ANOVA) was applied to continuous variables (eg, age, hearing thresholds, LSA score, cognitive and psychological measures), and chi-square tests were used for categorical variables (eg, gender, marital status, employment status, hearing aid use, fall history). Group comparisons were based on the WHO hearing impairment grades using better-ear pure-tone average (BPTA <20, 20–50, ≥50 dB HL) as well as a binary classification (BPTA <50 vs ≥50 dB HL).

Two logistic regression models were developed to explore predictors of low life-space mobility (LSA < 40). The first model used bilateral hearing impairment (BPTA ≥ 50 dB HL) as the main predictor, and the second model used worse-ear pure-tone average (WPTA, continuous variable). Three nested models were constructed in each:

Model 1 included age, gender, and marital status.

Model 2 added hearing aid/cochlear implant use.

Model 3 further included social frailty (QSFS score), depressive symptoms (CES-D score), Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated.

Statistical significance was set at $p < 0.05$. All analyses were conducted using SPSS version 17.0 (IBM Corp., Armonk, NY).

Result

A total of 90 community-dwelling adults aged 50–79 years (mean age: 64.21 ± 7.53) completed the study. Among them, 53.3% were female and 75.6% were married. Most participants held a university degree or higher (71.1%), 32.2% were employed, and 87.8% reported residing in urban areas. A minority (2.2%) required walking assistance, while 11.1% reported upper or lower limb mobility difficulties. The average number of prescription medications taken was 2.06 ± 2.11 . The most common chronic conditions included hypertension (27.5%), hyperlipidemia (19.8%), and diabetes (19.8%).

Objective pure-tone audiometry revealed an average better-ear hearing threshold (BPTA) of 31.34 ± 20.26 dB HL and a worse-ear threshold (WPTA) of 41.47 ± 27.47 dB HL. Hearing levels were categorized according to World Health Organization criteria as follows: normal hearing (BPTA < 20 dB HL: 40.0%), mild to moderate hearing loss (BPTA ≥ 20 to 50 dB HL: 44.4%), and moderate to severe hearing loss (BPTA > 50 dB HL: 15.6%). Based on these classifications, 15.6% met the threshold for bilateral hearing impairment (BPTA ≥ 50 dB HL), which was used for binary comparisons

and logistic regression. Among the total sample, 12.1% reported using hearing aids or cochlear implants; of these, 50% used the devices more than 5 hours per day, and 91.6% reported moderate to substantial perceived benefit.

The average Life-Space Assessment (LSA) score was 65.13 ± 14.73 . According to LSA level distribution, 5.6% scored within the restricted mobility range (LSA I: 20–40), while 63.3% were classified in the moderate range (LSA III: 61–80). The average depression score (CES-D) was 7.12 ± 0.75 , and the social frailty score (QSFS) was 0.74 ± 0.80 . Based on QSFS cutoffs, 43.3% were classified as non-frail, 43.3% as pre-frail, and 13.3% as social frailty. Cognitive status (0–30) was 28.81 ± 1.289 , with an average cognitive score of 28.73 ± 1.32 .

Table 1 shows that participants with bilateral hearing impairment (BPTA ≥ 50 dB HL) had significantly higher odds of restricted life-space mobility, with 21.4% classified in LSA I compared to only 2.6% in the non-impaired group ($p=0.005$). They also had a marginally lower representation in the moderate LSA group (LSA III: 35.7% vs 63.2%, $p=0.055$). Depression and social frailty scores did not significantly differ between hearing groups ($p=0.650$ and $p=0.884$, respectively).

Across the three-group modified WHO classification (Table 2), participants with moderate to severe hearing loss were significantly older (mean age 67.21 ± 8.85 years, $p=0.007$) and less likely to be married (85.7% married vs 62.5% in the mild group, $p=0.036$). Use of walking assistance was more common (14.3%, $p=0.004$), and this group also had significantly longer hearing loss durations (>10 years in 50.0%, $p<0.001$). Hearing aid or cochlear implant usage was highest in the moderate to severe group (57.1%, $p<0.001$). Notably, self-reported hearing problems after using hearing devices were more frequent in this group (64.3%, $p<0.001$), though satisfaction ratings did not significantly differ ($p=0.418$). Other sociodemographic characteristics—including education, employment, and urban residence—did not significantly differ across groups.

In logistic regression analyses based on BPTA categories (Table 3), bilateral hearing impairment (BPTA ≥ 50 dB HL) was significantly associated with low life-space mobility (LSA < 40). In Model 1, the unadjusted odds ratio (OR) was 8.31. After adjusting for age, gender, marital status, and hearing aid/cochlear implant use in Model 2, the OR increased to 36.61. Model 3, which additionally included CES-D and QSFS, showed a further elevated risk (OR = 48.34, 95% CI: 2.06–1136.35, $p<0.05$).

Table 4 reports the regression results using WPTA as a continuous predictor. In Model 1, each 1 dB increase in WPTA was marginally associated with higher odds of restricted LSA scores (OR = 1.03, $p=0.054$). The association reached statistical significance in Model 2 (OR = 1.055, $p=0.035$), and remained significant after adjustment for all covariates in Model 3 (OR = 1.06, 95% CI: 1.00–1.13, $p=0.039$). These findings indicate that both the degree and the ear-specific threshold of hearing loss are robustly linked to lower mobility outcomes.

Table 1 Correlation of Hearing Loss (WHO Hearing Impairment Grade, Cut off = 50 dB HL) with Life Space Score, Cognitive, Social Frailty and Depression n=90

Variable	No Hearing Impairment (BPTA < 50 dB HL)	Hearing Impairment (BPTA $\geq$ 50 dB HL)	p-value
Overall (%)	76 (84.44%)	14 (15.56%)	
Age (years)	63.66 ± 7.19	67.21 ± 8.85	0.111
Life-Space mobility (LSA) - Mean $\pm$ SD	65.91 ± 13.50	60.89 ± 20.25	0.244
LSA I (20–40)	2 (2.6%)	3 (21.4%)	0.005*
LSA II (41–60)	19 (25%)	4 (28.6%)	0.795
LSA III (61–80)	48 (63.2%)	5 (35.7%)	0.055
LSA IV (>80)	7 (9.2%)	2 (14.3%)	0.556
Social Frailty Score - Mean $\pm$ SD	0.75 ± 0.87	0.71 ± 0.61	0.884
Depression Score - Mean $\pm$ SD	8.95 ± 7.11	8.07 ± 7.37	0.650

Notes: Values are presented as mean $\pm$ standard deviation (SD) or number (percentage), as appropriate. Group comparisons for continuous variables (Age, Life-Space Mobility, Social Frailty Score, Depression Score) were conducted using independent-sample *t*-tests. Comparisons for categorical variables (LSA mobility levels I–IV) were analyzed using chi-square tests. * $p < 0.05$ bold type, statistically significant.

Table 2 Sample Characteristics Categorized by Hearing Loss (WHO Hearing Impairment Grade)

Variables	Total (%)	Normal Group (BPTA < 20 dB HL) n (%)	Mild to Moderate Hearing Loss (BPTA 20–50 dB HL) n (%)	Moderate to Severe Hearing Loss (BPTA ≥ 50 dB HL) n (%)	F-value	p-value
Total	90	36 (40%)	40 (44.4%)	14 (15.6%)		
Better-ear pure-tone average (dB HL)	31.34±20.26	14.76±3.07	33.79±9.42	66.98±19.25	141.077	0.000*
Worse-ear pure-tone average (dB HL)	41.47±27.47	21.10±10.93	43.71±15.55	87.43±26.05	86.689	0.000*
Age (years)	64.21±7.53	61.25±5.57	65.83±7.84	67.21±8.85	5.278	0.007*
Gender, Male	42 (46.7%)	14 (38.9%)	19 (47.5%)	9 (64.3%)		0.268
Marital Status (Married)	68 (75.6%)	31 (86.1%)	25 (62.5%)	12 (85.7%)		0.036*
Employment Status (Employed)	29 (32.2%)	11 (30.6%)	14 (35.0%)	4 (28.6%)		0.873
Education (University or above)	64 (71.1%)	29 (80.6%)	27 (67.5%)	8 (57.1%)		0.207
Living in Urban Area	79 (87.8%)	32 (88.9%)	34 (85.0%)	13 (92.9%)		0.717
Walking assistance	2 (2.2%)	0 (0.0%)	0 (0.0%)	2 (14.3%)		0.004*
Need Aid at Home or Yard	10 (11.1%)	1 (2.8%)	6 (15.0%)	3 (21.4%)		0.098
Self-reported Hearing problems	26 (28.9%)	2 (5.6%)	14 (35.0%)	10 (71.4%)		0.000*
LSA Score	65.13±14.73	65.69±11.24	66.11±15.40	60.89±20.25	0.790	0.504
Depression Score	7.12±0.75	8.53±7.42	9.33±6.89	8.00±7.37	0.220	0.803
Social Frailty Score	0.74±0.8	0.56±0.61	0.93±0.97	0.71±0.61	2.075	0.132
Duration of Hearing Loss (> 2 years)	32 (35.6%)	7 (19.4%)	14 (35.0%)	11 (78.6%)		0.000*
Duration of Hearing Loss (> 10 years)	14 (15.6%)	3 (8.3%)	4 (10.0%)	7 (50.0%)		0.000*
Self-reported Hearing problems after using Hearing Aids/Cochlear Implants	11 (12.2%)	0 (0.0%)	2 (5.0%)	9 (64.3%)		0.000*
Self-reported Hearing problems refused to use Hearing Aids/Cochlear Implants	35 (38.9%)	11 (30.6%)	19 (47.5%)	5 (35.7%)		0.000*
Hearing Aids/Cochlear Implants Benefit*	4.5±0.91	0	5±0.0	4.4±.966	0.714	0.418

Notes: Hearing aid benefit and daily usage duration are applicable only to hearing aid users and are included in the average scores for the 14 participants using hearing aids. Values are presented as mean ± standard deviation (SD) or number (percentage), as appropriate. For comparisons across the three hearing groups, one-way analysis of variance (ANOVA) was used for continuous variables (eg, Better-ear PTA, Age, LSA Score), as indicated by reported F-values. Chi-square tests were used for categorical variables (eg, Gender, Marital Status, Living Area, Walking Assistance). For the variable “Hearing Aids/Cochlear Implants Benefit”, ANOVA was conducted among the subset of participants using hearing aids. *p < 0.05 bold type, statistically significant.

Abbreviations: BPTA, Better Ear Four-Frequency Average Hearing Threshold (0.5, 1, 2, and 4 kHz); CES-D, Center for Epidemiologic Studies Depression Scale; QSFS, Questionnaire to define Social Frailty Status.

Table 3 Logistic Regression Model Estimates of Low Life-Space Mobility with Bilateral Hearing Impairment by Pure Tone Audiometer, n = 90

Variable	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Age	1.01[0.89,1.16]	0.97[0.83,1.14]	0.98[0.84,1.15]
Gender (reference: male)	0.27[0.25,2.92]	0.35[0.03,4.48]	0.41[0.27,6.285]
Bilateral hearing loss (reference: BPTA<50 dB)	8.31[1.14,60.78]* p=0.037	36.61[1.70,790.42]* p=0.022	48.34[2.06,1136.35]* p=0.016
Marital status (reference: married)	0.75[0.07,8.71]	0.50[0.04,6.40]	0.88 [0.53,14.43]
Hearing aids /Cochlear implant use (reference: not wearing)		0.11[0.00,3.03]	0.114[0.00,2.99]
QSFS			2.44[0.66,9.01]
CESD			1.02[0.88,1.18]
Constant	0.025	0.441	0.124

Notes: Odds ratios (ORs) and 95% confidence intervals (CIs) are derived from multivariate binary logistic regression models predicting low life-space mobility using bilateral hearing impairment as the main exposure. Models are adjusted incrementally for demographic and psychosocial covariates across Models 1–3. *p < 0.05, statistically significant.

Abbreviations: BPTA, Better Ear Four-Frequency Average Hearing Threshold (0.5, 1, 2, and 4 kHz); CES-D, Center for Epidemiologic Studies Depression Scale; QSFS, Questionnaire to define Social Frailty Status.

Discussion

We studied the association between hearing loss and life-space mobility among 90 cognitively normal individuals aged 50 and above in Southern Taiwan. After adjusting for gender, age, marital status, use of hearing aids, social frailty and depression, bilateral hearing loss was associated with a 48.34-fold increased risk of low life-space mobility. Additionally, we found that

Table 4 Logistic Regression Model Estimates of Low Life-Space Mobility with Worse-Ear Hearing Threshold (WPTA), *n* = 90

Variable	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Age	1.00[0.87,1.17]	0.96[0.82,1.12]	0.96[0.81,1.13]
Gender (reference: male)	0.21[0.02,2.33]	0.22[0.02,2.91]	0.30[0.02,4.49]
Worse ear hearing loss pure-tone average	1.03[1.00,1.06] <i>p</i> =0.054	1.055[1.000,1.11]* <i>p</i> =0.035	1.06[1.00,1.13]* <i>p</i> =0.035
Marital status (reference: married)	0.86[0.08,9.61]	0.94[0.76,11.52]	0.15[0.09,14.89]
Hearing aids /Cochlear implant use (reference: not wearing)		0.10[0.00,4.03]	0.08[0.00,3.86]
QSFS			2.234[0.66,7.582]
CESD			0.98[0.83,1.16]
Constant	0.027	0.149	0.14

Notes: Odds ratios (ORs) and 95% confidence intervals (CIs) are estimated from binary logistic regression models using worse-ear hearing threshold as a continuous predictor of low life-space mobility. **p* < 0.05, statistically significant.

Abbreviations: BPTA, Better Ear Four-Frequency Average Hearing Threshold (0.5, 1, 2, and 4 kHz); CES-D, Center for Epidemiologic Studies Depression Scale; QSFS, Questionnaire to define Social Frailty Status.

worse-ear hearing loss also posed a risk, with each 1 dB difference in the worse-ear hearing threshold increasing the risk of low life-space mobility by 1.06 times. Hearing loss may be an independent predictor of life-space mobility (LSA).

Comparison with Previous Research

Our study aligns with previous findings that hearing loss is related to restricted life-space mobility. After controlling for covariates, bilateral hearing loss was associated with a 48.34-fold increased risk of restricted life-space mobility (*p* < 0.05). A 2015 study by Polku showed that mild and severe hearing loss increased the risk of restricted life-space mobility by 1.8 (95% CI = 1.0–3.2) and 2.0 (95% CI = 1.0–3.9) times, respectively. Mikkola et al⁵ also noted that severe hearing problems affect daily activities, short-distance mobility, stair climbing, and walking 2 km, with even 0.5 km walking becoming more challenging. Our study similarly observed that participants with moderate-to-severe hearing loss had a higher rate of needing assistance for mobility (14.3% vs 0%, *p* < 0.01) and a higher proportion of self-reported mobility difficulties (21.4% vs 2.8%, *p* = 0.098), approaching statistical significance. Physiologically, individuals with hearing loss face more mobility difficulties, associated with loss of independence.^{2,4,5,7,8,21,22} The seventh cross-sectional analysis of the English Longitudinal Study of Ageing (ELSA) in 2020 found that self-reported measures of hearing loss were limited in accuracy and sensitivity for detecting hearing loss.²³

Therefore, this study employed pure-tone audiometry to determine the hearing thresholds of participants in each ear, understanding the actual hearing situation. This method allows for the identification of hearing perception performance in both the better and worse ears, and can detect hearing loss issues through hearing threshold measurements in a timely manner, enabling the development of intervention plans.

Role of Worse-Ear Hearing Thresholds

Our study also considered the risks associated with worse-ear hearing loss. Results indicated that for each 1 dB difference in worse-ear hearing thresholds, the risk of restricted life-space mobility increased by 1.06 times. Early researchers noted the impact of unilateral hearing loss on occupation and social activities, causing discomfort, shame, and helplessness.²⁴ Individuals with unilateral hearing loss have difficulty locating sounds and understanding speech in noise,²⁵ potentially impacting social communication²⁶ and leading to social isolation.²⁷ This suggests that the hearing status of the better ear does not fully represent an individual's overall bilateral hearing ability, and future research should consider the potential negative impacts of unilateral and asymmetric hearing loss.

Hearing Loss and Social Frailty

This study found no significant association between hearing loss and social frailty, which differs from previous research findings. The QSFS, developed by Makizako in Japan,¹⁹ provides an operational definition of social frailty grounded in empirical evidence. Communication difficulties and frustration are common among those with hearing loss, with prior

studies indicating that older adults with hearing impairments experience communication barriers and avoid situations where they might feel frustrated or abandoned.^{28,29}

In our study, 7.1% of participants with moderate-to-severe hearing loss did not have daily conversations ($p = 0.78$), most were not living alone (92.9%, $p = 0.36$), and lived in urban areas (92.9%, $p = 0.717$), though these were not statistically significant. This suggests that the negative impacts of hearing loss may be mitigated through other means, or due to the study's participant limitations. Possible reasons include the small sample size, leading to non-significant differences; secondly, the use of hearing aids among those with moderate-to-severe hearing loss (71.4%), which may have improved communication difficulties and positively impacted social frailty; and thirdly, better-ear hearing in those with mild-to-moderate hearing loss, allowing for improved communication through repetition or increased volume, especially in group conversations, thereby avoiding frustration from hearing loss and maintaining good social participation.

Benefits of Hearing Intervention

Maintaining the ability to move is fundamental to active aging. Good mobility means more vitality and independent living for older adults. Life-space mobility reflects how an individual moves across different life spaces over a certain period, combining frequency and independence of movement, reflecting actual movement in daily life. Higher life-space mobility contributes to a better quality of life.³⁰ Individuals with higher life-space mobility have more opportunities to engage in activities of interest.

In 2018, Polku et al³¹ conducted a study in the Netherlands to examine life-space mobility among 702 community-dwelling older adults aged 70 to 91 years with hearing loss. Results indicated that those benefiting from hearing aids had higher life-space mobility scores, with significant statistical differences. This suggests that hearing aid technology can provide sufficient environmental cues and speech, improving self-efficacy and independence.³²

Self-sufficiency and independence relate to whether individuals with hearing loss can complete daily activities independently. Hearing aids can reduce environmental noise through processors, delivering high-quality processed signals to the ears, enhancing speech audibility and clarity. Hearing aids have been shown to improve cognitive function³³ and reduce depression.³⁴ Users of hearing aids have more social activities and avoid worry and paranoia.³⁵ Hearing aids are one of the most effective interventions for hearing loss, with numerous studies demonstrating their benefits. Common benefits include improved cognitive function,³³ enhanced communication among older adults,³⁶ reduced depression, improved mood, and increased social activities.³⁵ Despite these benefits, the use of hearing aids remains low, with only 12.1% of participants in this study using hearing aids or cochlear implants. Users often have many complaints about hearing aids, including limited help, high cost, noise, inconvenience, and difficulty changing batteries.

Strengths and Limitations

This study demonstrated a significant association between hearing impairment and reduced life-space mobility among older adults. Bilateral hearing loss, especially at the threshold for moderate to severe impairment, was consistently linked to lower mobility scores, even after adjusting for demographic, emotional, and social variables.

A major strength of this study is its comprehensive scope, incorporating detailed and clinically valid measures of hearing thresholds, psychological status (depression), and social frailty. Unlike prior studies that relied solely on self-reported hearing difficulty, our use of pure-tone audiometry allows for objective classification, thus strengthening the validity of our findings. The inclusion of validated instruments, such as the CES-D and QSFS, further enhances the robustness of our analysis by accounting for potential emotional and social confounders.

However, several limitations should be acknowledged. First, the study sample was relatively small ($N=90$) and drawn from a single medical center in southern Taiwan, which may limit generalizability to other populations or settings. Second, although we adjusted for key variables, other unmeasured factors—such as physical comorbidities, vestibular function, or environmental accessibility—may also influence life-space mobility and were not included. Third, the cross-sectional design precludes causal inference. Longitudinal studies are needed to establish the directionality of the relationship between hearing loss and mobility limitation. Fourth, the number of participants with restricted life-space mobility was relatively small (approximately 5.6% of the total sample), resulting in a limited number of outcome events for logistic regression modeling. Although we applied standard modeling practices and focused on effect sizes and

confidence intervals, this constraint may reduce statistical stability. The findings should therefore be interpreted with caution, and future studies with larger event rates are recommended.

Lastly, hearing aid use was self-reported and not confirmed through device verification or usage data, which may introduce recall bias.

These findings align with and extend previous research by highlighting the potential of hearing impairment to serve as an early and modifiable factor in limiting mobility. Notably, bilateral hearing loss at the modified WHO-defined threshold for moderate to severe impairment ($\text{BPTA} \geq 50$ dB HL) was associated with markedly reduced life-space mobility ($\text{OR} = 48.34$), and each 1 dB increase in worse-ear thresholds was linked to a 6% higher risk of restriction. This underscores the clinical importance of assessing both ears independently and integrating audiometric screening into early geriatric evaluations. Though interventions were not tested here, existing evidence suggests that aural rehabilitation—including hearing aid use, auditory training, and communication strategies—may help preserve autonomy and delay frailty onset. Further longitudinal studies are warranted to evaluate whether targeted intervention for bilateral or asymmetrical hearing loss can mitigate mobility decline and promote aging in place.

Conclusion

This study demonstrates that bilateral hearing impairment—specifically, at a pure-tone average (BPTA) threshold ≥ 50 dB HL, consistent with moderate to severe hearing loss—is significantly associated with reduced life-space mobility among adults aged 50 and older, while worse-ear hearing thresholds also contribute meaningfully to spatial limitations. These findings extend prior research by indicating that mobility restrictions may emerge earlier than previously recognized, and that ear-specific hearing deficits—including asymmetrical loss—deserve closer clinical attention. Given the observed associations, hearing impairment may represent an early and modifiable risk factor in the development of social frailty, especially through its impact on autonomy and engagement in everyday life.

Implication and Future Directions

These findings underscore the value of integrating life-space mobility into future hearing-related research and suggest that early identification of hearing loss—particularly bilateral or asymmetrical patterns—may be critical in identifying individuals at risk of social frailty and functional decline. Future longitudinal and interventional studies should test whether hearing rehabilitation can meaningfully alter mobility trajectories, delay the onset of social frailty, and preserve autonomy across the aging continuum.

Abbreviation

LSM, Life-Space Mobility; PTA, Pure Tone Audiometry; dB, Decibel; HL, Hearing Loss; ARHL, Age-Related Hearing Loss; Hz, Hertz; -, Disabling Hearing Loss; BPTA, Better-ear Pure Tone Average; WPTA, Worse Ear Pure Tone Average; LSA, University of Alabama at Birmingham Life-Space Assessment; CI, Cochlear Implants; HA, Hearing Aids; AR, Aural Rehabilitation; SF, Social Frailty.

Human Ethics and Consent to Participate Declarations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the National Cheng Kung University Hospital Institutional Review Board (IRB), approval number A-ER-111-409. All participants provided written informed consent before their inclusion in the study. The IRB determined that this study involves no foreseeable risks to participants.

Acknowledgments

This work was supported by the Basic Clinical Cooperation Project no. 11207037 from National Cheng Kung University Hospital. An unauthorized version of the Chinese MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR (www.parinc.com).

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Basic Clinical Cooperation Project no. 11207037 from National Cheng Kung University Hospital.

Disclosure

There are no conflicts of interest to declare.

References

1. Allman RM. The UAB study of aging: background and insights into life-space mobility among older Americans. *Aging Health*. 2006;2(3):417–429. doi:10.2217/1745509X.2.3.417
2. Agmon M, Lavie L, Doumas M. The association between hearing loss, postural control, and mobility in older adults: a systematic review. *J Am Acad Audiol*. 2017;28(6):575–588. doi:10.3766/jaaa.16044
3. Chen YJ, Matsuoka RH, Tsai KC. Spatial measurement of mobility barriers: improving the environment of community-dwelling older adults in Taiwan. *J Aging Phys Act*. 2015;23(2):286–297. doi:10.1123/japa.2014-0004
4. Kamil RJ, Li L, Li FR. Association between hearing impairment and frailty in older adults. *J Am Geriatr Soc*. 2014;62(6):1186–1188. doi:10.1111/jgs.12860
5. Mikkola TM, Polku H, Portegijs E, Rantakokko M, Rantanen T, Viljanen A. Self-reported hearing status is associated with lower limb physical performance, perceived mobility, and activities of daily living in older community-dwelling men and women. *J Am Geriatr Soc*. 2015;63(6):1164–1169. doi:10.1111/jgs.13381
6. Viljanen A, Kaprio J, Pyykkö I, et al. Hearing as a predictor of falls and postural balance in older female twins. *J Gerontol Ser a Biomed Sci Med Sci*. 2009;64(2):312–317. doi:10.1093/gerona/gln015
7. Lin FR, Ferrucci L. Hearing loss and falls among older adults in the United States. *Arch Intern Med*. 2012;172(4):369–371. doi:10.1001/archinternmed.2011.728
8. Chen DS, Betz J, Yaffe K, et al. Association of hearing impairment with declines in physical functioning and the risk of disability in older adults. *J Gerontol Ser a Biomed Sci Med Sci*. 2015;70(5):654–661. doi:10.1093/gerona/glu207
9. Deal JA, Betz J, Yaffe K, et al. Hearing impairment and incident dementia and cognitive decline in older adults: the health ABC study. *J Gerontol Ser a Biomed Sci Med Sci*. 2017;72(5):703–709.
10. Martinez-Amezcu P, Powell D, Kuo P-L, et al. Association of age-related hearing impairment with physical functioning among community-dwelling older adults in the US. *JAMA Netw Open*. 2021;4(6):e2113742–e2113742. doi:10.1001/jamanetworkopen.2021.13742
11. Yévenes-Briones H, Caballero FF, Struijk EA, et al. Association between hearing loss and impaired physical function, frailty, and disability in older adults: a cross-sectional study. *JAMA Otolaryngol Head Neck Surg*. 2021;147(11):951–958. doi:10.1001/jamaoto.2021.2399
12. Polku H, Mikkola TM, Rantakokko M, et al. Self-reported hearing difficulties and changes in life-space mobility among community-dwelling older adults: a two-year follow-up study. *BMC Geriatr*. 2015;15(1):1–7. doi:10.1186/s12877-015-0119-8
13. World Health Organization. *World Report on Hearing*. World Health Organization; 2021.
14. Humes LE. Examining the validity of the World Health Organization's Long-standing hearing impairment grading system for unaided communication in age-related hearing loss. *Am J Audiol*. 2019;28(3s):810–818. doi:10.1044/2018_aja-heal18-18-0155
15. Guthrie DM, Davidson JGS, Williams N, et al. Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: analysis of interRAI data for home care and long-term care recipients in Ontario. *PLoS One*. 2018;13(2):e0192971. doi:10.1371/journal.pone.0192971
16. Lin C-Y, Yang Y-C, Leon Guo Y, Wu C-H, Chang C-J, Wu J-L. Prevalence of hearing impairment in an adult population in Southern Taiwan. *Int J Audiol*. 2007;46(12):732–737. doi:10.1080/14992020701448986
17. Miller MH. Dysacusis. *Pediatr Clin North Am*. 1968;15(3):729–745. doi:10.1016/s0031-3955(16)32173-3
18. EOS/ESDA Association. *ANSI/ESD STM11. 13-2004 Two Point Resistance Measurement*. EOS/ESD Association, Incorporated; 2004.
19. Makizako H, Shimada H, Tsutsumimoto K, et al. Social frailty in community-dwelling older adults as a risk factor for disability. *J Am Med Direct Assoc*. 2015;16(11):5. doi:10.1016/j.jamda.2015.08.023
20. Lin FR, Metter EJ, O'Brien RJ, Resnick SM, Zonderman AB, Ferrucci L. Hearing loss and incident dementia. *Arch. Neurol*. 2011;68(2):214–220. doi:10.1001/archneurol.2010.362
21. Jiam NT, Li C, Agrawal Y. Hearing loss and falls: a systematic review and meta-analysis. *Laryngoscope*. 2016;126(11):2587–2596. doi:10.1002/lary.25927
22. Viljanen A, Kaprio J, Pyykkö I, Sorri M, Koskenvuo M, Rantanen T. Hearing acuity as a predictor of walking difficulties in older women. *J Am Geriatr Soc*. 2009;57(12):2282–2286. doi:10.1111/j.1532-5415.2009.02553.x
23. Tsimpida D, Kontopantelis E, Ashcroft D, Panagioti M. Comparison of self-reported measures of hearing with an objective audiometric measure in adults in the English longitudinal study of ageing. *JAMA Netw Open*. 2020;3(8):e2015009–e2015009. doi:10.1001/jamanetworkopen.2020.15009
24. Pronk M, Deeg DJH, Smits C, et al. Prospective effects of hearing status on loneliness and depression in older persons: identification of subgroups. *Int J Audiol*. 2011;50(12):887–896. doi:10.3109/14992027.2011.599871
25. Weaver J. Single-sided deafness: causes, and solutions, take many forms. *Hear J*. 2015;68(3):20,22,23,24. doi:10.1097/01.HJ.0000462425.03503.d6

26. Giolas TG, Wark DJ. Communication problems associated with unilateral hearing loss. *J Speech Hear Disord.* 1967;32(4):336–343. doi:10.1044/jshd.3204.336
27. Tokita J, Dunn C, Hansen MR. Cochlear implantation and single-sided deafness. *Curr Opin Otolaryngol Head Neck Surg.* 2014;22(5):353–358. doi:10.1097/moo.0000000000000080
28. Arlinger S. Negative consequences of uncorrected hearing loss--a review. *Int J Audiol.* 2003;42 Suppl 2:2s17–20.
29. Gopinath B, Hickson L, Schneider J, et al. Hearing-impaired adults are at increased risk of experiencing emotional distress and social engagement restrictions five years later. *Age Ageing.* 2012;41(5):618–623. doi:10.1093/ageing/afs058
30. Allman RM, Baker PS, Maisiak RM, Sims RV, Roseman JM. Racial similarities and differences in predictors of mobility change over eighteen months. *J Gen Intern Med.* 2004;19(11):1118–1126. doi:10.1111/j.1525-1497.2004.30239.x
31. Polku H, Mikkola TM, Gagné JP, et al. Perceived benefit from hearing aid use and life-space mobility among community-dwelling older adults. *J Aging Health.* 2018;30(3):408–420. doi:10.1177/0898264316680435
32. Rantakokko M, Portegijs E, Viljanen A, Iwarsson S, Kauppinen M, Rantanen T. Changes in life-space mobility and quality of life among community-dwelling older people: a 2-year follow-up study. *Qual Life Res.* 2016;25(5):1189–1197. doi:10.1007/s11136-015-1137-x
33. Mulrow CD, Aguilar C, Endicott JE, et al. Quality-of-life changes and hearing impairment. A randomized trial. *Ann Intern Med.* 1990;113(3):188–194. doi:10.7326/0003-4819-113-3-188
34. Garstecki DC, Erler SF. Hearing loss, control, and demographic factors influencing hearing aid use among older adults. *J Speech Lang Hear Res.* 1998;41(3):527–537. doi:10.1044/jslhr.4103.527
35. Kochkin S, Rogin CM. Quantifying the obvious: the impact of hearing instruments on quality of life. *Hear Rev.* 2000;7(1):6–34.
36. Crandell CC. Hearing aids: their effects on functional health status. *Hear J.* 1998;51(2):22,24,27–28,30,32. doi:10.1097/00025572-199802000-00002

Clinical Interventions in Aging

Publish your work in this journal

Clinical Interventions in Aging is an international, peer-reviewed journal focusing on evidence-based reports on the value or lack thereof of treatments intended to prevent or delay the onset of maladaptive correlates of aging in human beings. This journal is indexed on PubMed Central, MedLine, CAS, Scopus and the Elsevier Bibliographic databases. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/clinical-interventions-in-aging-journal>

Dovepress
Taylor & Francis Group