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Original Article

A path analysis of the interdependent relationships between life space assessment scores and relevant factors in an elderly Japanese community

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Abstract. [Purpose] This study aimed to examine the direct and indirect effects of factors influencing the risk of life space assessment using path analysis. [Participants and Methods] A sample of 212 elderly residents (at least 65 years old) with no clear indications of cognitive dysfunction, visual impairment, and physical dysfunction were recruited for the study. Data on these factors were collected from the participants at a community gathering using measures of life space assessment, skeletal muscle mass, lower extremity muscle strength, mobility, cognitive function, and fear of falling. Correlational and path analyses were used to investigate the relationships between these variables. [Results] The final path model satisfied the requisite statistical criteria, and subsequently, the relationships between the physiological and psychological factors associated with life space assessment were structured and represented visually. Age, skeletal muscle mass, fear of falling, and mobility had a direct effect on life space assessment, whereas lower extremity muscle strength and cognitive function affected it indirectly. [Conclusion] In this study, direct and indirect effects of physiological and psychological factors related to risk of life space assessment of the elderly were clarified using path analysis.
Key words: Life Space Assessment of elderly, Path analysis, Risk factor

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INTRODUCTION

The LSA measures the normal range of locations associated with the pursuit of activities during a defined period[1]. This reflects both physical functions and social participation[2]. Life space is conceptualized as a series of concentric zones radiating from an individual's bedroom, in the center, to other areas in the vicinity of the immediate household and further towards environments beyond the home[3]. LSA has been used to predict the life expectancy of elderly individuals[4], as factors such as the impact of falls and fractures[5], the fear of falling[6], decreased cognitive function[7, 8], and decreased skeletal muscle mass[9] have all been reported as affecting life-space mobility. However, the relationship between the risk factors and the decrease in LSA has not been reported in detail. Furthermore, any direct or indirect impact of the factors affecting the risk of LSA has not been confirmed. In a multivariate analysis, only a few variables have a significant effect because their influence is considered

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along with other variables included in the model; therefore, performing a multivariate analysis along with univariate analysis can prevent false interpretations. Further, path analysis is one of the advanced multivariate methods, by which not only can the effects of each variable on the dependent variables be measured but also can classify the effects into direct and indirect categories. In this cross-sectional study, we aimed to examine the direct and indirect effects of physiological and psychological factors related to LSA using path analysis.

PARTICIPANTS AND METHODS

A total of 212 study participants were recruited from elderly community residents (mean age 77.2 ± 5.7 years) taking part in a physical fitness measurement project for the elderly in the city of Okawa located in Japan's Fukuoka prefecture. The study was conducted at 13 community centers from April 2017 to August 2017. Participants that were determined on the day of the assessment to be under the influence of medication, have severely diminished cognitive function such that they were unable to comprehend the physical function evaluation or measurement process, or were not able to complete all the items due to a visual impairment or physical dysfunction were excluded. Written consent was obtained after the participants were provided with a full explanation of the details of the study. This study was conducted with the approval of the International University of Health and Welfare Ethics Committee (approval no.15-Ifh-67).

The Japanese version of the LSA scale, that was developed from Baker et al.'s scale[10] was used in this study. The LSA score is calculated using scores for the range of activity, frequency of activity, and degree of independence from the previous month. The range of activity is divided into six zones, namely inside the home, outside the home, near the home (800 m or less), in the neighborhood (800 m to 16 km), and outside the neighborhood (more than 16 km). Scores were calculated for each zone based on the presence or absence of reported departures as well as the frequency of departure and the method used (i.e., independent, with physical aid, or assisted). Final scores were calculated as the sum of scores from each activity range with the highest possible total score of 120. These LSA scores served as an index where higher scores indicated broader spatial mobility in life. For the measurement of muscle mass, body composition was measured using a specialized instrument (the InBody270 Body Composition Analyzer from Biospace). Three measurement frequencies of 5 kHz, 50 kHz, and 500 kHz were applied using an eight contact-point electrode method to supply current from the extremities of the limbs. For the measurement, the palms of the hands and soles of the feet of the participants were swabbed with alcohol, after which the participants adopted a standing posture according to the instructions of the InBody instrument. As an index of skeletal muscle mass, we adopted the Skeletal Muscle Mass Index (SMI) described by Baumgartner et al.[11] that divides the volume of muscle in the limbs by the square of the height. As an evaluation and index of lower extremity muscle strength, we adopted the Chair-To-Stand 5 Times (CTS-5) Test[12]. The time required for five repetitions of the motion of rising from the chair as quickly as possible was measured twice, with the fastest value measured used as the representative value. The Timed Up and Go (TUG) Test was used as an evaluation of mobility. The TUG test measures the time required to stand from a sitting position, walk around a pole positioned 3 m away, and return to a sitting position. According to the original method[13], the walking speed was set at a comfortable level. The Mini-Mental State Examination (MMSE) was adopted for the evaluation of cognitive function. The MMSE is a widely used and comprehensive international measure of cognitive function that consists of 11 questions that allow for a total possible score of 30 points[14]. Scores used in the analysis were obtained from measurements carried out face-to-face. Participants' fear of falling was measured using a Japanese version of the Fall Efficacy Scale (FES) developed by Tinetti et al.[15] and applied in Japan by Haga[16]. The FES asks respondents about how confident they are performing daily life activities without falling. For each of the 10 activity items, respondents answer on a scale from one to four. Scores ranged from 10 to 40, with a higher score indicating less fear. Statistical processing was carried out using the SPSS Amos 23 statistics package developed by IBM. To investigate the possible relationships between LSA, SMI, CTS-5, FES, TUG, and MMSE analyses were performed using Spearman's test. Furthermore, a multiple regression analysis was performed using LSA as the dependent variable and the other measurement items as independent variables. Based on the logical background and results of the correlation and multiple regression analyses, we formulated a hypothetical model of relationships between the factors considered to influence LSA and then performed a path analysis to clarify the interdependent relationships between these factors. To determine the overall fit of the model, we used the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and root mean squares error of approximation (RMSEA). Based on a previous study[17], it was determined that good fit was indicated by values in the ranges of GFI >0.95, AGFI >0.90, and RMSEA<0.05. Additionally, in the path analysis, we further examined the direct, indirect, and overall effects of each factor influencing LSA. The level of significance was set at a 5% risk rate.

RESULTS

Table 1 summarizes participants' basic information, execution times for TUG and CTS-5, MMSE scores, FES scores, and LSA scores. Correlation results between measurement scores revealed the existence of significant relationships between all of the factors with the exception of SMI and CTS-5, and SMI and TUG (Table 2). Additionally, in the results of the multiple regression analysis with age as the adjustment factor and LSA as the dependent variable, age (β=−0.25), FES (β=0.15), SMI (β=0.23), and TUG (β=−0.19) were shown to be significant factors (R=0.54, R^2=0.29). Moreover, although the Variance

Inflation Factor (VIF) indicated a low value in terms of multiple collinearity between measurement items (VIF=1.09–1.42), although this was not judged to be a problem. The value of the VIF in the multiple regression analysis was based on 10. Therefore, in this study, we determined that there is no multiple collinearity among the factors as the VIF was small. Based on the observed correlations between the measurement items and the results of multiple regression analysis, we created a hypothetical model showing the interdependent relationships between the factors associated with LSA. Following the criteria for model fitness[17)], we then modified this hypothetical model to formulate a final model (Fig. 1). In the modified hypothetical model, χ^2=9.23 (p=0.32), GFI=0.99, AGFI=0.96, and RMSEA=0.03, thereby satisfying all criteria for this adoption. Further, from the results of the path analysis, we showed the direct, indirect, and overall effects of each variable on LSA (Table 3). The path normalization coefficient showed a range from −1.0 to 1.0, where a value of <0.1 indicated a low level of effect, a value between 0.11 and 0.30 indicated a medium level of effect, and values between 0.31 and 0.50 indicated a substantial effect. Age was found to have a substantial overall effect on LSA, while SMI, FES, and TUG had a medium level of effect. MMSE and CTS-5 were confirmed as having indirect effects on LSA.

DISCUSSION

In this study, we investigated the interdependent relationships between various factors associated with LSA using a correlation analysis and path analysis. Each measurement item showed a relationship with LSA (Table 2). Significant relationships were confirmed between measurement items with the exceptions of SMI and CTS-5, and SMI and TUG. Moreover, in the path analysis, age, SMI, FES, and TUG were all found to have direct effects on LSA (Fig. 1, Table 3). Age was confirmed to have a significant relationship with each measurement item and to have both direct and indirect effects on LSA. Given that it is possible that these factors may appear as direct effects of age on LSA, this represents a topic for future study. In addition,

Table 1. Descriptive statistics of the participants (n=212)

Participants characteristics	Descriptive statistics n (%) or mean (SD)
Gender	
Male	70 (33.0)
Female	142 (67.0)
Age (years)	77.2 (5.2)
Fall	
Yes	34 (16.0)
No	178 (84.0)
BMI (kg/m^2)	23.1 (3.4)
SIM (kg/m^2)	6.2 (1.0)
LSA (scores)	88.0 (21.9)
CTS-5 (sec)	10.3 (6.5)
MMES (scores)	26.8 (3.0)
FES (scores)	37.2 (4.6)
TUG (sec)	9.1 (2.4)

BMI: Body mass index; SMI: Skeletal muscle mass index; LSA: Life Space Assessment; CTS-5: The Chair-To-Stand 5 Times test; MMSE: The mini-mental state examination; TUG: Timed up and go test; FES: Fall Efficacy Scale.

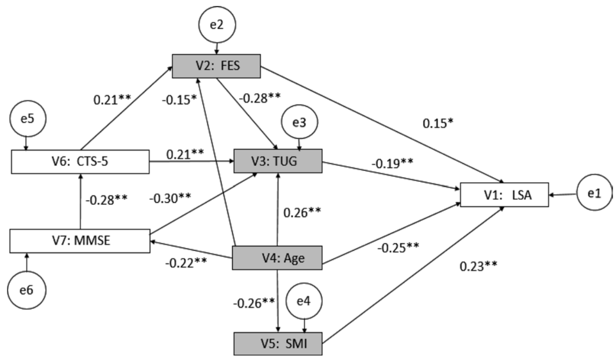

Fig. 1. Interconnectedness of the factors related to the LSA for the elderly (final model).

e: error variable ; v: observed variables; LSA: Life Space Assessment; SMI: Skeletal muscle mass index; MMSE: The mini-mental state examination; CTS-5: The Chair-To-Stand 5 Times test; FES: Fall Efficacy Scale; TUG: Timed up and go test.

Path analysis *p<0.05, **p<0.01, χ^2=9.23 (p=0.32), goodness of fit index=0.99, adjusted goodness of fit index=0.96, root mean squares error of approximation=0.03.

Table 2. Correlation between the measurement items

	LSA	SMI	MMSE	CTS-5	FES	TUG
LSA						
SMI	0.33**					
MMSE	0.19**	0.12*				
CTS-5	−0.23**	−0.07	−0.28**			
FES	0.30**	0.14*	0.13*	−0.27**		
TUG	−0.37**	−0.07	−0.45**	0.41**	−0.42**	

LSA: Life Space Assessment; SMI: Skeletal muscle mass index; MMSE: The mini-mental state examination; CTS-5: The Chair-To-Stand 5 Times test; FES: Fall Efficacy Scale; TUG: Timed up and go test. *p<0.05, **p<0.01.

Table 3. Each variable in the Life space assessment directly effects, indirect effects, overall effectiveness

Variable	Directly effects	Indirect effects	Overall effectiveness
Age	−0.25	−0.16	−0.41
SMI	0.23	—	0.23
MMSE	—	0.08	0.08
CTS-5	—	−0.09	−0.09
FES	0.15	0.05	0.20
TUG	−0.19	—	−0.19

SMI: Skeletal muscle mass index; MMSE: The mini-mental state examination; CTS-5: The Chair-To-Stand 5 Times test; FES: Fall Efficacy Scale; TUG: Timed up and go test. The path normalization coefficient showed a range from −1.0 to 1.0, where a value of <0.1 indicated a low level of effect, a value between 0.11 and 0.30 indicated a medium level of effect, and values between 0.31 and 0.50 indicated a substantial effect.

decreased physiological stamina and decreased physiological and psychological function due to aging were also predicted as indirect effects of age, indicating the presence of possible relationships for each measurement item. In the presence of frailty, it is understood that vulnerability to health disorders increases owing to various functional changes and preliminary capacity reductions that accompany the aging process. Fried et al.[18] used factors such as decreased walking speed, muscle weakness, fatigue, weight loss, and decreased physical activity to determine the level of frailty among elderly individuals, suggesting a relationship between age and each measurement item. SMI showed a direct effect on LSA (Fig. 1, Table 3). Interestingly related to this, a longitudinal study of Japanese nationals reported that lean tissue mass in the upper and lower limbs decreases significantly in men who are 70 years and older, whereas lean tissue mass in the lower limbs already begins decreasing among women who are 40 years and older[19]. In addition, the skeletal muscle mass in the lower limbs associated with aging significantly decreases in the femoral muscle, and the gluteal muscle is significantly associated with LSA score among elderly women[9]. Yet, this study did not identify any relationship between SMI and TUG. Lower limb skeletal muscle mass and lower extremity muscle strength were reflected in mobility, and no relationship appeared to be found with SMI, including the upper limbs. To help the elderly move around, walking aids such as a cane and a walker are often used. In such cases, the muscle mass of the upper limb is considered to be related. In the future, the relationship between SMI and LSA needs to be further studied. FES showed direct and indirect effects on LSA (Fig. 1, Table 3). It was suggested that fear of falling is an important psychological factor associated with decreased life space for elderly people with different social and cultural backgrounds, and that increasing mobility in the local community would lead to increases in social participation[6]. In addition, activity restrictions and fear of falling among elderly people have a deleterious effect on ambulatory function and aggravate ambulatory instability[20]. The results of this study also confirmed a relationship with TUG, as well as an indirect effect on LSA, suggesting FES to be an important factor associated with LSA. On the other hand, cognitive function disorders among elderly people were considered to be an important factor restricting LSA, since they contribute to mobility restrictions[21] and are associated with loss of functional autonomy[22] and decreased time spent outside of the home[23]. However, while the results of this study found MMSE to be related to CTS-5, FES, and TUG, it showed no more than an indirect effect on LSA. Previous studies[24] using multivariate analysis showed a relationship between living space and cognitive function based on the findings of the analysis adjusted for other variables included in the model. However, these results could not be used to determine whether the decline in cognitive function was a direct or indirect effect on LSA. The current study presents a new finding that cognitive function has an indirect effect on LSA via lower limb muscular strength and mobility. Executive function, which is a cognitive function, has been shown to have a relationship with ambulatory control among elderly individuals[25] as well as balance, while decreases in executive function are related to increased ambulatory instability[26, 27]. In this study, MMSE also showed a correlation with fear of falling and TUG, which are associated with ambulatory instability. However, since the MMSE represents a comprehensive evaluation of cognitive function and is not specialized for evaluating executive function, it was possible that no direct effect on LSA would appear. One limitation to this study, is the fact that although we investigated the relationship of LSA to physiological and psychological function, other relevant factors related to age, including but not limited to, the loss of social roles, possible hindrances to intellectual activities, and Instrumental Activities of Daily Living were not considered[28]. Moreover, this study has not comprehensively investigated the possible influence of characteristics of elderly subjects such as social background, general health condition, material and human environments[29], or leisure pursuits, and this could arguably be positioned as a future direction for research. We believe that describing the direct and indirect effects on LSA shows that path analysis as a statistical method, in general, can contribute to the further development of LSA research.

Conflict of interest

None.

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