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Life-space mobility in older persons with cognitive impairment after discharge from geriatric rehabilitation

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ABSTRACT

Objectives: To describe life-space mobility and identify its determinants in older persons with cognitive impairment after discharge from geriatric rehabilitation.
Methods: A cross-sectional study in older community-dwelling persons with mild to moderate cognitive impairment (Mini-Mental State Examination, MMSE: 17–26) following geriatric rehabilitation was conducted. Life-space mobility (LSM) was evaluated by the Life-Space Assessment in Persons with Cognitive Impairment (LSA-CI). Bivariate analyses and multivariate regression analyses were used to investigate associations between LSM and physical, cognitive, psychosocial, environmental, financial and demographic characteristics, and physical activity behavior.
Results: LSM in 118 older, multimorbid participants (age: 82.3 ± 6.0 years) with cognitive impairment (MMSE score: 23.3 ± 2.4 points) was substantially limited, depending on availability of personal support and equipment. More than 30% of participants were confined to the neighborhood and half of all patients could not leave the bedroom without equipment or assistance. Motor performance, social activities, physical activity, and gender were identified as independent determinants of LSM and explained 42.4% (adjusted R^2) of the LSA-CI variance in the regression model.
Conclusion: The study documents the highly restricted LSM in older persons with CI following geriatric rehabilitation. The identified modifiable determinants of LSM show potential for future interventions to increase LSM in such a vulnerable population at high risk for restrictions in LSM by targeting motor performance, social activities, and physical activity. A gender-specific approach may help to address more advanced restrictions in women.

1. Introduction

The ability to move independently where and when a person wants to move is relevant for challenges in everyday life (Satariano et al., 2012), quality of life (Metz, 2000), and participation in society and natural environment (Barnes et al., 2007; Rosso, Taylor, Tabb, & Michael, 2013). In the course of progressive cognitive decline complex activities, such as outdoor activities, are the first to be lost (Njegovan, Hing, Mitchell, & Molnar, 2001). Especially older persons are, as a consequence of physical and cognitive decline, at high risk for reduced community mobility (Gill, Gahbauer, Murphy, Han, & Allore, 2012), being homebound (A. R. Smith, Chen, Clarke, & Gallagher, 2016), or institutionalized (Luppa et al., 2010; Sheppard, Sawyer, Ritchie, Allman, & Brown, 2013). To sustain social networks and familiar environment, most of older persons prefer to "age in place" (Gitlin, 2003). Thus maintaining or improving mobility in and out of home is particularly important as a prerequisite for independence.

Webber, Porter, & Menec (2010) developed a theoretical framework, which depicts mobility – broadly defined as life-space mobility (LSM) – to be influenced by physical, cognitive, psychosocial, financial and environmental factors embedded by influences of gender, cultural and biographical aspects (Webber et al., 2010). The framework has been successfully tested in older persons (Umstattd Meyer, Janke, & Beaujean, 2014) and has been supported by empirical research that provide evidence for relationships between the individual factors and LSM in older community-dwelling persons: Associations with LSM have

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been found for relative stable or immutable factors including socio-demographic variables such as age (Al Snih et al., 2012; Suzuki, Kitaike, & Ikezaki, 2014), gender (Peel et al., 2005; Phillips, Dal Grande, Ritchie, Abernethy, & Currow, 2015), marital status (Phillips et al., 2015), educational level (Eronen et al., 2016; Phillips et al., 2015), or financial situation (Peel et al., 2005; Phillips et al., 2015), as well as environmental conditions such as housing standard, living environment (Rantakokko, Iwarsson, Portegijs, Viljanen, & Rantanen, 2015), or weather conditions (Portegijs, Iwarsson, Rantakokko, Viljanen, & Rantanen, 2014). Associations were also found for variable or modifiable factors including health-related factors such as physical performance or medical diagnoses (Al Snih et al., 2012; Peel et al., 2005; Phillips et al., 2015), hospitalization (Brown et al., 2009), which constitutes also a risk factor for institutionalization (Goodwin, Howrey, Zhang, & Kuo, 2011), psychosocial status documented as fear of falling (FOF), depression, apathy, or social involvement (Al Snih et al., 2012; Auais et al., 2017; Peel et al., 2005; Uemura et al., 2013), global cognitive status (Peel et al., 2005), and domain-specific cognitive functions (processing speed) (Uemura et al., 2013). Physical activity (PA), itself influenced by physical, cognitive and psychosocial factors and environmental conditions (Franco et al., 2015; Stubbs et al., 2014), has also been closely linked to LSM (Portegijs, Tsai, Rantanen, & Rantakokko, 2015; Sawyer & Allman, 2010; Tsai et al., 2015), representing - as well as LSM - an aspect of movement behavior. Among the factors that have been related to LSM, motor and functional performance stand out as major determinant for LSM in older adults (Al Snih et al., 2012; Peel et al., 2005). Overall, accumulation of deficits, such as motor and cognitive impairments, might be associated with an accumulation of restrictions in LSM and an extraordinary risk of losing independence and autonomy. Studies in populations associated with multiple risk factors for LSM restrictions are, however, lacking. Previous studies most frequently focused on healthy older individuals (Al Snih et al., 2012; Peel et al., 2005), and only few studies addressed subgroups with single risk factors, such as orthopedic disorders (Suzuki et al., 2014), hospitalization (Brown et al., 2009), or persons with amnestic mild cognitive impairment (Uemura et al., 2013). Some studies assessed life-space (LS) in persons with CI using a questionnaire (Stalvey, Owsley, Sloane, & Ball, 1999) or GPS-based tracking devices (Tung et al., 2014), though these measures do not include frequency, the use of equipment or assistance, or indoor activity and are therefore not comparable. LSM was usually assessed via self-administered questionnaires with rather long retrospective assessment periods (Brown et al., 2009; Peel et al., 2005). However, the use of such questionnaires in cognitively impaired persons may hamper the accuracy of LSM documentation, as declining cognitive abilities (e.g., memory impairment, loss of orientation in time and locus) are associated with relevant recall bias (Bhandari & Wagner, 2006), which may have resulted in the exclusion of older people with cognitive impairment (CI) from most previous studies. To cope with such limitations and to document LSM in persons with CI, an interview-based assessment tool adjusted to their specific requirements has recently been developed and successfully validated for use in this population group closing this methodological gap (Ullrich et al., 2018).

In summary, the objectives of the study were to describe the LSM in older patients with mild to moderate CI after geriatric rehabilitation, representing a highly vulnerable population with multiple risk factors, and to investigate potential determinants of LSM in this population.

2. Methods

2.1. Study design

The present study is based on cross-sectional baseline data from a double-blinded, randomized, placebo-controlled trial (RCT) to improve motor performance and PA in older patients with mild to moderate CI discharged from geriatric rehabilitation (ISRCTN82378327; (Bongartz et al., 2017). The RCT was approved by the ethics committee of the Medical Department of the Heidelberg University (S-252/2015) in accordance with the Declaration of Helsinki and was registered at www.isrctn.com (ISRCTN82378327).

2.2. Recruitment and participants

Participants were recruited consecutively from rehabilitation wards of a German geriatric hospital between September 2015 and April 2017. Eligible participants were assessed for CI using the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). Only individuals with MMSE scores of 17 to 26, indicating mild to moderate CI, were included in the study (Monsch et al., 1995). Further inclusion criteria to participate in the RCT were: age ≥ 65 years; ability to walk at least 4 m without a walking aid; residence within 30 km of the study center; discharge to the patients' home (i.e., no nursing home residents); no terminal disease; no delirium; German-speaking, and written informed consent.

2.3. Measurements

The measurements were conducted right before randomization and start of the intervention. Only tests established in geriatric assessment and validated in older persons and if available in cognitively impaired individuals were used.

2.3.1. Life-space assessment

LSM was assessed using the Life-Space Assessment in Persons with Cognitive Impairment (LSA-CI), a modified version of the University of Alabama at Birmingham Study of Aging Life-Space Assessment (UAB-LSA) (Baker, Bodner, & Allman, 2003) specifically developed and validated for use in persons with CI (Ullrich et al., 2018). The assessment captures the life-space (LS) zones (from bedroom = 0, home = 1, immediate surroundings of one`s home = 2, neighborhood = 3, home town = 4 to unlimited area = 5) within the previous week, the frequency of mobility for each zone (1 = "1–3 times per week", 2 = "4-6 times per week", 3 = "daily"), and the assistance needed to travel within a zone (1 = "help of another person", 1.5 = "use of assistive device only", 2 = "no assistance"), while using an interview technique specifically developed for older people with CI (Ullrich et al., 2018). A composite score can be calculated by multiplying the zone score with scores for frequency and assistance, and then adding the scores for each zone. The lowest LSA-CI score of 0 indicates total immobility and the maximum LSA-CI score of 90 indicates daily independent out-of-town mobility. The LSA-CI covered also subscores (range 0–5) for (1) the maximum LS zone achieved without any assistance, or with equipment or personal assistance (LSA-CI-M); (2) the maximum LS zone achieved with equipment (e.g. walking sticks, rollator), if needed, but without personal assistance (LSA-CI-E), and (3) the maximum LS zone achieved independently without equipment and without personal assistance (LSA-CI-I). To extract the role of the specific assistance (i.e., equipment, personal assistance) in individual's LS, we developed two new subscores in addition to the established subscores based on the available LSA-CI data. The subscore (a) for the LS increased due to the assistance by another person (LSA-CI-AP) was calculated by subtracting the equipment-assisted from the maximal LS score (i.e. LSA-CI-M – LSA-CI-E) and subscore (b) for the LS increased due to the assistance by equipment (LSA-CI-AE) was calculated by subtracting the independent from the equipment-assisted LS score (i.e. LSA-CI-E – LSA-CI-I). By this approach, we were able to document the specific effect of personal assistance and equipment, respectively, which represents a novel perspective for LSA assessment.

2.3.2. Potential determinants of life-space mobility

Based on the mobility framework by Webber et al. (2010), physical, cognitive, psychosocial, environmental, and financial status and

gender, cultural and biographical variables were assessed to examine their associations with LSM. Physical variables included the Short Physical Performance Battery (SPPB) for the assessment of motor performance (Guralnik et al., 1994), the number of diagnoses as documented in patient charts indicating multimorbidity, and the Body Mass Index (BMI) documenting relative weight. Cognitive status was assessed using the Mini-Mental State Examination (MMSE) (Folstein et al., 1975). To assess different domains of psychosocial status we used the Falls Efficacy Scale – International (FES-I) (Hauer et al., 2011), the Fear of Falling Avoidance-Behavior Questionnaire (FFABQ) (Landers, Durand, Powell, Dibble, & Young, 2011; translated according to Beaton, Bombardier, Guillemin, & Ferraz (2000), stage 1–4), the 15-item version of the Geriatric Depression Scale (GDS) (Allgaier, Kramer, Mergl, Fejtkova, & Hegerl, 2011; Greenberg, 2007), the Apathy Clinical Evaluation Scale – Clinical Version (AES-C) (Lueken et al., 2006; Marin, Biedrzycki, & Firinciogullari, 1991), and the total duration of private, unpaid care by family members or friends within the previous three months (one item of a questionnaire for health-related resource use (Seidl et al., 2015)). A questionnaire for the assessment of the social situation (Erhebungsbogen SOziale Situation - SOS) (Nikolaus, Specht-Leible, Bach, Oster, & Schlierf, 1994) with four components was used to measure social contacts (including frequency, quantity and quality of relationships to other persons), social activities (existence and development of hobbies/interests), living situation (including indoor and outdoor aspect of the living situation such as comfort, barriers, infrastructure, duration of residence), and financial status (addressing the self-related sufficiency of actual income and the existence of savings). To complement environmental status in addition to living situation, weather data comprising mean temperature, precipitation height and snow depth for each of the subject`s assessment period were recorded at the weather station closest to the study center. Sociodemographic characteristics including age and gender were documented from patient charts, educational and marital status were assessed by standardized interviews. PA was assessed by the number of steps within 48 h measured with a body-fixed accelerometer (PAMSys™, BioSensics, Cambridge, MA, USA), using a validated algorithm for older persons (Najafi et al., 2003). For sample description, also falls in the previous year were documented by standardized interview (Zieschang, Schwenk, Becker, Oster, & Hauer, 2012).

2.4. Statistical analysis

Descriptive data are presented as frequencies and percentages for categorical variables, and means and standard deviations or median and range for continuous variables as appropriate. Differences in descriptive variables and LSA-CI scores between participants who received and those who did not receive personal assistance or equipment were analyzed by unpaired t-tests for continuous variables and chi-square tests for categorical variables. To identify potential determinants of LSM, we calculated bivariate correlation coefficients (Spearman (r_s) and point-biserial (r_{pb}) correlation coefficients) between LSA-CI composite score and variables for physical (SPPB, number of diagnoses, BMI), cognitive (MMSE), psychosocial (FES-I, FFABQ, GDS, AES-C, social contacts and social activities – SOS, duration of private unpaid care), environmental (living situation - SOS), financial (financial situation - SOS), sociodemographic status (age, gender, marital status, educational level), and total amount of PA (number of steps). Correlation coefficients (r) were interpreted as low ($r < 0.2$), moderate ($r = 0.2–0.5$), or high ($r > 0.5$) (Cohen, 1988). Variables that showed significant correlations ($p < 0.05$) were entered in a standard multiple linear regression analysis to examine independent determinants of LSM. Potential multicollinearity of independent variables was taken into account defined as correlation coefficients among independent variables $r > 0.7$ (Kleinbaum & Kupper, 1978) and a variance inflation factor (VIF) < 10 (Chatterjee & Hadi, 2013). Appropriateness of further assumptions of linear regression models of homoscedasticity and normality of the residuals (Ernst & Albers, 2017) and autocorrelation was considered. Two regression models were constructed: Model 1: a basic model including significant correlated variables for physical, cognitive, psychosocial, environmental, financial status, and sociodemographic influences oriented at the model by Weber et al (Webber et al., 2010); Model 2: all status-based variables from model 1 amended by a quantitative parameter for movement behavior (number of steps). Beta weights for all independent variables included in the regression equations (range of values: −1 to 1) and adjusted R^2 (including p-values for significance) for the total model were analyzed. A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 23 for Windows (IBM Corp., NY, USA).

3. Results

3.1. Participant characteristics

Out of 1981 patients screened for eligibility, 118 community-dwelling individuals were enrolled according to predefined inclusion criteria. The study sample comprised multimorbid (number of diagnoses = 11.4 ± 4.4), older patients (82.3 ± 6.0 years) with motor (SPPB = 5.2 ± 2.3) and cognitive impairment (MMSE = 23.3 ± 2.4), and mild depressive (GDS = 5.3 ± 3.0) and apathetic (AES-C = 40.2 ± 9.1) symptoms approximately 7.5 weeks (45.7 ± 47.1 days) after discharge from geriatric rehabilitation. Further sample characteristics are detailed in Table 1.

3.2. Description of life-space mobility

Based on 117 participants (one participant was excluded due to unrealistic statements, advanced disorientation, and confabulation), the mean LSA-CI composite score was 23.9 ± 13.2 within a range of 4.5 to 70 out of a maximum score of 90 (Table 2) with mainly highly restricted and dependent persons as well as a few relatively unrestricted and independent persons (Fig. 1). Results for LSA-CI subscores differed substantially (Table 2), depending on the degree of assistance with the highest scores when support by equipment or another person was included (LSA-CI-M), substantially lower scores for the LS achieved with equipment but without personal assistance (LSA-CI-E), and very low scores for the LS achieved independently without any assistance by equipment or another person (LSA-CI-I). The maximum LS achieved (LSA-CI-M), independent of the degree of assistance, indicated an activity area between the neighborhood (= LS zone 3) and the hometown (= LS zone 4) (LSA-CI-M = 3.7 ± 1.2). Despite support from another person or equipment, seven participants (6.0%) were completely homebound (LSA-CI-M ≤ 1) and 38 participants (32.5%) were restricted to their neighborhood (LSA-CI-M ≤ 3; Table 3). The equipment-assisted LS score (LSA-CI-E) showed that without personal assistance LS decreased substantially by more than one LS zone (-1.1 ± 1.3) and covered an area between the immediate surroundings of the home (= LS zone 2) and the neighborhood (= LS zone 3) (LSA-CI-E = 2.5 ± 1.2; Table 2). Further analysis of the LS achieved with equipment showed that more than half of the participants (n = 70, 59.8%) were bound to the immediate surroundings of the home (≤ LS zone 2), and more than three fourths (n = 90, 76.9%) were restricted to the neighborhood (≤ LS zone 3; Table 3). The LS achieved independently without any assistance (LSA-CI-I) was on average restricted to the home (= LS zone 1) (LSA-CI-I = 1.1 ± 1.4; Table 2). A closer look at the independent LS revealed that - without equipment or personal assistance - half of all participants (n = 58, 49.6%) were not able to leave their bedroom, overall 84.7% (n = 99) were restricted to the immediate surroundings of the home (LSA-CI-I ≤ 2), and 92.4% (n = 108) were restricted to their neighborhood (LSA-CI-I ≤ 3; Table 3). The analysis of the specific benefit from personal assistance (LSA-CI-AP) revealed that more than half of all participants (n = 63,

Table 1
Sample characteristics.

Characteristics	Variables	n = 118
Physical status	SPPB Score (0–12), mean (SD)	5.2 (2.3)
	Number of diagnoses, mean (SD)	11.4 (4.4)
	Body Mass Index, mean (SD)	27.3 (5.3)
	At least one fall in the previous year, n (%)	79 (67)
Cognitive status	MMSE Score (0–30), mean (SD)	23.3 (2.4)
Psychosocial status	Social Contacts Score (0–6; SOS), mean (SD)	5.4 (0.7)
	Social Activities Score (0–5; SOS), mean (SD)	2.5 (1.1)
	FES-I Score (7–28), median (range)	11 (7-25)
	FFABQ Score (0–56), mean (SD)	18.5 (12.6)
	GDS Score (0–15), mean (SD)	5.3 (3.0)
	AES-C Score (18–72), mean (SD)	40.2 (9.1)
Environmental status	Living situation (0–11), mean (SD)	8.7 (1.4)
Sociodemographic status	Age (years), mean (SD)	82.3 (6.0)
	Gender (female/male), n (%)	90(76.3) / 28(23.7)
	Marital status (married/not married), %	30.5/69.5
	Educational level (only school/vocational education/ university or comparable), %	31.4/50.0/18.6
Physical activity	Number of steps per day, mean (SD)	2843 (2264)

Presented are the characteristics of the study sample. *Abbreviations:* AES-C: Apathy Evaluation Scale – Clinical Version; FES-I: Falls Efficacy Scale – International; FFABQ: Fear of falling Avoidance Behavior Questionnaire; GDS: Geriatric Depression Scale; MMSE: Mini Mental State Examination; SOS: Questionnaire on social status; SPPB: Short Physical Performance Battery.

Table 2
Results of life-space assessment in persons with cognitive impairment.

LSA-CI score	Mean	(SD)	Median	Range
LSA-CI composite score (-C)	23.9	(13.2)	20.5	4.5–70
LSA-CI maximal score (-M)	3.7	(1.2)	4.0	1–5
LSA-CI equipment assisted score (-E)	2.5	(1.2)	2.0	1–5
LSA-CI independent score (-I)	1.1	(1.4)	1.0	0–5

Presented are results of the LSA-CI composite score and subscores; n = 117, one measurement had to be excluded due to unrealistic statements by the patient. *Abbreviations:* LSA-CI = Life-Space Assessment for Persons with Cognitive Impairment.

Table 3
Subscore analysis - Life-space zones and part of persons that reached maximal the respective zone.

Life-space zone	LSA-CI-M	LSA-CI-E	LSA-CI-I
0 (bedroom)	0 (0.0)	1 (0.9)	58 (49.6)
1 (home)	7 (6.0)	19 (16.2)	20 (17.2)
2 (immediate surroundings of the home)	20 (17.1)	50 (42.7)	21 (17.9)
3 (neighborhood)	11 (9.4)	20 (17.1)	9 (7.7)
4 (home town)	45 (38.5)	17 (14.5)	5 (4.3)
5 (unlimited area)	34 (29.1)	10 (8.5)	4 (3.4)

Presented are subscore analyses and the number of persons (percentage of persons) that reached maximal the respective zone; Abbreviations: LSA-CI-M = maximum life-space with equipment or personal assistance if needed; LSA-CI-E = maximum life-space with equipment if needed; LSA-CI-I = maximum independent life-space without equipment or personal assistance.

53.8%) increased their maximal LS through personal assistance, with more than two thirds of them (n = 45) showing an increase of at least two LS zones (Table 4). Participants who benefitted from personal assistance showed a significantly higher maximal LS (LSA-CI-M, $p < 0.001$), but a lower equipment-assisted (LSA-CI-E, $p < 0.001$) and independent LS (LSA-CI-I, $p = 0.004$), a lower motor performance (SPPB) ($p = 0.038$), and were mostly female ($p = 0.015$) compared to those who did not receive personal assistance (n = 54, 46.2%), indicating that personal assistance may be related to decreased functional status. No significant differences between these two groups were found

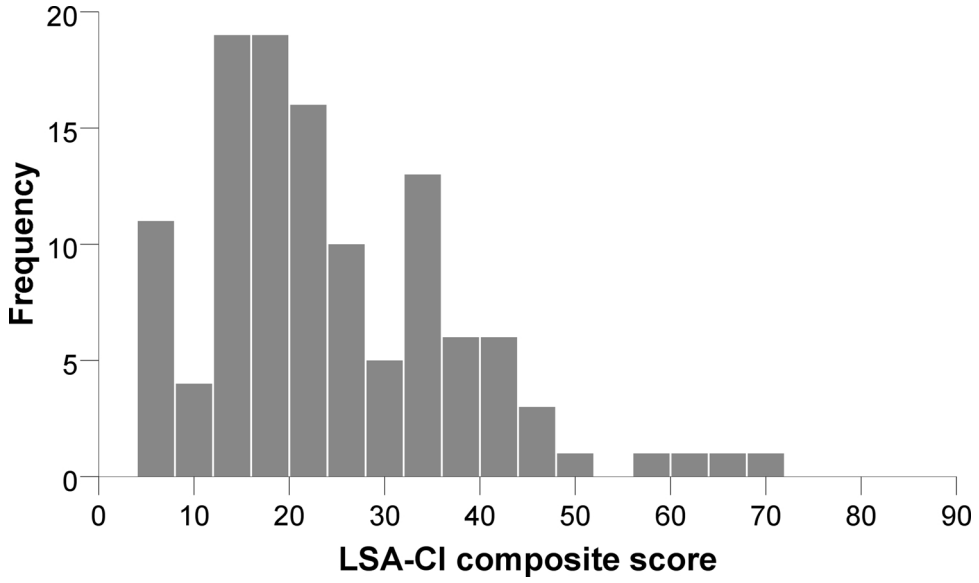

Fig. 1. Histogram of the LSA-CI composite score for the sample of 117 multimorbid, older people with cognitive impairment.

Table 4
Use of and benefit from personal assistance and equipment.

Increase of life-space zone by…	LSA-CI-AP, n (%)	LSA-CI-AE, n (%)
+ 0	54 (46.2)	38 (32.5)
+ 1	18 (15.4)	20 (17.1)
+ 2	24 (20.5)	41 (35.0)
+ 3	18 (15.4)	8 (6.8)
+ 4	2 (1.7)	8 (6.8)
+ 5	1 (0.9)	2 (1.7)

Presented are increases in life-space zones due assistance by a person or equipment. Abbreviations: LSA-CI-AP = life-space increased in persons with cognitive impairment due to assistance by a person; LSA-CI-AE = life-space increased in persons with cognitive impairment due to assistance by equipment.

Table 5
Differences between persons using and benefitting from personal assistance (LSA-CI-AP) and persons using and benefitting from equipment (LSA-CI-AE).

	LSA-CI-AP		LSA-CI-AE	
Group difference with respect to:	LSA-CI-AP ≥ 1 vs. LSA-CI-AP = 0	p	LSA-CI-AE ≥ 1 vs. LSA-CI-AE = 0	p
LSA-CI-C	23.0 vs. 25.0	.409	26.9 vs. 22.5	.113
LSA-CI-M	4.2 vs. 3.0	**< .001**	3.6 vs. 3.7	.794
LSA-CI-E	2.1 vs. 3.0	**< .001**	2.5 vs. 2.6	.820
LSA-CI-I	0.8 vs. 1.5	**.004**	2.5 vs. 0.4	**< .001**
age	83.0 vs. 81.5	.192	81.0 vs. 82.9	.125
gender (female)	85.7% vs. 66.7%	**.015**	85.5% vs. 63.2%	**.014**
diagnoses	11.8 vs. 10.8	.247	11.0 vs. 11.6	.464
MMSE	23.1 vs. 23.5	.347	22.9 vs. 23.5	.189
SPPB	4.8 vs. 5.7	**.038**	6.4 vs. 4.6	**< .001**
social activities	2.5 vs. 2.5	.951	2.5 vs. 2.5	.837
falls	1.1 vs. 1.0	.715	0.9 vs. 1.2	.141
FES-I	12.4 vs. 12.1	.749	11.1 vs. 12.8	**.035**
FFABQ	20.4 vs. 16.7	.118	13.1 vs. 21.3	**.001**
GDS	5.3 vs. 5.3	.966	5.0 vs. 5.4	.417
AES-C	22.2 vs. 21.9	.868	23.2 vs. 21.5	.375
PA (steps)	2538 vs. 3191	.127	3363 vs. 2591	.074

Presented are differences between groups according to use and benefit with respect to life-space zones due assistance by a person or equipment. Abbreviations: LSA-CI-AP = life-space increased in persons with cognitive impairment due to assistance by a person; LSA-CI-AE = life-space increased in persons with cognitive impairment due to assistance by equipment.

for the LSA-CI composite score and other descriptive variables (Table 5). Over two thirds of all participants (n = 79, 67.5%) specifically benefited from the use of equipment (LSA-CI-AE), with 59 (74.7%) of them showing an increase of at least two LS zones (Table 4). These participants showed significantly lower independent LS (LSA-CI-I, $p < 0.001$) and motor performance ($p < 0.001$) compared to those who did not use equipment (n = 38, 32.5%), but showed higher levels of FOF ($p = 0.035$) and avoidance behavior due to FOF ($p < 0.001$) and were mostly female ($p = 0.014$). No significant group differences were found in other LSA-CI scores or in other descriptive variables (Table 5).

3.3. Determinants of life-space mobility

As basis of the regression models, bivariate correlational analyses revealed that physical activity (PA) showed the highest correlations with LSA-CI score (PA/number of steps: $r_s = 0.590$; $p < 0.001$), followed by moderate correlations with social activities (social activities – SOS), motor performance (SPPB), FOF (FES-I), FOF-related avoidance behavior (FFABQ), age, gender, and living situation (living situation – SOS) ($r = |0.233\text{-}0.435|$; $p = < 0.001\text{–}0.012$). Correlations with duration of private unpaid care and cognition (MMSE) were low although reaching significance($r = |0.186\text{-}0.199|$; $p = 0.031\text{-}0.045$). Significant variables were included in the subsequent regression

Table 6
Correlation between life-space mobility and related factors.

Factors	Variable	r_s or r_{pb}	p
Physical status	SPPB Score	**.387****	< .001
	Number of diagnoses	.015	.875
	Body Mass Index (BMI)	−.028	.766
Cognitive status	MMSE Score	**.186***	.045
Psychosocial status	Social Contacts Score (SOS)	−.028	.762
	Social Activities Score (SOS)	**.435****	< .001
	FES-I Score	**−.238****	.010
	FFABQ Score	**−.380****	< .001
	GDS Score	−.108	.246
	AES-C Score	−.141	.129
	Private unpaid care	**−.199***	.031
Environmental status	Living Situation Score (SOS)	**.233***	.012
	Weather: Average temperature	−.005	.961
	Weather: Precipitation height	.007	.940
	Weather: Average snow depth	−.080	.392
Financial status	Financial Status (SOS)	−.021	.825
Sociodemographic factors	Age	**−.321****	< .001
	Gender[a]	**.282****	.002
	Marital Status[a]	−.074	.431
	Educational Level	.072	.442
Physical activity	Number of steps[b]	**.590****	< .001

Presented are Spearman coefficients rho between LSA-CI composite score and associated factors; n = 117; except for [a]point biserial correlation (dichotomous measures); [b]n = 114; [c]n = 112; [d]n = 108. Correlations coefficients (r): < 0.20 = low, .20–.50 = moderate, > 0.50 = high. Bolding indicates significant correlations; *p < .05; **p < .01. *Abbreviations:* AES-C: Apathy Evaluation Scale – Clinical Version; FES-I: Falls Efficacy Scale – International; FFABQ: Fear of falling Avoidance Behavior Questionnaire; GDS: Geriatric Depression Scale; LSA-CI: Life-Space Assessment for Persons with Cognitive Impairment; MMSE: Mini Mental State Examination; SOS: Questionnaire for social status; SPPB: Short Physical Performance Battery.

models. No significant correlations ($r = |0.005\text{–}0.141|$; $p = 0.129\text{–}0.961$) were found for number of diagnoses, BMI, measures of social contacts (social contacts - SOS), depressive and apathetic symptoms (GDS, AES-C), weather, financial status, marital status and educational level (Table 6). Regression model 1 (without PA) revealed that higher motor performance (SPPB), more social activities and being male were independently associated with higher LSA-CI-C scores, with the highest β-weight for motor performance, while cognition, FOF-related factors (FFABQ, FES-I), duration of private unpaid care, living situation and age were not independently associated with the LSA-CI-C score (Table 7). No multicollinearity between included variables or

Table 7
Regression model for determinants of life-space mobility.

	Model 1 (n = 117)	Model 2 (n = 114)
adjusted R^2	.363	.424
Variable	ß	ß
MMSE	.076	.064
SPPB	**.341****	**.243****
Social activities (SOS)	**.296****	**.257****
FES-I	.083	.025
FFABQ	−.076	−.064
Living situation	.058	.033
Gender	**.218****	**.182***
Age	−.109	−.102
Private unpaid care	.007	.027
No. of steps	–	**.265****

Bolding indicates significant correlations; *p < 0.05; **p < 0.01.
Presented are linear regression analyses for LSA-CI composite score and potential determinants. Bolding indicates significant factors. Abbreviations: FES-I: Falls Efficacy Scale – International; FFABQ: Fear of falling Avoidance Behavior Questionnaire; LSA-CI = Life-Space Assessment for Persons with Cognitive Impairment; MMSE: Mini Mental State Examination; SOS: Questionnaire for social status; SPPB: Short Physical Performance Battery.

autocorrelation was found (highest r = 0.642 for FES-I and FFABQ; max VIF = 2.045; Durbin-Watson 1.920). Model 1 explained a variance of 36.3% in the LSA-CI-C score (adjusted R^2 = 0.363). When the activity behavior-related variable for PA was additionally included in the regression model 2, higher motor performance (SPPB), more social activities, being male and higher amount of PA were independently associated with higher LSA-CI-C scores, with the highest β-weight for PA. No multicollinearity between included variables was found also for this model (max VIF = 2.019; Durbin-Watson 2.096). By adding PA into model 2, the total amount of explained variance increased from 36.3% to 42.4% (adjusted R^2 = 0.424, Table 7).

4. Discussion

To the best of our knowledge, this is the first study to investigate LSM and its determinants in multimorbid, older patients with CI after discharge from geriatric rehabilitation, a highly vulnerable population with multiple risk factors for LSM restrictions. Study results show that: 1) LSM is highly restricted in such a population, which becomes particularly apparent when analyzing the LS achieved independently without assistance of another person or equipment. 2) Higher motor performance, increased PA, more social activities, and male gender were identified as important determinants for increased LSM, explaining a considerable part of the LSA-CI´s variance.

4.1. Description of life-space mobility

The mean LSA-CI-C of 23.9 out of maximal 90 scores demonstrated that LSM was substantially limited among the study population. The majority of the participants were highly restricted and dependent on personal assistance as well as equipment. Previous studies in cognitively intact community-dwelling older adults have shown that average maximal LS covered an activity area between the hometown (= LS zone 4) and areas beyond (= LS zone 5) (maximal LS: 4.2–5.0) (Baker et al., 2003; Curcio et al., 2013; Fristedt, Kammerlind, Bravell, & Fransson, 2016). As expected, due to the impaired physical, cognitive and psychological status and the preceding hospitalization of the vulnerable study population, average maximal LS only ranged between neighborhood (= LS zone 3) and hometown (= LS zone 4) (LSA-CI-M: 3.7) in this study. The restricted mobility status in our population became particularly obvious when support mechanisms (personal assistance and use of equipment) were excluded, indicating a higher dependence on transportation support and a higher number of unfulfilled transportation needs (Cvitkovich & Wister, 2001). Without any assistance, the vast majority of persons were restricted to the home area, which is associated with decreased opportunities for participation in social and community activities (Szanton et al., 2016).

The use of equipment and personal assistance seem to play a key role in the LSM of multimorbid, older persons with motor and cognitive impairment as demonstrated by the newly introduced subscores LSA-CI-AP and LSA-CI-AE that enabled us to document separately the effect of personal assistance or equipment. The majority of participants used equipment and received help of another person, thus increasing their LSM to a level comparable to that of persons without the need for personal assistance or equipment. Interestingly, the participants receiving assistance and/or using equipment were those with a lower independent LS, lower motor performance, higher FOF, and higher avoidance behavior due to FOF, indicating that such limitations can successfully be compensated by personal assistance and equipment. Both, personal assistance and equipment, have been crucial to broaden the LSM in the multimorbid sample and therefore represent potential targets for increasing the mobility in vulnerable populations with multiple risk factors for LSM restrictions (Bertrand, Raymond, Miller, Martin Ginis, & Demers, 2017; Latham, Clarke, & Pavela, 2015), for example promoting the use and acceptance of existing equipment, examining the need of specific additional equipment, or encouraging relatives or caregivers to support outdoor mobility.

4.2. Determinants of life-space mobility

Based on the theoretical mobility framework by Webber et al. (2010), we considered a high number of potentially relevant factors to provide a comprehensive analysis of LSM in our sample. To our best knowledge, only one study in a large sample of older community-dwelling persons examined a comparable range of potentially relevant factors to analyze community mobility, identifying physical, cognitive, environmental and sociodemographic variables, but not psychosocial and financial factors, as independent determinants of mobility with physical health as strongest predictor (Umstattd Meyer et al., 2014). The current study conducted in multimorbid, older persons with motor and cognitive impairment focused, for the first time, on a specific population at high risk for restricted LSM, dependency, and institutionalization. Study results revealed that only variables addressing the participants' physical and (psycho-) social status, gender, and PA were independent determinants of LSM, accounting for a considerable part of the LSA-CI´s variance, while cognitive, financial, environmental, cultural and biographical factors as assessed in this population were negligible.

Among the physical variables, a comprehensive assessment for key motor functions (SPPB) was identified as an independent determinant of LSM, representing also the strongest factor in the first regression model. The result is in accordance with previous studies investigating multiple, potential factors of LSM in mixed populations of older adults with and without CI, that also identified functional and motor performance as the most powerful determinants of LSM (Al Snih et al., 2012; Peel et al., 2005). LSM was not significantly associated with number of medical diagnoses as a surrogate marker for multimorbidity, nor with the moderate BMI in our sample, thus supporting previous results observed in older adults with and without CI (Al Snih et al., 2012; Sawyer & Allman, 2010). In contrast to functional status as indicated by the SPPB, diseases or body characteristics seem to play rather a minor role for LSM. This is consistent with the World Health Organization's International Classification of Functioning, Disability and Health and its basic idea that a disease itself provides an incomplete perspective on health status and disability. Instead, the impact of diseases on an individual's functional status and impairment level as shown by the motor performance status is important for engagement in everyday life (Escorpizo et al., 2013).

Global cognitive status was not independently associated with LSM in our study population which was homogenous in this respect with a small-ranging mild to moderate CI level (MMSE range 17–26). Previous studies investigating associations between cognitive status and LSM showed conflicting results (Beland et al., 2018). Cross-sectional studies that showed associations between cognitive status and LSM included samples that covered the full range of cognitive performance including cognitively intact and severely impaired persons (MMSE range 0–30) (Al Snih et al., 2012; Peel et al., 2005), which might explain the different study results. Differences in outdoor activity might be more obvious in cognitive demanding outdoor activities (Wettstein et al., 2015), however, these differences with respect to the cognitive demand of an activity cannot be assessed using the LSA-CI. Our study design did not allow analysis of the risk of developing cognitive impairment as investigated in previous studies (Beland et al., 2018; James, Boyle, Buchman, Barnes, & Bennett, 2011).

Among the variables for psychosocial factors, we identified social activities as a significant and independent determinant of LSM, corresponding to results reported for cognitively healthy adults using a questionnaire assessing only LS, more specifically spatial distances (Barnes et al., 2007). Given that social activities are based on the volition of an individual to get around outside the own home and participate in the community or society (Levasseur, Richard, Gauvin, & Raymond, 2010) and that social activities had been identified to

account for a substantial proportion (about 20%) of trips outside the home among older adults (Mollenkopf et al., 1997), this finding is reasonable. Thus, our results support the idea of the LSM concept depicting not only spatial-temporal movement patterns, but also reflecting participation in the society (Parker, Baker, & Allman, 2002). Social contacts as documented by the SOS questionnaire and private unpaid care were not identified as independent determinants of LSM, even though the initial descriptive analysis of LSM showed that the assistance provided of another person increased LS substantially in our sample (LSA-CI-E = 2.5 ± 1.2 vs. LSA-CI-M = 3.7 ± 1.2). This might be explained by the assessment of social contacts and private unpaid care that was more likely to cover passive forms of social interaction that were mainly located in the home as suggested by Dale et al. (Dale, Saevareid, Kirkevold, & Soderhamn, 2008), while assessment of social activities included questions on active engagement (existence and development of hobbies/interests), thus better reflecting outdoor activity. FOF-related factors (FES-I and FFABQ) were bivariately associated with LSM, but these associations were not statistically independent of other determinants as shown by the regression analysis. These findings contrasted with previous studies demonstrating independent associations of LSM and FOF in older adults with (Uemura et al., 2013) and without CI (Auais et al., 2017). The effects may be mediated by motor performance and PA, as these variables were moderately correlated with FOF (Denkinger, Lukas, Nikolaus, & Hauer, 2015), or compensated by the use of equipment as suggested by the descriptive analysis with higher benefit by equipment in persons with higher levels of FOF. No associations between LSM and depressive or apathetic symptoms were found in our study sample, in contrast to previous studies in older mixed populations with and without CI (Al Snih et al., 2012; Peel et al., 2005). Apathy and depression may especially affect higher-level daily activities (e.g., shopping, public transportation) (Fitz & Teri, 1994; Kazama et al., 2011; Yeager & Hyer, 2008), and to a less extent lower-level activities of daily living (e.g. food preparation, doing the laundry), which might be the focus in everyday life in our vulnerable study population.

Environmental factors did not significantly influence the LSM of our sample. The living situation and weather conditions may have an influence on higher outdoor LSM, however, due to the low outdoor activity observed in our sample, the potential impact of such factors may have been reduced in our study.

Out of the sociodemographic factors (financial, cultural, biographical factors) only gender was identified as an independent determinant of LSM in our study population, with females showing lower LSM than males. The influence of gender on LSM was previously also reported for persons with orthopedic diseases (Suzuki et al., 2014), or unspecific populations (Peel et al., 2005; Phillips et al., 2015) and might be related to the generally higher disability level (Gill, Gahbauer, Lin, Han, & Allore, 2013), lower physical activity level (L. Smith, Gardner, Fisher, & Hamer, 2015) or to a preference for home leisure activities in older women (Gagliardi et al., 2007). Age was not independently associated with LS, which may be due to mediation effects of motor performance and PA that are in turn predicted by age (Browning, Sims, Kendig, & Teshuva, 2009; Guralnik et al., 1993).

PA behavior was identified as the strongest independent determinant of LSM in our second regression model. High associations of PA with LSM have also been previously reported by studies in older persons without CI, showing that a higher amount of PA is accompanied by greater spatial extension of mobility (Portegijs et al., 2015; Sawyer & Allman, 2010; Tsai et al., 2015). PA and LSM both represent aspects of movement behavior, with PA focusing on activity regardless of location and target and LSM focusing on the location and spatial extent of activity regardless of physically active or passive locomotion. Thus, the results were in line with our expectations of PA to explain a large amount of the LSA-CI´s total variance, which was the reason for calculating a second regression model with PA in addition to the first model, including only status-based variables. Furthermore, it might be also argued that the number of steps (i.e., walking), by which we quantified PA in our study, is a prerequisite to moving through LS zones independently (Collia, Sharp, & Giesbrecht, 2003; Satariano et al., 2012).

In summary, the theoretical mobility framework by Webber et al. (Webber et al., 2010), successfully tested in older persons (Umstattd Meyer et al., 2014), may only have a relevance for specific variables in multimorbid, older people with motor and cognitive impairment, as not all model assumptions were met in our study sample. However, our comprehensive analysis of LSM revealed independent determinants that were modifiable, except for gender. Previous studies have already demonstrated that physical training is feasible and effective to improve motor performance in older people with and without CI (for review, see (Heyn, Johnson, & Kramer, 2008), that social interventions (e.g., support interventions, home visiting, service provision) can promote social activities in older people (for review, see (Dickens, Richards, Greaves, & Campbell, 2011), and that physical home training (Hauer et al., 2017) or specific behavior change intervention techniques (goal setting, social support, using a credible source) (Nyman, Adamczewska, & Howlett, 2018) can increase PA. Thus, interventions that address motor performance, social activities, and PA may also have a high potential to increase LSM in a vulnerable population of multimorbid older adults with motor and cognitive impairment. Women were identified as a high risk subgroup for LSM restriction with a potential accumulation of converging negative factors, indicating a special need for interventions with focus on women.

Future studies could include differentiated analyses of social contacts, activities and support, specific diseases and cognitive subdomains or behavioral factors (activities of daily living). As a limitation of the study, we have to mention that the SOS was not validated in persons with cognitive impairment. However, as the documentation of the SOS was interview-based and performed by trained assessor, representing an established procedure to compensate potential record bias in persons with cognitive impairment, we assume that the documentation meets established documentation standards.

5. Conclusions

LSM was substantially restricted in a multimorbid, vulnerable population of older persons with CI following geriatric rehabilitation. Equipment and personal assistance played a key role for LSM in this population, as dependency on both is highly prevalent, providing opportunities for increasing LSM by improving the availability and use of equipment or by providing personal assistance. The identified determinants of LSM show potential for future interventions to increase LSM in such vulnerable persons at high risk for LS restrictions by targeting motor performance, social activities, and PA.

Conflict of interest

The authors declare that there is no conflict of interest.

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