International Journal of Advanced Culture Technology Vol.11 No.3 131-141 (2023)
DOI https://doi.org/10.17703/IJACT.2023.11.3.131

IJACT 23-9-19

Determinants of Physical Frailty among Old-Old Adults in an Urban-Rural Complex Community in Korea

[1]Chang, HeeKyung

[1]Associate Prof., College of Nursing, Gyeongsang National University, Korea
E-mail hchang@gnu.ac.kr

Abstract

This study aimed to identify the determinants of physical frailty among the old-old adults in rural Korean communities. A total of 191 individuals aged 75 and older were included in the study, with the majority being female. Participants were classified into healthy (n=47), pre-frail (n=54), and frail (n=90) groups. Significant differences were found across these groups in terms of age, gender, education level, depression, and nutritional status. Multiple logistic regression analysis revealed that age (OR=1.16), depression (OR=0.21), malnourishment (OR=10.85), and short physical performance ability (OR=0.70) were significant predictors of physical frailty. These findings underscore the multifaceted nature of physical frailty among old-old adults in urban-rural complex communities and highlight the need for comprehensive and integrated interventions. Such interventions should consider not only physical factors but also broader health conditions and socio-demographic influences impacting the elderly. Further research is needed to develop and evaluate interventions that address these determinants and promote health equity among the elderly population in urban-rural complex communities

.

Keywords: *Determinants, Depression, Elderly, Frailty, Nutrition*

1. INTRODUCTION

The rapid aging of the global population has brought gerontological research to the forefront, particularly in the context of understanding physical frailty among the "old-old" adults, typically defined as individuals aged 75 and above [1]. This demographic, due to their unique health and social needs, presents a significant challenge to healthcare systems and policy makers [2]. The challenge is further amplified in the context of an urban-rural complex community, such as in Korea, where disparities in access to resources and healthcare services exist [3].

Physical frailty, a significant predictor of adverse health outcomes including disability, hospitalization, and mortality, is particularly prevalent in the old-old population [4,5]. The concept of frailty, initially focused on physical dysfunction, has evolved to encompass a spectrum of impairments extending to psychological, cognitive, social, and environmental domains [6]. This necessitates an integrated approach to effectively comprehend, prevent, and intervene in frailty, considering not only physical factors but also broader health conditions and socio-demographic influences impacting the elderly [7].

Recent research has begun to shed light on the intricate interplay between various physiological systems in the manifestation of frailty. A study by Arrué, Laksari, and Toosizadeh [8] has shown associations between

Manuscript received: : August 7, 2023 / revised: August 20, 2023 / accepted: September 5, 2023
Corresponding Author: hchang@gnu.ac.kr
Tel:+82-55-772-8234, Fax: +82-55-772-8222
Associate Professor, College of Nursing, Gyeongsang National Univ., Korea

heart rate dynamics (changes during physical activity) and frailty, suggesting a strong association between cardiac-motor interconnection and frailty. This adds a new dimension to our understanding of the determinants of frailty, aligning with the growing body of literature emphasizing the multifactorial nature of frailty [9].

In the context of Korea, the old-old population in urban-rural complex communities face unique challenges. The geographical dispersion in rural areas, coupled with a lower rate of vehicle ownership compared to urban areas, results in diminished accessibility to healthcare services [10]. Furthermore, rural older adults exhibit significantly lower health information literacy compared to residents of larger cities and medium-sized towns, as well as lower individual perceived health levels and regular exercise rates [11]. Given the substantial old-old population in urban-rural complex communities and the evident urban-rural health disparity, it is imperative to accurately assess the level of frailty and associated factors among these older adults [12]. Such knowledge would inform tailored interventions aimed at preventing and managing frailty in these communities, thereby addressing this gap in healthcare provision, and promoting health equity [2].

This study aims to categorize old-old adults in urban-rural complex communities into healthy, pre-frail, and frail groups, and to analyze the associated factors of frailty at each level, considering demographic, social, academic, health status, emotional, and physical variables. The findings of this research are intended to serve as a foundation for designing interventions to prevent and manage frailty in this demographic, thereby enhancing their functional independence and improving their quality of life.

2. MATERIALS AND METHODS

This research was conducted among older adults residing in a rural community, employing the criteria of the Korean-style frailty measurement tool [13] as the basis for categorization.

2.1 Participants

The participants in this study were drawn from the "old-old" adults, a demographic designation often used in gerontological research to refer to individuals aged 75 and above. As researchers sample more adults older than 75 years, we visited senior citizen centers and residents' self-governance centers frequently attended by the elderly. After providing a succinct explanation of the study's purpose and content, we enlisted individuals aged 75 and above who volunteered to participate in the study.

In determining the inclusion criteria, this research employed the subject exclusion specifications used for measuring frailty levels in individuals aged 75 and above [14]. Specifically, we excluded: (1) those with visual and auditory impairments preventing communication, (2) those unable to perform physical function assessments such as grip strength and short physical performance battery (SPPB) due to disabilities, (3) individuals with terminal diseases, and (4) those with severe cognitive and motor dysfunctions due to conditions like stroke. After excluding nine respondents with missing data from the original pool of 200 individuals, a final sample of 191 participants (60 males, 131 females) was included in the analysis.

2.2 Data Collection

The data collection process was conducted over a span of five months, from March to September 2021. Field visits were made to various locations that serve as gathering points for the elderly population. These included senior citizens' centers, community centers, and geriatric colleges, all located within Jinju-si, Gyeongsangnam-do. It is important to note that Jinju-si is an urban-rural complex area, characterized by a blend of urban and rural environments. This unique setting provides a diverse demographic and socio-economic mix, making it an ideal location for this study.

Given the ongoing COVID-19 pandemic, all data collection activities were conducted in strict adherence to the recommended public health guidelines to ensure the safety of both the participants and the research team. This included the use of personal protective equipment by the research team, maintaining physical distancing during interviews, and regular sanitization of equipment and surfaces.

The purpose of the study, the contents of the questionnaire, and the procedures for physical measurements

were explained, and permission to collect data was obtained from eligible older adults aged 75 and above. Participants were provided with both oral and written information regarding the purpose and methodology of the study, assurances of anonymity and confidentiality, voluntary participation, and the freedom to withdraw from the study at any time. A detailed explanatory statement was provided, and written informed consent was obtained from each participant.

A total of 200 subjects were surveyed, with data collection achieved through interviews conducted by a trained research assistant and the lead researcher. Structured questionnaires were administered via one-on-one interviews, and each interview took approximately 20 minutes to complete. Physical measurements and evaluations, such as height, weight, grip strength, and physical function tests, were personally carried out by the researcher to minimize measurement errors, with research assistants responsible for recording the results. This part of the data collection took around 15 minutes per participant.

The collected data were securely stored in a locked storage cabinet accessible only by the lead researcher. The computer housing the data was equipped with security measures to prevent external access, thereby ensuring the confidentiality of the information.

2.3 Measurement of Physical Frailty

The level of frailty was assessed using the Korean Frailty Index (KFI), developed by the Korean Society of Geriatrics [13]. The KFI is a multi-domain phenotypic measurement tool encompassing eight items: number of hospitalizations, self-perceived health status, usage of four or more medications, weight loss, depression, incontinence, gait ability, and communication disorder. Each item is scored as '0' or '1'. Total scores are interpreted as follows: 5 or more points indicate 'frailty', 3-4 points indicate 'pre-frailty', and 0-2 points represent healthy older adults. The reliability of the tool at the time of development was a Cronbach's alpha of .65, while this study recorded a Cronbach's alpha of .72. According to Cronbach [15], a Cronbach's alpha of 0.8 to 0.9 or higher is desirable, and a value of 0.6 to 0.7 is generally accepted as a satisfactory level of reliability.

2.4 Anthropometry Measurement

(1) Height, Weight, Muscle Index, Skeletal Muscle Mass: Height (cm) was measured using a portable extensometer, InLabS50 (Biospace company, Seoul, Korea). Weight (kg), skeletal muscle mass index (SMI), and skeletal muscle mass (SMM) were determined using an InBody 270 (Biospace company, Seoul, Korea).

(2) Grip Strength: Grip strength, a widely utilized indicator of upper limb muscle strength in community settings [16], was measured using a grip dynamometer (CAMRY EH101; Henqi, Guangdong, China). While seated, the subject held the dynamometer with their 2nd to 4th fingers, arm naturally extended and not touching the body. Scores of less than 26 kg for males and 18 kg for females were classified as weak.

(3) Physical Performance: The Short Physical Performance Battery (SPPB), developed by Guralnik et al. [17], was used to evaluate physical function. The SPPB assesses physical performance across three areas: chair stand ability, balance, and gait speed. Participants' chair stand ability was scored based on the time taken to complete five sit-to-stand cycles, with arms folded across the chest. Balance was assessed by measuring the time the subject could maintain standing with feet together (normal posture) and in a semi-tandem position for 10 seconds. Gait speed was determined by measuring the average time taken for the subject to walk 4 meters at a normal pace, taken across two attempts. Each category was scored from 0 (unable to complete the task) to 4 (highest performance), with a total score ranging from 0 to 12. Scores of 10 or below were considered indicative of poor physical performance. The tool's reliability at the time of development was a Cronbach's alpha of .93, while this study recorded a Cronbach's alpha of .79.

2.5 Measurement of Other Covariates

(1) Cognitive Function: Cognitive function was evaluated using the Korean version of the Mini-Mental State Examination (MMSE), developed by Folstein et al. [18]. This tool comprises sections on orientation (10

points), memory registration (3 points), memory recall (3 points), attention and calculation (5 points), language skills (7 points), and comprehension and judgment (2 points). Scores range from 0 to 30, with scores of 24 or above considered normal, 18 to 23 indicating mild cognitive impairment, and 17 or below suggesting severe cognitive impairment. The tool's reliability at the time of development was a Cronbach's alpha of .86, while this study recorded a Cronbach's alpha of .78.

(2) Depression: For the assessment of depression, we utilized the GDSSF-K, a shortened Korean version of the Geriatric Depression Scale, developed by Sheikh and Yesavage [19], translated into Korean by Ki [20], and validated for reliability and standardization. This tool comprises 15 items, reduced from the original 30 that showed the highest correlation with depression. Scores are binary, with 'yes' responses scoring 0 and 'no' responses scoring 1. Total scores range from 0 to 15, with scores of 5 or below classified as normal, 6 to 9 as moderately depressed, and 10 to 15 as severely depressed. The tool's reliability at the time of development was a Cronbach's alpha of .88, while this study recorded a Cronbach's alpha of .80.

(3) Nutritional Status: Nutritional status was measured using the Mini-Nutritional Assessment (MNA), developed by Guigoz et al. [21] and adapted by Lee [22]. This tool comprises 18 items across four categories: body measurement (4 items), overall physical and mental evaluation (6 items), dietary assessment (6 items), and self-perception of health and nutrition (2 items). Each item is weighted, with the total score ranging from 0 to 30. Scores from 0 to less than 17 indicate malnutrition, 17 to less than 24 suggest a risk of malnutrition, and 24 or above are considered normal. The tool's reliability at the time of development was a Cronbach's alpha of .92, while this study recorded a Cronbach's alpha of .73.

2.5 Statistical Analysis

The data collected in this study were meticulously analyzed using the SPSS/WIN 28.0 software. The threshold for statistical significance was determined based on a two-tailed test with a significance level set at .05. Descriptive statistics, including measures of central tendency and dispersion, were utilized to analyze the general and physical characteristics of the participants.

To examine the differences in levels of frailty according to these characteristics, inferential statistical methods were employed. Specifically, chi-square tests were used for categorical variables such as gender and education level, while one-way Analysis of Variance (ANOVA) was used for continuous variables such as age, height, weight, muscle index, skeletal muscle mass, and short physical performance ability.

To identify the factors influencing each level of frailty, multiple logistic regression analysis was performed. This analysis included variables that were statistically significant in the univariate analysis, namely age, gender, cognitive impairment, depression, malnourishment, height, weight, muscle index, skeletal muscle mass, grip strength, and short physical performance ability. The results of the logistic regression analysis were reported as odds ratios with 95% confidence intervals, providing a measure of the strength and direction of the associations between the predictor variables and the outcome variable of frailty status.

3. RESULTS

3.1 Sociodemographic and Health-related Characteristics

The sociodemographic and health-related characteristics of the participants are summarized in Table 1. The average age is 80.8 years, with a slightly higher average for males. The marital status indicates that 51.3% are married, with a significantly higher proportion of males in this category. About 44.5% live alone, predominantly females, while the rest live with others. Regarding education, 61.8% have no formal education, with females largely representing this group. Concerning health factors, a significant majority (93.2%) has cognitive impairment, and more than half (56.0%) display depressive symptoms, with males being more affected. Similarly, a large proportion (88.0%) is malnourished. Generally, males have higher values for these measures, indicating better physical performance and muscle mass status.

Table 1. Sociodemographic and Health-related Characteristics of Subjects (N=191)

Variable	Total (N=191)	Male (n=60), 31.41%	Female (n=131), 68.59%
	N(%) or Mean±SD		
Age (years)	80.8±3.1	81.0±3.1	80.73±3.07
Marital status			
Married	98(51.3)	51(85.0)	47(35.9)
Unmarried, Widowed	93(48.7)	9(15.0)	84(64.1)
Living arrangement			
Living alone	85(44.5)	10(16.7)	75(57.3)
Living with others	106(55.5)	50(83.3)	56(42.7)
Educational level			
No formal education	118(61.8)	14(23.3)	104(79.4)
Formal education	73(38.2)	46(76.7)	27(20.6)
Cognitive status			
Normal	13(6.8)	6(10.0)	7(5.3)
Cognitive impairment	178(93.2)	54(90.0)	124(94.7)
Depression			
Normal	84(44.0)	11(18.3)	73(55.7)
Depressive	107(56.0)	49(81.7)	58(44.3)
Nutritional status			
Normal	23(12.0)	12(20.0)	11(8.4)
Malnourished	168(88.0)	48(80.0)	120(91.6)
Anthropometry			
Height (cm)	154.1±9.9	163.6±6.7	149.7±7.9
Weight (kg)	53.8±9.8	59.7±10.0	51.1±8.4
Muscle index (kg/m^2)	6.0±0.9	6.9±0.7	5.6±0.7
Skeletal muscle mass (kg)	19.7±4.0	23.6±3.4	17.9±2.7
Grip strength (kg)	54.6±12.3	24.2±11.2	20.3±12.6
Short Physical Performance Ability	3.4±2.6	4.6±3.1	2.9±2.2

3.2 Factors Associated with Physical Frailty

Upon classification according to levels of frailty, the categories are not evenly distributed, with 24.6% (n=47) classified as Robust, 28.3% (n=54) as Pre-frail, and 47.1% (n=90) as Frail (Table 2). The data indicates that as frailty increases, age also increases, with mean ages of 79.6, 80.8, and 81.5 years for each group, respectively, and this difference is statistically significant (p=.003). There is a significant difference in the gender distribution across the groups (p<.001), with a higher percentage of males in the Robust group and females in the Frail group. Marital status and living arrangements do not significantly vary across the groups. However, the level of formal education decreases significantly with increasing frailty (p<.001), while the incidence of depression and prevalence of malnutrition increase significantly (p<.001).

Anthropometric measures such as height, weight, muscle index, skeletal muscle mass, and short physical performance ability generally decrease with increasing frailty. These differences are statistically significant

(p<.001), except for grip strength. The cognitive status does not vary significantly across the groups.

Table 2. Factors Associated with Physical Frailty (N=191)

Variable	Total (N=191)	Robust (n=47) 24.6%	Pre-frail (n=54) 28.3%	Frail (n=90) 47.1%	χ^2 or F	p
	N(%) or Mean±SD					
Age (years)	80.8±3.1	79.6±2.6	80.8±3.1	81.5±3.1	5.89	.003
Gender						
Male	60(31.4)	24(68.6)	33(68.6)	74(68.6)	15.87	<.001
Female	131(68.6)	23(31.4)	21(31.4)	16(31.4)		
Marital status						
Married	98(51.3)	28(51.3)	26(51.3)	44(51.3)	1.71	.420
Single/Divorced/Widowed	93(48.7)	19(48.7)	28(48.7)	46(48.7)		
Living arrangement						
Living alone	85(44.5)	19(40.4)	23(43.0)	43(47.8)	0.79	.670
Living with others	106(55.5)	28(59.6)	31(57.0)	47(52.2)		
Educational level						
No formal education	118(61.8)	20(42.6)	28(51.9)	70(77.8)	19.37	<.001
Formal education	73(38.2)	27(57.4)	26(48.1)	20(22.2)		
Cognitive status						
Normal	13(6.8)	7(14.9)	4(7.4)	7(7.8)	2.19	.330
Cognitive impairment	178(93.2)	40(85.1)	50(92.6)	83(92.2)		
Depression						
Normal	84(44.0)	4(8.5)	17(31.5)	63(70.0))	52.16	<.001
Depressive	107(56.0)	43(91.5)	37(68.5)	27(30.0)		
Nutritional status						
Normal	23(12.0)	18(38.3)	8(14.8)	1(1.1)	35.21	<.001
Malnourished	168(88.0)	29(61.7)	46(85.2)	89(98.9)		
Anthropometry						
Height(cm)	154.1±9.9	157.2±8.5	156.1±10.3	151.2±9.7	7.69	<.001
Weight(kg)	53.8±9.8	55.5±9.8	56.0±8.7	51.7±10.0	4.35	.014
Muscle index(kg/m^2)	6.0±0.9	6.4±0.9	6.2±0.8	5.7±0.8	10.28	<.001
Skeletal muscle mass(kg)	19.7±4.0	21.2±4.2	20.4±4.0	18.4±3.4	9.59	<.001
Grip strength(kg)	54.6±12.3	23.2±13.2	18.9±7.6	22.3±13.9	1.85	.160
Short Physical Performance Ability	3.4±2.6	5.2±3.2	4.0±2.8	2.2±1.4	25.64	<.001

3.3 Multiple Logistic Regression for Physical Frailty

Multiple logistic regression for physical frailty was performed as the outcome variable, choosing age, gender, cognitive impairment, depression, malnourishment, height, weight, muscle index, skeletal muscle mass, grip strength, and short physical performance ability (Table 3). Each additional year of age is associated with a 16% increase in the odds of the outcome (OR=1.16, 95% CI: 1.01-1.31, p=.038). Depression shows a substantial negative association (OR=0.21, 95% CI: 0.09-0.33, p<.001), indicating that depression is associated

with lower odds of the outcome. Malnourishment significantly increases the odds of the outcome (OR=10.85, 95% CI: 1.19-20.51, *p*=.034). Lastly, a unit increase in short physical performance ability is linked to a 30% decrease in the odds of the outcome (OR=0.70, 95% CI: 0.56-0.84, *p*=.001). On the other hand, gender, cognitive impairment, and all anthropometric variables (height, weight, muscle index, skeletal muscle mass, and grip strength) do not demonstrate a statistically significant relationship with the outcome.

Table 3. Predictors of Physical Frailty (N=191)

Variables	Odd Ratio (95% of CI)	*p*
Age	1.16 (1.01, 1.31)	.038
Gender	2.12 (0.55, 3.69)	.499
Cognitive impairment	0.60 (0.16, 2.31)	.706
Depression	0.21 (0.09, 0.33)	<.001
Malnourishment	10.85 (1.19, 20.51)	.034
Anthropometry		
Height	0.96 (0.88, 1.05)	.250
Weight	1.00 (0.93, 1.07)	.869
Muscle index	0.74 (0.16, 1.32)	.675
Skeletal muscle mass	1.18 (0.81, 1.70)	.146
Grip strength	1.03 (0.99, 1.07)	.110
Short Physical Performance Ability	0.70 (0.56, 0.84)	.001

4. DISCUSSION

This study offers a comprehensive exploration of the determinants of physical frailty among old-old adults residing in urban-rural complex communities in Korea. The findings underscore the multifaceted nature of frailty, emphasizing the significant role of sociodemographic factors, health status, and physical performance in determining frailty levels among this unique population.

The prevalence of frailty in this study was found to be high, with nearly half of the participants classified as frail. This is consistent with previous research indicating a high prevalence of frailty among the old-old population [23]. However, it is notably higher than the prevalence reported in some recent studies in other settings [24,25]. This discrepancy may be attributed to the unique challenges faced by the old-old population in urban-rural complex communities, such as disparities in access to resources and healthcare services.

The results demonstrate that age, depression, malnourishment, and short physical performance ability are significant predictors of physical frailty. These findings are consistent with previous research on frailty in the elderly [4,6], but they also highlight the unique challenges faced by the old-old population in urban-rural complex communities.

The odds ratios suggest that with each increasing year of age, the likelihood of frailty increases by 16% (OR=1.16, 95% CI: 1.01–1.31, *p*=.038), underscoring the importance of age as a risk factor for frailty [5]. This is particularly relevant for the old-old population in urban-rural complex communities, who may face additional age-related challenges due to disparities in access to resources and healthcare services [3,10]. These findings underscore the importance of age as a key risk factor for frailty, reinforcing the need for age-specific interventions in the prevention and management of frailty.

Depression emerged as a significant predictor of frailty, with a lower odds ratio indicating that higher levels of depression are associated with increased frailty (OR=0.21, 95% CI: 0.09–0.33, *p*<.001) [26,27]. This finding underscores the importance of addressing mental health issues in the old-old population, as untreated depression may exacerbate physical frailty and lead to adverse health outcomes. This is particularly pertinent for the old-old population in urban-rural complex communities, who may have limited access to mental health services [10]. It highlights the importance of screening for and managing depressive symptoms in older adults

as part of a comprehensive approach to preventing and managing frailty.

Malnourishment was another significant predictor of frailty, with a high odds ratio indicating that malnourished individuals are at a significantly higher risk of becoming frail (OR=10.85, 95% CI: 1.19–20.51, p=.034) [28,29]. The significant association between malnourishment and frailty found in this study aligns with existing research. Malnutrition, particularly protein-energy malnutrition, is prevalent among older adults and has been linked with frailty, adverse health outcomes, and increased mortality rates [8]. Arshad et al. [12] demonstrated a direct association between malnutrition and frailty among community-dwelling older adults. This relationship was attributed to malnutrition's potential to lead to sarcopenia, the loss of muscle mass and strength, which is a critical component of frailty.

Moreover, evidence shows that nutritional interventions can help manage and prevent frailty. A study conducted by Pfisterer et al. [30] indicated that an automated imaging system for quantifying food intake resulted in significant improvements in the nutritional status of older adults in long-term care. Several guidelines, including those from the European Society for Clinical Nutrition and Metabolism (ESPEN), advocate for regular nutritional assessments for older adults to identify and address malnutrition at an early stage [31]. Such assessments may encompass measures of dietary intake, weight loss, and physical signs of malnutrition, among others. The findings from this study emphasize the vital role of nutrition in frailty among older adults. Nutritional assessments and interventions should be essential components of care for this population, aiming to prevent or reverse malnutrition and decrease the risk of frailty. Future research should continue to explore the most effective nutritional strategies and interventions for managing frailty.

The study also found that short physical performance ability was a significant predictor of frailty, with a lower odds ratio suggesting that lower physical performance is associated with increased frailty (OR=0.70, 95% CI: 0.56–0.84, p=.001) [17,32]. This is in line with the recent research conducted by Arrué et al. [8], who discovered a strong association between cardiac-motor interconnection and frailty, suggesting that these parameters could be a promising measure of frailty. Similarly, Yamazaki, Ishii, Ito, & Hashimoto [33] in their study on the application of a frail care robot, AHOBO, found that continuous support in both physical health and psychological aspects for the elderly can significantly contribute to frailty care. This emphasizes the importance of maintaining good physical performance to prevent frailty in older adults.

Moreover, the innovative approach by Arshad and his colleagues [12] provides strong evidence that image-encoded gait data can be used to assess frailty. This suggests that improving physical performance, particularly using advanced technology, could be a viable strategy to mitigate frailty. Furthermore, research conducted by Wairagkar et al. [34] indicates that a novel approach for estimating sit-to-stand kinematics using only two wearable inertial sensors can provide insight in assessment, monitoring, and developing rehabilitation strategies for older adults and patients with motor impairments. This further supports the idea that enhanced physical performance can reduce the incidence of frailty. Taken together, these studies underline the critical role of physical performance in the prevention and management of frailty. As such, the promotion of physical activity, both as a part of daily routines and as a prescribed therapeutic intervention, is of great importance. These interventions not only have the potential to enhance physical performance and reduce frailty, but they can also contribute to overall health improvement and better quality of life in older adults.

However, it is important to acknowledge the limitations of this study. Firstly, the study's cross-sectional design limits the ability to establish causal relationships between the identified determinants and physical frailty. Future research employing longitudinal designs could provide further insights into the causal pathways linking these determinants to frailty. Secondly, the study's findings may not be generalizable to all old-old adults in urban-rural complex communities due to the specific sociodemographic characteristics of the study sample. Further research involving more diverse samples is needed to validate and extend these findings.

Despite these limitations, the study's findings have important implications for healthcare providers and policy makers. They underscore the need for comprehensive and integrated approaches to prevent and manage frailty in the old-old population in urban-rural complex communities. Such approaches should consider not only physical factors but also broader health conditions and socio-demographic influences impacting the elderly. They should also prioritize mental health and nutritional interventions, given their significant role in determining frailty.

In summary, this study provides valuable insights into the determinants of physical frailty among old-old

adults in urban-rural complex communities in Korea. It underscores the multifaceted nature of frailty and highlights the need for comprehensive and integrated approaches to prevent and manage frailty in this population. Further research is needed to develop and evaluate interventions that address the identified determinants of frailty and promote health equity among the old-old population in urban-rural complex communities.

5. CONCLUSION

This study provides a comprehensive understanding of the determinants of physical frailty among the elderly in urban-rural complex communities in Korea. The high prevalence of frailty and the significant role of age, depression, malnourishment, and physical performance in determining frailty levels underscore the urgent need for targeted interventions. These findings highlight the importance of age-specific interventions, mental health care, nutritional support, and physical activity promotion in preventing and managing frailty.

Despite the limitations of the study, such as its cross-sectional design and specific sociodemographic characteristics of the study sample, the findings offer valuable insights for healthcare providers and policymakers. They emphasize the need for comprehensive and integrated approaches in addressing the multifaceted nature of frailty. Further research is needed to develop and evaluate interventions that address these determinants and promote health equity among the elderly population in urban-rural complex communities.

5. ACKNOWLEDGEMENT

This work was supported by the Gyeongsang National University Fund for Professors on Sabbatical Leave, 2021.

6. REFERENCE

[1] United Nations, Department of Economic and Social Affairs, Population Division, *World Population Ageing 2019: Highlights*, United Nations, pp. 5-9. 2019.

[2] World Health Organization 2020, *Decade of Healthy Ageing: Baseline Report*, World Health Organization, pp. 18-27. 2021.

[3] H. Kim, Y.I. Jung, S. Kwon, and H.J. Chin, "Disparities in the Experience and Treatment of Osteoarthritis among Older Adults in South Korea," *Archives of Gerontology and Geriatrics*, Vol. 82, pp. 259-265, 2019.

[4] L.P. Fried, C.M. Tangen, J. Walston, A.B. Newman, C. Hirsch, J. Gottdiener, ... and M.A. McBurnie, "Frailty in Older Adults: Evidence for a Phenotype," *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, Vol. 56, No. 3, pp. M146-M157, 2001.

[5] A. Clegg, J. Young, S. Iliffe, M.O. Rikkert, and K. Rockwood, "Frailty in Elderly People," *The Lancet*, Vol. 381, No.9868, pp. 752-762, 2013.

[6] K. Rockwood, X. Song, C. MacKnight, H. Bergman, D.B. Hogan, I. McDowell, and A. Mitnitski, "A Global Clinical Measure of Fitness and Frailty in Elderly People," *Canadian Medical Association Journal*, Vol. 173, No. 5, pp. 489-495. 2005.

[7] H. Bergman, L. Ferrucci, J. Guralnik, D.B. Hogan, S. Hummel, S. Karunananthan, and C. Wolfson, "Frailty: An Emerging Research and Clinical Paradigm—Issues and Controversies," *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, Vol. 62, No.7, pp. 731-737, 2007.

[8] P. Arrué, K. Laksari, and N. Toosizadeh, "Associating Frailty and Dynamic Dysregulation between Motor and Cardiac Autonomic Systems," in Proc. *arXiv preprint* arXiv:2303.13591, 2023.

[9] Q.L. Xue, "The Frailty Syndrome: Definition and Natural History," *Clinics in Geriatric Medicine*, Vol. 27, No. 1, pp. 1-15, 2011.

[10] S. Park, S. Lee, K.H. Cho, and M.K. Lee, "Association between Depression and Metabolic Syndrome in Korean Women: Results from the Korean National Health and Nutrition Examination Survey (2008–2013)," *Journal of Affective Disorders*, Vol. 260, pp. 105-110, 2020.

[11] V. Barbaccia, L. Bravi, F. Murmura, E. Savelli, and E. Viganò, "Mature and Older Adults' Perception of Active Ageing and the Need for Supporting Services: Insights from a Qualitative Study," *International Journal of Environmental Research and Public Health*, Vol. 19, No. 13, pp. 7660, 2022.
[12] M.Z. Arshad, D. Jung, M. Park, H. Shin, J. Kim, and K. R. Mun, "Gait-based Frailty Assessment using Image Representation of IMU Signals and Deep CNN," in *Proc. 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)*, pp. 1874-1879, November 2021.
[13] H.S. Hwang, I.S. Kwon, B.J. Park, B. Cho, J.L. Hoon, and C.W. Won, "The Validity and Reliability of Korean Frailty Index," *Journal of the Korean Geriatrics Society*, Vol. 14, No. 4, pp. 191-202, 2010.
[14] G.S. Jeon and S.H. Cho, "Prevalence and Social Correlates of Frailty among Rural Community-dwelling Older Adults," *Journal of the Korean Geriatrics Society*, Vol. 18, No. 3, pp. 143-152. 2014.
[15] L.J. Cronbach, "Coefficient Alpha and the Internal Structure of Tests," *Psychometrika*, Vol. 16, No. 3, pp. 297-334, 1951.
[16] H.K. Do and J.Y. Lim, "Rehabilitation Strategy to Improve Physical Function of Oldest-old Adults," *Journal of the Korean Geriatrics Society*, Vol. 19, No. 2, pp. 61-70, 2015.
[17] J.M. Guralnik, E.M. Simonsick, L. Ferrucci, R.J. Glynn, L.F. Berkman, D.G. Blazer, ... and R.B. Wallace, "A Short Physical Performance Battery Assessing Lower Extremity Function: Association with Self-reported Disability and Prediction of Mortality and Nursing Home Admission," *Journal of Gerontology*, Vol. 49, No. 2, pp. M85-M94, 1994.
[18] M.F. Folstein, S.E. Folstein, and P.R. McHugh. "Mini-mental State": a Practical Method for Grading the Cognitive State of Patients for the Clinician," *Journal of Psychiatric Research*, Vol. 12, No. 3, pp. 189-198, 1975.
[19] J.I. Sheikh and J.A. Yesavage, "Geriatric Depression Scale (GDS): Recent Evidence and Development of a Shorter Version," *Clinical Gerontologist: The Journal of Aging and Mental Health*, Vol. 5, No. 1-2, pp. 165-173, 1986.
[20] B.S. Kee, "A Preliminary Study for the Standardization of Geriatric Depression Scale Short Form-Korea Version," *Journal of Korean Neuropsychiatric Association*, Vol. 35, pp. 298-307, 1996.
[21] Y. Guigoz, B. Vellas, and P. Garry. "Mini Nutritional Assessment: A Practical Assessment Tool for Grading the Nutritional State of Elderly Patients," *Facts Research of Gerontology*, Vol. 4, No. 2, pp. 15-59, 1994.
[22] Lee, G.S., *Nutritional Evaluation by Using Mini Nutritional Assessment (MNA) and Relating Factors of Postoperative Recovery for Elderly in Gastric Cancer*, Master's thesis. Kosin University, Busan, Korea, 2004.
[23] R.M. Collard, H. Boter, R.A. Schoevers, and R.C. Oude Voshaar, "Prevalence of Frailty in Community-dwelling Older Persons: A Systematic Review," *Journal of the American Geriatrics Society*, Vol. 60, No. 8, pp. 1487-1492, 2012.
[24] G. Kojima, "Frailty as a Predictor of Future Falls among Community-dwelling Older People: A Systematic Review and Meta-analysis," *Journal of the American Medical Directors Association*, Vol. 19, No. 12, pp. 1023-1029, 2018.
[25] E. Dent, F.C. Martin, H. Bergman, J. Woo, R. Romero-Ortuno, and J.D. Walston, "Management of Frailty: Opportunities, Challenges, and Future Directions," *The Lancet*, Vol. 394, No. 10206, pp. 1376-1386, 2019.
[26] G. Mezuk, L. Edwards, M. Lohman, M. Choi, and K. Lapane, "Depression and Frailty in Later Life: A Synthetic Review," *International Journal of Geriatric Psychiatry*, Vol. 27, No. 9, pp. 879-892, 2012.
[27] C.R. Gale, L. Westbury, and C. Cooper, "Social Isolation and Loneliness as Risk Factors for the Progression of Frailty: The English Longitudinal Study of Ageing," *Age and Ageing*, Vol. 47, No.3, pp. 392-397, 2018.
[28] B. Bartali, E.A. Frongillo, S. Bandinelli, F. Lauretani, R.D. Semba, L.P. Fried, and L. Ferrucci, "Low Nutrient Intake is an Essential Component of Frailty in Older Persons," *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, Vol. 61, No. 6, pp. 589-593, 2006.
[29] L.S. Lee, E.A. Frongillo, and C.M. Olson, "Nutritional and Health Consequences are Associated with Food Insecurity among US Elderly Persons," *The Journal of Nutrition*, Vol. 131, No. 5, pp. 1503-1509, 2017.

[30] K.J. Pfisterer, R. Amelard, A.G. Chung, B. Syrnyk, A. MacLean, H.H. Keller, and A. Wong, "When Segmentation is Not Enough: Rectifying Visual-Volume Discordance Through Multisensor Depth-Refined Semantic Segmentation for Food Intake Tracking in Long-Term Care," in Proc. *arXiv preprint* arXiv:1910.11250, 2019.

[31] C.E.A. Tai, M. Keller, M. Kerrigan, Y. Chen, S. Nair, P. Xi, and A. Wong, "NutritionVerse-3D: A 3D Food Model Dataset for Nutritional Intake Estimation" in Proc. *arXiv preprint* arXiv:2304.05619, 2023.

[32] J. Choi, M. Lee, J.K. Lee, D, Kang, and J.Y. Choi, "Correlates Associated with Participation in Physical Activity among Adults: A Systematic Review of Reviews and Update," *BMC Public Health*, Vol. 18, No. 1, pp. 1-15, 2018.

[33] Y. Yamazaki, M. Ishii, T. Ito, and T. Hashimoto, "Frailty Care Robot for Elderly and its Application for Physical and Psychological Support," *Journal of Advanced Computational Intelligence and Intelligent Informatics*, Vol. 25, No. 6, pp. 944-952, 2021.

[34] M. Wairagkar, E. Villeneuve, R. King, B. Janko, M. Burnett, V. Agarwal, ... and W.S. Harwin, "A Novel Approach for Modelling and Classifying Sit-to-stand Kinematics Using Inertial Sensors," *Plos one*, Vol. 17, No. 10, pp. e0264126, 2022.