INTRODUCTION

The life space is the physical and social environment in which people live and function in their daily life. Life-space mobility (LSM) reflects the extent to which people move in the community, need assistance in doing so, use community amenities, maintain social relationships and roles, and participate in meaningful activities. LSM considerably affects the quality of life of older people. Because both the living space and mobility of older people decrease as their physical and mental functions decline, a theoretical framework to identify and hierarchize the factors that affect LSM would appear to be essential.

Considering the importance of LSM in the context of older peoples’ living space, Kaufmann et al. developed a framework based on the factors related to motivation for mobility and environment and subdivided them into categories such as access, skills, and appropriateness. Access includes older people’s access to infrastructures, services, and facilities and services; physical and cognitive skills include driving a car and other relevant skills; and psychosocial factors include planning, personal needs, values, and motivations. Regarding the relationship between the abovementioned categories and life space, the factors in the “appropriateness”
category are reportedly the strongest, followed by those in the “skills” category. Reduced LSM in older people depends on the fear of falling, cognitive decline, and the sequels of falls and fractures. Reduced LSM in older people is promoted by a smaller life space, for instance, being homebound, thereby increasing the risk of serious illnesses and rates of hospitalization and mortality; this translates into increased healthcare costs for this age group.

Recent studies on narrowed life space have focused on disparities in the life space and mobility that result from gender and race differences. For instance, black people tend to have inferior life spaces over time than white people; this tendency is prominent in older women as they have decreased life spaces because their activities are limited to their neighborhood. Furthermore, during their post-reproductive life, the LSM of women is influenced by age marginalization and expected gender roles and differences with men in terms of domestic tasks and social roles. Therefore, LSM appears to be a crucial assessment factor for improving the wellbeing of community-dwelling older people; LSM is also a comprehensive measure of resilience against physical and social isolation in the later period of life. Taken together, the aforementioned evidence demonstrates that disparities in decreased life space and LSM vary across older people based on gender and disrupt their quality of life. Therefore, knowledge regarding the gender dissimilarities in the structures restricting LSM is essential for developing interventions to enhance the health and functionality of older people, particularly women.

The LSM of older people appears to highly relate to the abovementioned factors in the “appropriateness” and “skills” categories; there is a gender-based unevenness in life space and mobility among older people. However, to the best of our knowledge, concrete differences among factors associated with LSM and the relevance of gender differences in older people remain to be clarified. A structural analysis of the life space of older people has been reported; however, that study did not include any assessment of the sociality of older people or gender differences. Consequently, the current cross-sectional examination aimed to determine the gender differences in LSM-related factors and, through path analysis, the corresponding structure of influence in older people.

**Participants**
The data used in the present cross-sectional study were taken from an elderly physical fitness measurement project. This project started in 2015 to check the health condition of community-dwelling people aged 65 years or older. Several reports have been published, and we used the data newly obtained in 2018. The current study included a total of 294 community-dwelling participants aged ≥65 (mean age, 78.0 ± 5.4) years (106 men and 188 women). The inclusion criteria were as follows: age ≥65 years and resident in Okawa, Fukuoka Prefecture, Japan. The only exclusion criterion was having missing data (five participants).

**Assessment**
Data regarding the age and gender of our participants were collected. For all participants, we measured height, body mass index (BMI), and muscle mass. BMI and muscle mass were measured with an InBody 270 composition analyzer (InBody270, Biospace, Cerritos, CA, USA), using bioelectrical impedance analysis (BIA). Muscle mass was calculated by subtracting the mass of fat and bone from the body weight because it has been reported that muscle mass obtained using the BIA method highly correlates with the values obtained through dual-energy X-ray absorptiometry. Using the InBody 270, we assessed skeletal muscle mass on the basis of the water content of each body part by applying three frequencies of alternating current (5, 50, and 500 kHz) to the distal extremities. A decrease in skeletal muscle mass with age often leads to the development of sarcopenia and weakness. Therefore, the skeletal muscle mass index (SMI), as reported by Baumgartner et al., was used as an indicator of muscle dimensions: SMI is calculated by dividing limb muscle mass by the square of subject’s height.

LSM was determined using the Japanese version of the Life-Space Assessment (LSA) scale developed by Baker et al. The LSA score was calculated after questioning participants about their range of activities, frequency of engaging in activities, and level of independence over the previous month. The activity range comprised five levels: inside their residence only, at the residence premises, near home (<800 m), within town (<16 km), and outside town (>16 km). Subsequently, the total LSA score was determined according to the presence or absence of outings to each activity area, the frequency of outings, and the method of mobility (independent or with physical or other types of assistance). The LSA score ranges from 0 (indicating that the individual has not been outside of his or her bedroom in the past 4 weeks) to 120 (indicating that the individual has traveled outside of his

**Materials and Methods**

**Study Design**
This was a cross-sectional study involving path analysis.

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or her town daily without assistance in the previous 4 weeks).

Concerning the “appropriateness” category, social isolation and fall self-efficacy were studied as LSM-associated factors. The extent of social isolation was obtained using the Japanese version of the Lubben Social Network Scale (LSNS-6), which is a six-item version of the LSNS and is a reliable and validated scale. This classification system comprises items related to emotional and instrumental support, i.e., three items on family networks and three items on nonfamily networks. The total score ranges between 0 and 30 points, and a score of <12 points indicates a socially isolated individual. Fall self-efficacy was assessed using the Fall Efficacy Scale developed by Tinetti et al. (Japanese version). This tool comprises ten items related to the activities of daily living; the level of confidence about performing an activity without falling was evaluated using a 4-point scale. The total score ranges from 10 to 40 points; higher scores indicate a lower fear of falling.

Concerning the “skill” category, cognitive function, lower limb muscle strength, and mobility were investigated as LSM-associate factors. The former was analyzed utilizing the Mini-Mental State Examination (MMSE), which has good reliability and supported validity. The MMSE comprises 11 items—7 items related to verbal tasks and 4 related to movement tasks; the total score ranges between 0 and 30 points.

Lower limb muscle strength was determined using the five-chair stand test (5-CST). The participants were asked to execute five chair stand movements as rapidly as possible. In addition to assessing the lower limb muscle strength, this test is recommended for the initial screening of sarcopenia. Evaluations were performed twice, and the shortest time was used as the representative value. Furthermore, the Timed Up and Go test was used to assess mobility. A multi-timer was used (Multi-timer T.K.K.5801, Takei Kiki Kogyo, Niigata, Japan) to measure the time taken to rise from a chair, walk 3 m, return to the chair, and sit down. The walking speed was set at a comfortable speed based on a previous study. The measurements were conducted in duplicate, and the maximum values were considered important.

**Ethical Considerations**

Written informed consent was obtained from each participant after they were provided complete information regarding the purpose of this study, the associated risks and benefits, confidentiality, anonymity, and freedom of participation/withdrawal. This study was approved by the Ethics Committee of the International University of Health and Welfare in Okawa, Japan (approval number: 18-Ifh-092).

**Statistical Analysis**

For data analysis, the participants were divided into two groups: women and men. Endpoint data were evaluated using the Shapiro–Wilks test to test for normal distribution. Between-group comparisons were performed using Mann–Whitney or Student’s t-test in the case of continuous variables.

Spearman’s correlation analysis was used to identify the association between the LSA scores and each categorical factor separately for men and women. Multiple regression analysis was performed with the LSA scores as dependent variables and the scores of the “appropriateness” and “skills” factors as independent variables. Age, BMI, and SMI were included in the multiple regression analysis for adjustment.

Male and female LSM models were previously created to determine the interrelationships between LSM and its associated factors and among these factors. The goodness-of-fit index (GFI), adjusted GFI (AGFI), and the root mean squared error of approximation (RMSEA) were calculated to judge the global fitness of the model. Based on a previous study, GFI >0.95, AGFI >0.90, and RMSEA <0.05 were defined as acceptable GFI criteria. If a model did not fulfill all of these criteria, a modified version was created and tested. For path analysis, standardized direct and indirect effects in addition to the total standardized effect of related factors on LSM were determined. An effect size (ES) of ≤0.1 was considered small, 0.11–0.30 moderate, and 0.31–0.50 high. All statistical analyses were performed using the SPSS Amos 23 statistics package (IBM); the significance level was set at P <0.05. Additionally, the sample size was determined considering the number of independent variables used in the multiple regression analysis.

**RESULTS**

Comparisons between male and female subjects revealed significantly lower values for SMI and LSA scores in women than in men (Table 1), whereas the proportion of socially isolated participants was similar in men (13.1%) and women (13.6%). In women, LSM was significantly correlated with age (r=−0.364, P <0.001), SMI (r=0.251, P=0.010), fall self-efficacy (r=0.306, P <0.001), social isolation (r=0.210, P=0.004), lower limb muscle strength (r=−0.259, P <0.001), mobility (r=−0.370, P <0.001), and cognitive function (r=0.200, P=0.006). In men, however, LSM was significantly associated only with social isolation (r=0.200, P=0.004).
The results of multiple regression analysis in women, with LSM as the dependent variable, revealed age ($\beta=-0.22$), BMI ($\beta=-0.27$), SMI ($\beta=0.32$), fall self-efficacy ($\beta=0.15$), social isolation ($\beta=0.13$), and mobility ($\beta=-0.16$) as significant factors influencing the LSM ($R=0.57$, $R^2=0.32$; Table 2); in men, however, BMI ($\beta=-0.35$), SMI ($\beta=0.25$), social isolation ($\beta=0.27$), and lower limb muscle strength ($\beta=-0.20$) were identified as significant independent variables ($R=0.50$, $R^2=0.25$; Table 3). Multicollinearity between the endpoints was considered to be unproblematic; this assumption was

| Table 1. Gender differences in the data of community-dwelling older people |
|-------------------------------------------------|---------------|---------------|
|                                                  | Women (n=188) | Men (n=106)   | P-value |
| Age                                              | 78.4 ± 5.5    | 77.5 ± 5.3    | 0.19    |
| BMI (kg/m$^2$)                                   | 23.0 (20.6–25.6) | 22.8 (20.9–24.6) | 0.45    |
| SMI (kg/m$^2$)                                   | 5.6 (5.2–6.1) | 6.9 (6.4–7.4) | 0.00    |
| 5-CST (s)                                        | 9.3 (7.7–13.4) | 9.7 (8.1–11.1) | 0.60    |
| MMSE (score)                                     | 27.5 (25.0–29.0) | 28.0 (26.0–29.0) | 0.83    |
| TUG (s)                                          | 8.3 (7.4–11.2) | 8.4 (7.7–9.4) | 0.75    |
| FES (score)                                      | 40.0 (36.0–40.0) | 40.0 (37.8–40.0) | 0.87 |
| LSNS-6 (score)                                   | 18.0 (14.0–21.0) | 17.0 (13.8–20.0) | 0.54    |
| LSA (score)                                      | 82.0 (66.0–100.0) | 92.0 (82.0–104.0) | 0.00 |

Data are shown as mean ± SD or median (25% percentile − 75% percentile). Fall Efficacy Scale (FES).

| Table 2. Multiple regression analysis of factors associated with the life-space mobility of older women |
|--------------------------------------------------------------------------------------------------|
| Model                                                                                         | Unstandardized coefficients | Standardized coefficients | T      | Significance | Collinearity statistics |
|                                                                                               | B    | Standard error | Beta  | T    | Significance | Tolerance | Variance inflation factor |
| Constant                                                                                      | 115.64 | 30.18         | —     | 3.83 | 0.00        | —         | —                        |
| Age                                                                                            | -0.91 | 0.29          | -0.22 | -3.17 | 0.02        | 0.75      | 1.33                     |
| BMI                                                                                            | -1.81 | 0.58          | -0.27 | -3.10 | 0.02        | 0.48      | 2.08                     |
| SMI                                                                                            | 10.64 | 3.02          | 0.32  | 3.52  | 0.01        | 0.45      | 2.21                     |
| Social isolation                                                                              | 0.41  | 0.25          | 0.13  | 1.67  | 0.09        | 0.94      | 1.07                     |
| Fall self-efficacy                                                                            | 0.79  | 0.35          | 0.15  | 2.26  | 0.03        | 0.86      | 1.16                     |
| Mobility                                                                                      | -1.95 | 0.92          | -0.16 | -2.12 | 0.01        | 0.64      | 1.60                     |

Dependent variable: life-space mobility ($r=0.57$, $r^2=0.32$).

| Table 3. Multiple regression analysis of factors associated with the life-space mobility of older men |
|--------------------------------------------------------------------------------------------------|
| Model                                                                                         | Unstandardized coefficients | Standardized coefficients | T      | Significance | Collinearity statistics |
|                                                                                               | B    | Standard error | Beta  | T    | Significance | Tolerance | Variance inflation factor |
| Constant                                                                                      | 97.32 | 17.48         | 5.57  | 0.00 | —          | —         | —                        |
| BMI                                                                                            | -2.10 | 0.82          | -0.35 | -2.56 | 0.01        | 0.45      | 2.21                     |
| SMI                                                                                            | 5.86  | 3.16          | 0.25  | 1.85  | 0.06        | 0.45      | 2.21                     |
| Social isolation                                                                              | 0.89  | 0.32          | 0.27  | 2.81  | 0.04        | 0.93      | 1.07                     |
| Lower limb muscle strength                                                                     | -1.27 | 0.60          | -0.20 | -2.12 | 0.01        | 0.99      | 1.01                     |

Dependent variable: life-space mobility ($r=0.50$, $r^2=0.25$).
based on the variance inflation factor (VIF) obtained for both women (VIF=1.07–2.21) and men (VIF=1.01–2.21; Tables 2 and 3).

Path analysis was performed to establish separate models for men and women by applying the initially determined correlations between the category items and LSM along with the results of multiple regression analysis. The female LSM model was created using participant characteristics such as age and SMI along with items in the “appropriateness” category (fall self-efficacy and social isolation) and in the “skills” category (mobility) as direct factors; the two other characteristics in the “skills” category (lower limb muscle strength and cognitive function) served as indirect factors (Fig. 1). The GFI scores of the female LSM model ($\chi^2=19.44$, GFI=0.98, AGFI=0.93, and RMSEA=0.04) indicated an adequate fit. Similarly, the male LSM model was created using participant characteristics such as BMI and SMI along with social isolation and lower limb muscle strength in the “appropriateness” and “skills” categories, respectively, as direct factors; the remaining factors, such as cognitive function, age, mobility, and fall self-efficacy were used as indirect factors (Fig. 2). The goodness of fit of the male LSM model ($\chi^2=37.92$, GFI=0.93, AGFI=0.90, and RMSEA=0.04) was also deemed to be adequate. In addition to the different results for men and women, path analysis revealed that SMI and social isolation were common direct factors for LSM, whereas the single common indirect factor was cognitive function. For the male LSM model, the direct factors in descending order of ES were social isolation (ES=0.26), SMI (ES=0.25), lower limb muscle strength (ES=−0.19), and BMI (ES=−0.17). In the female LSM model, the direct factors in descending order of ES were age (ES=−0.37), fall self-efficacy (ES=0.23), mobility (ES=−0.21), social isolation (ES=−0.13), and SMI (ES=0.12); age was found to have indirect effects on all the other LSM-associated factors (Table 4).

**DISCUSSION**

In the present study, there were large differences between older men and women in the factors associated with LSM and the relationships among these factors. Path analysis revealed that in the female LSM model, the direct factors in descending order of ES were age, fall self-efficacy, mobility, social isolation, and SMI; moreover, age had an indirect effect on the other factors. In the LSM male and female models, only SMI and social isolation were common direct factors, and cognitive function was the only common indirect factor. To
the best of our knowledge, this study is the first to focus on a structural analysis of the factors affecting LSM in older men and women while considering individual and environmental influences.

**LSM-associated Factors and Structures Common to the Male and Female Models**

The current study identified SMI as a common factor affecting LSM in both older men and older women. The
Asian Working Group for Sarcopenia cutoff SMI values for sarcopenia are <5.7 kg/m² for women and <7.0 kg/m² for men; in the present cohort, the mean SMIs in men and women were lower than the reference values, suggesting the presence of age-related loss of muscle mass. Sarcopenia is reportedly an independent factor mediating the activities of daily living, increased risk of falls because of frailty, and impaired physical activity; therefore, SMI appears to be a potential common biomarker of LSM in both genders.

A clear association has been reported between mental health and life space in older women, with these individuals being particularly vulnerable to social isolation because of their limited life space and low spatial mobility. Although working after retirement is not expected of women, women who actively engage in household chores appear to continue to bear the burden of such work even after retirement, with studies predicting that the life space of these women will eventually narrow down to their home. In Japan, many older people participate in voluntary local group activities at “community salons”. Local salon activities provide an environment for social connection, thereby motivating older women to stay physically active through small communities. For such participants, the influence of psychological and social network factors on LSM, as indicated in the currently established LSM models, is thus understandable. Older men in urban areas of Japan spend considerably more time out of their homes than women do because of working, participating in groups and associations, socializing with friends, and engaging in hobbies. In rural Japanese regions, establishing a role for older men in organizations and improving opportunities for social participation are crucial because of their benefits in improving physical and mental health. A substantial number of older men in urban areas who participated in our physical fitness study held positions in the respective local community and participated in salon activities. These facts support the finding that social engagement and networking activities are direct factors influencing LSM in the male LSM model.

Cognitive function represents an indirect factor that affects LSM via mobility in men and women similarly (Figs. 1 and 2). The components of cognitive function such as processing speed, attention, and executive function decline with age, thereby impairing mobility. Executive function represents the cognitive basis for walking; a lower processing speed leads to a delay between sensory input and response of the motor control system in movement. In addition to attention deficit, a decline in cognitive function poses a risk of balance loss and impaired gait management. Therefore, cognitive function is further verified as a central mediator of mobility limitations.

**Factors and Structures Associated with LSM with Differences Between Male and Female Models**

In the female model, age was used as an adjustment factor in path analysis with a high overall ES (−0.37) (Fig. 1 and Table 4). Contrary to the situation in men, women have a higher incidence of chronic diseases such as arthritis, depression, osteoporosis, and consecutive fractures; therefore, women experience more physical functional limitations and frailty than men. Women also spend more years than men living with disability, likely during old age. Therefore, older women may be more strongly affected by various factors such as age and have a smaller LSM than older men.

In the female model, fall self-efficacy (ES=0.23) and mobility (ES=−0.21) are direct factors with moderate ESs (Fig. 1 and Table 4). Self-efficacy is a cognitive control system comprising the perceptions of ability and functioning, and it is known to be strongly dependent on individual behavior as well as actual physical ability. The fear of falling is reportedly significantly higher in older women than in older men regardless of whether the women have a history of falling. Furthermore, this fear is associated with poor balance and gait, a poor sense of well-being, depression, and anxiety. Therefor, older women appear to experience an intense decline in cognitive function, lower limb muscle strength, and impairment of other physical functions, with age; all these negative effects translate into psychological anxiety and directly affect the activities of daily living and LSM of older women (Fig. 1).

In the male LSM model, lower limb muscle strength (ES=−0.19) and BMI (ES=−0.17) were representative direct factors, whereas fall self-efficacy (ES=0.02) and mobility (ES=−0.07) were indirect factors with small ESs (Fig. 2 and Table 4). Older people with impaired lower extremity function are at an increased risk of developing life-space limitations, particularly if obesity is also present. Furthermore, weight loss has been associated with muscle strength and future walking ability. For men in particular, lower extremity muscle weakness is associated with increased BMI until the age of 65 years; in older men, muscle weakness has been associated with decreased relative leg lean mass. Men are affected earlier than women by age-related changes in BMI, SMI, and lower extremity muscle strength, and in men, age has been considered a direct factor in LSM limitation. This study has some limitations. First, a relatively small
A number of community-dwelling older people living in a single prefecture of Japan was included. Therefore, it may not be appropriate to extrapolate the results to older adults belonging to dissimilar cultural or social backgrounds. Second, the numbers of female and male participants in this study were different. Although there was no significant heterogeneity in the age of the participants, this disparity might have been because of the low male participation in the previous elderly physical fitness measurement study. Consequently, future studies must repeat these analyses with an equal number of men and women to verify the reproducibility of the current results. Finally, because of the cross-sectional design of this study, causal relationships between LSM and associated factors could not be determined. Nevertheless, we attempted to comprehensively analyze the factors affecting the LSM of older people and to clarify the mechanisms underlying such effects according to gender differences.

In conclusion, we hypothesized in this study that there are significant differences in the factors and structures associated with LSM in older men and older women. The male and female LSM models and associated factors herein established revealed adequate GFls, suggesting that gender disparities do exist in the process and overarching structure of mobility restriction. Understanding gender variations in the structure of LSM is crucial for designing interventions aimed at improving the health and functioning of older people. The findings of the present study emphasize the need to consider culture, regional characteristics, and social conjunctures when designing relevant interventions for older people. The causal associations between LSM and its associated factors in older men and women need to be investigated in a future longitudinal study.

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CONFLICT OF INTEREST

There are no conflicts of interest to declare.

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