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Original Article

The Mediating Effect of Frailty in the Relationship between Depression and Falls among Older People Living Alone in Korea

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Abstract

Background: We explored the potential mediating role of frailty in the relationship between depression and falls.

Methods: The participants were 1,408 community-dwelling older people living alone in South Korea. The potential mediating role of frailty in the relationship between depression and falls was evaluated through univariate and multivariate logistic regression. Baron and Kenny's three-step criteria for mediation were used to examine the mediating effect.

Results: Frailty fully mediated the association between severe depression and falls in univariate (t=11.58, *P*<.05) and multivariate (t=10.42, *P*<.05) analyses.

Conclusion: Frailty is a valuable target for fall interventions in severely depressed older people living alone.

Keywords: Accidental falls; Depression; Frail elderly; Health service; Living independent

Introduction

Frailty, a state of vulnerability, has emerged as a serious issue in South Korea in recent years (1). According to the 2011 Korea Living Status and Welfare Needs of Older Adults Survey, the prevalence of frailty in older people was 8.4% (2), whereas it was 17.4% in a cross-sectional study (3). The prevalence of frailty varies widely across nations (4, 5). For example, the United States Cardiovascular Health Study 2001 reported that the prevalence was 6.9% (5, 6), and cross-sectional studies reported a prevalence of 17.1% (6, 7). These studies showed wide ranges in the prevalence of frailty despite using the same frailty phenotype scale.

In Korea, older people living alone account for 19.8% of people aged 65 years and over (2). They are an at-risk group whose socially isolated and insufficiently supported environment intensifies physical and psychological vulnerability, increasing their risk of frailty compared to those living with others. However, their health problems are complex, and older adults living alone have been reported to be have higher risks for somatic comorbidities, psychological impairment, current smoking status, alcohol consumption, low consumption of fruit and fiber, and limited physical activity (7-10). In particular, they were more likely to have multiple falls than those living with others (9). Many previous studies used the frailty pheno-

type or FRAIL scale (4-7, 11) to report the prevalence of frailty in older adults, but both of these frailty indexes primarily focus on mobility and weight loss. The need for a broader conceptual framework of frailty assessment has emerged, with the goal of identifying older individuals' functional capacity in a more comprehensive and multidomain way, including mobility and weight loss as well as nutritional supplements, oral hygiene, and daily activities (8, 12-14). For these reasons, frailty should be evaluated in older people living alone more comprehensively, given the greater complexity of their health problems compared to those of older adults living with others.

There is evidence that psychological impairment, especially depression, shares features and symptoms with frailty, which is triggered when vulnerable individuals experience extreme stress (6, 11). Frailty reduces physiological functions and increases the risk of falls in later life. Despite effective interventions targeting falls, approximately 30% of community-dwelling older people experience at least one fall, and this proportion is even higher (nearly 50%) among those who live alone (15). Falls are substantially associated with minimal interaction and support from family members, friends, and other acquaintances (9, 16). Frailty and depression are closely related as similar comorbid and conceptual conditions, and for this reason, depression and frailty (either independently or in combination) may play an important role in the risk of falls. Although frailty may be a mediator between depression and falls, little is known about the mechanisms linking frailty with the relationship between depression and falls.

Previous studies focused frailty as an outcome of depression (11, 17, 18), falls (19, 20), obesity (21), multiple comorbidities (8, 22), balance impairment (23), and protein intake (24) among older people. However, to our knowledge, insufficient research has examined the effects of frailty on falls originating from depression. In addition, most existing studies have measured frailty based on the frailty phenotype and FRAIL scale (4-7, 11), lacking a comprehensive frailty assessment.

Therefore, we explored the potential mediating role of frailty in the relationship between depression and falls in older people living alone based on a broader conceptual assessment. We hypothesized the following cases (Fig. 1): higher depression would be associated with higher frailty ("a" path); 2) higher frailty would be associated with higher falls ("b" path); and 3) higher depression would be associated with higher falls ("c" path), whereas higher depression would be indirectly associated with falls when mediated by higher frailty ("a×b" path).

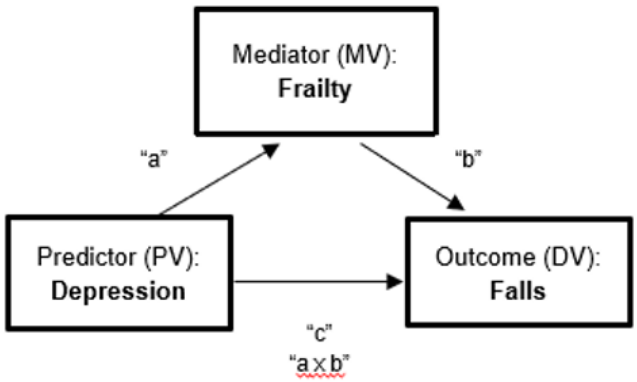


Fig. 1: Conceptual model examining the effect of depression on falls outcomes mediate by frailty.
Note: "a×b" indicates the indirect effect of PV on DV through MV.
"c" indicates the total effect of PV on DV

Methods

Design and Samples

In this cross-sectional study, Baron and Kenny's three-step criteria for mediation methods were used to explore the potential mediating role of frailty in the relationship between depression and falls (25).

Participants were older adults living alone in K city near Seoul, the capital of South Korea. According to the 2012 statistics from the Korean Statistical Information Service (KOSIS) (26), the number of older people aged 65 and older in K city was 30,501 (8.5%), of whom 7,048 lived alone. The sample was selected using the following criteria. The inclusion criteria were being at least 65 years old; having a Mini-Mental State Examination

(MMSE) score of over 24; being ambulatory; and living alone. The exclusion criteria were age under 65 years; neurological and major musculoskeletal impairments that prevented the participants from walking unaided for over 20 m; cognitive impairment (MMSE score < 24); prescriptions of antidepressants or antipsychotic medications; and noncompliance with the participation guidelines. The final study sample comprised 1,408 older people living alone.

Measures

Frailty

The Kihon checklist (KC25) (12, 13), a broad conceptual framework of frailty assessment, was developed as a 25-item questionnaire on daily life (five items), physical ability (five items), nutrition (two items), oral condition (three items), outdoor activities (two items), cognitive status (three items), and mood (five items). This validated tool closely correlates with the frailty criteria of Fried et al. (1). The KC25 was translated into Korean with validation testing (Korean version of KC25; KC25-K) (27). Since this study's objective was to explore the mediating role of frailty related to depression, we evaluated the KC25-K using all items except the five items for mood (KC20-K), as these items might overlap with symptoms of depression. Previous research has validated the Kihon checklist without the five items for mood for identifying community-dwelling older adults who are vulnerable to frailty (14). This KC20-K was dichotomized using cut-off criteria established in a prior study (11). Scores <10 points indicated no functional frailty, and scores of 10-20 indicated frailty.

Depression

The widely validated Geriatric Depression Scale: Short Form (GDS-15) was used to determine depression. Fifteen self-rated items measured the severity of depression (28), with 1 point given for answers of "yes" and 0 points for answers of "no." Positive symptoms were reverse-coded, so that their absence indicated depressive symptoms. Scores of 0 to 5 indicated no depression, scores of 6–10 suggested mild depression, and scores >10 indicated severe depression.

Falls

The term "fall" referred to an unexpected event in which a person came to rest on the ground, floor, or lower level. The respondents reported each fall event according to this definition that resulted in an injury in the prior 12 months. Fall status was dichotomized as having one or more falls versus no falls regardless of mobility status.

Covariates

Demographic characteristics and other health-related variables were collected. The covariables included somatic comorbidities (hypertension, diabetes, hypercholesterolemia, osteoarthritis, stroke, heart disease, cancer, chronic obstructive pulmonary disease, and bladder continence) and lifestyle factors (current smoking status, alcohol consumption, physical activity).

Data Collection

The study was undertaken between November 2013 and December 2016. All participants underwent fall, frailty, and psychological assessments by qualified home visiting nurses trained by the National Health Service, Ministry of Health and Welfare. The nurses visited older people living alone and used face-to-face interviews to capture the patient's health status, current smoking status, alcohol consumption, and physical activity. A physical examination, including a blood pressure check, rapid blood glucose test, and cholesterol test, was conducted to decrease variation and maintain the consistency of data collection. An explanation of the study's objectives and the participants' rights was given to all participants and written informed consent was provided.

We assured participants of confidentiality and anonymity. The Institutional Review Board of S University (No. SSWUIRB 2016-040) approved this study.

Analytic Strategy

The analysis was performed using SPSS for Windows version 23.0 (IBM Corp., Armonk, NY, USA). The potential mediating role of frailty in the relationship between depression and falls was

evaluated through univariate and multivariate logistic regression following Baron and Kenny's three-step criteria for mediation (25). Age, drinking alcohol, osteoarthritis, walking, walking days/week, and the number of comorbidities were corrected as confounders in multivariate logistic regression. The three steps required that 5) the association between depression and falls was significant; 4) the association between depression and frailty was significant; and 1) the association between depression, frailty, and falls was not significant. Full mediation would be supported by the finding that depression is no longer significant when the mediator is controlled, whereas partial mediation would be supported by the finding that depression remained significant.

To examine the effectiveness of the intervening variable, the Freedman and Schatzkin test of mediation was used. This test involved determining the difference (B-B^) in the unstandardized regression coefficients for the associations between depression and falls (B) and between depression and falls adjusted with frailty (B^) (29).

Results

General Characteristics of Participants

In total, 255 (18.1%) participants experienced falls, of whom 33 (12.9%) and 222 (87.1%) were men and women, respectively. The mean age of participants who experienced falls was 78.87±6.66 years.

Of the participants who consumed alcohol, regularly walked for physical activity, had osteoarthritis showed significant differences according to whether participants had experienced falls. The mean number of age, walking days, number of comorbid diseases, frailty level, and depression level showed significant differences according to whether participants had experienced falls (Table 1).

Table 1: Characteristics of subjects by fallers and non-fallers

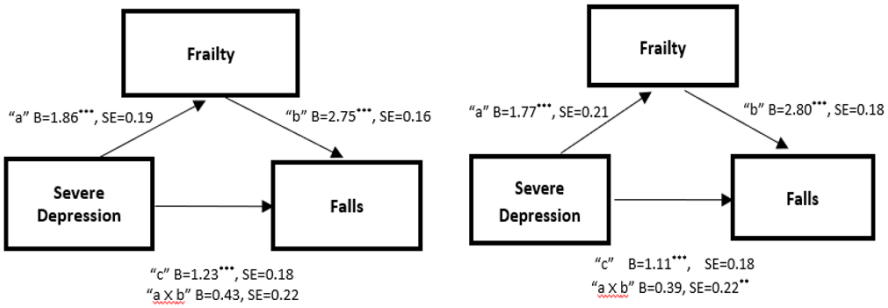
Variable	*Total*	*Fallers*	*Non-fallers*	χ^2/t	*P*
	n(%), Mean±SD	n(%), Mean±SD	n(%), Mean±SD		
Gender	1408(100.0)	255(18.1)	1153(81.9)		
Male	191(13.6)	33(12.9)	158(13.7)	0.103	.748
Female	1217(86.4)	222(87.1)	995(86.3)		
Age(yr)	77.73±6.26	78.87±6.66	77.48±6.14	3.23	.001
65-74	431(30.6)	62(24.3)	369(32.0)	16.35	<.001
75-84	787(55.9)	140(54.9)	647(56.1)		
85≥	190(13.5)	53(20.8)	137(11.9)		
BMI	23.50±3.19	23.41±3.34	23.52±3.16	-0.49	.618
18.5>BMI	67(4.8)	15(5.9)	52(4.5)	2.06	.560
18.5≤BMI<23.0	441(31.3)	86(33.7)	355(30.8)		
23.0≤BMI<25.0	577(41.0)	100(39.2)	477(41.4)		
25.0≤BMI	323(22.9)	54(21.2)	269(23.3)		
Current smoker(yes)	99(7.0)	16(6.3)	83(7.2)	0.27	.601
Drinking alcohol(yes)	129(9.2)	11(4.3)	118(10.2)	8.79	.003
Physical activity					
Vigorous	25(1.8)	4(1.6)	21(1.8)	0.07	.782
Moderate	45(3.2)	6(2.4)	39(3.4)	0.71	.398
Walking	934(66.3)	136(53.3)	798(69.2)	23.57	<.001
Walking(days/week)	3.16±2.61	2.49±2.67	3.31±2.57	-4.60	<.001
Comorbid disease					
Hypertension	1174(83.4)	219(85.9)	955(82.8)	1.40	.236
Diabetes	427(30.3)	90(35.3)	337(29.2)	3.63	.057
Hypercholesterolemia	70(5.0)	10(3.9)	60(5.2)	0.72	.394

Osteoarthritis	741(52.6)	154(60.4)	587(50.9)	7.53	.006
Malignancies	70(5.0)	17(6.7)	53(4.6)	1.89	.201
Bladder continence	30(2.1)	9(3.5)	21(1.8)	2.92	.095
Stroke	66(4.7)	17(6.7)	49(4.2)	2.73	.098
Heart disease	89(6.3)	14(5.5)	75(6.5)	0.36	.547
COPD	30(2.1)	8(3.1)	22(1.9)	1.51	.230
Number of comorbidities(n=9)	1.86±0.97	2.07±1.01	1.82±0.96	3.59	<.001
Frail level(0-25)	4.99±6.15	12.95±6.66	4.03±3.98	20.58	<.001
Daily activities(0-5)	0.86±1.54	2.15±2.07	0.57±1.22	11.71	<.001
Mobility(0-5)	1.48±1.68	3.72±1.36	0.99±1.30	29.13	<.001
Nutrition(0-2)	0.14±0.48	0.56±0.85	0.05±0.28	16.32	<.001
Oral health(0-3)	0.74±1.09	1.80±1.28	0.50±0.89	15.37	<.001
Outdoor activities(0-2)	0.33±0.65	0.99±0.85	0.19±0.49	14.46	<.001
Cognition(0-3)	0.38±0.82	1.09±1.25	0.22±0.59	10.80	<.001
Frailty (yes)	261(18.5)	156(61.2)	105(9.1)	374.92	<.001
Psychological variable					
GDS(range 0-15)	5.17±3.78	6.78±4.18	4.81±3.58	6.95	<.001
Depression(normal)	880(62.5)	112(43.9)	768(66.6)	53.80	<.001
Depression(mild)	336(23.9)	79(31.0)	257(22.3)		
Depression(severe)	192(13.6)	64(25.1)	128(11.1)		

COPD=Chronic Obstructive Pulmonary Disease; GDS=Geriatric Depression Scale

Mediating Effect of Frailty in the Relationship between Depression and Falls

Table 2 and Fig. 2 show the results for the relationship between depression and falls as mediated by frailty. Frailty was associated with a significantly higher likelihood of falls, even after adjustment for age, drinking alcohol, osteoarthritis, physical activity, and comorbid diseases ("b" path). Severe depression showed significant associations with frailty ("a" path) and with falls ("c" path). This association diminished when frailty was included and showed nonsignificant results, showing a full mediating effect ("a×b" path). Severe depression, adjusted for age, drinking alcohol, osteoarthritis, physical activity, and comorbid diseases, was significantly associated with frailty ("a" path).



Unadjusted Model Adjusted Model

Fig. 2: The mediating effects of frailty on the links between severe depression and falls outcomes.
Note:Frailty and depression adjusted with adjusted with age, drinking alcohol, osteoarthritis, walking, walking days/week, number of comorbidities.

"a x b" indicates the indirect effect of PV on DV through MV. "c" indicates the total effect of PV on DV.
$^{***}P<.001$, $^{**}P<.05$

The total effect of adjusted severe depression on falls was significant ("c" path). The direct effect of adjusted severe depression on falls decreased when frailty was included and showed nonsignificant results, showing a full mediating effect ("a×b" path).

Table 2: The mediating effect of frailty in the relationship between depression and falls

Variables	***Frailty→Falls***											
	B	S.E.	*P*	OR(95% CI)								
Frailty												
Unadjusted	2.75	0.19	<.001	15.68(10.69-23.01)								
Adjusted	2.74	0.17	<.001	15.59(10.98-22.14)								
Variables	***Depression(PV)→Frailty(MV)***				***Depression(PV)→Falls(DV)***				***Depression(PV), Frailty(MV)→Falls(DV)***			
	B	S.E.	*P*	OR(95% CI)	B	S.E.	*P*	OR(95% CI)	B	S.E.	*P*	OR(95% CI)
Depression(mild)												
Unadjusted	0.40	0.20	.052	1.49 (0.99-2.23)	0.74	0.16	<.001	2.10(1.52-2.90)	0.74	0.18	<.001	2.11(1.47-3.02)
Adjusted	0.17	0.21	.418	1.19(0.77-1.83)	0.64	0.16	<.001	1.89(1.36-2.64)	0.70	0.18	<.001	2.03(1.41-2.92)
Depression(severe)												
Unadjusted	1.86	0.19	<.001	6.44(4.42-9.37)	1.23	0.18	<.001	3.42 (2.39-4.91)	0.43	0.22	.055	1.54(0.99-2.39)
Adjusted	1.77	0.21	<.001	5.88(3.90-8.88)	1.11	0.18	<.001	3.04(2.10-4.39)	0.39	0.22	.082	1.48(0.95-2.31)

PV=Potential Variable; MV=Mediating Variable; DV=Dependent Variable;
Adjusted =Frailty and depression adjusted with age, drinking alcohol, osteoarthritis, walking, walking days/week, number of comorbidities

Although the total effect of mild depression on falls was significant ("c" path), mild depression was not associated with frailty ("a" path) and showed significant results when frailty was included ("a×b" path), indicating the absence of a mediating effect. The results were similar when age, drinking alcohol, osteoarthritis, physical activity, and comorbid diseases were adjusted; therefore, mild depression did not satisfy Baron and Kenny's three-step criteria.

Assessment of Significance of Mediating Effects

To confirm the mediating effect, the Freedman and Schatzkin test was done (Table 3). There was a difference between the direct and indirect effects of severe depression on falls (B-B^). Severe depression showed a significant mediating effect.

Table 3: Assessment of significance of mediating effects

Variable	*Depression(PV) →Falls(DV)*		*Depression(PV), Frailty(MV) →Falls(DV)*		*Difference*	*t†*
	B	SE	B^	SE	B-B^	
Depression(severe)						
Unadjusted	1.23	0.18	0.43	0.22	0.80	11.58**
Adjusted	1.11	0.18	0.39	0.22	0.72	10.42**

†Freedman and Schatzkin test statistic

B=Unstandardized Coefficient; SE=Standard Error

Adjusted =Frailty and depression adjusted with adjusted with age, drinking alcohol, osteoarthritis, walking, walking days/week, number of comorbidities

***P*<.001, ** *P*<.05

Discussion

We examined the mediating role of frailty in the relationship between depression and falls among older adults living alone. Consistent with our hypothesis, the results revealed that severe depression was associated with higher frailty, and higher frailty was further associated with a higher risk of falling. We have found no other studies that reported the mediating mechanism of frailty based on a comprehensive frailty assessment. Moreover, no other studies have reported the role of frailty in the relationship between depression and falls among older people living alone in South Korea.

Association between Depression and Frailty ("a" Path)

In older people living alone, severe depression showed a much higher association with frailty than mild depression. This finding aligns with a previous study finding that more severely depressed older people were more prone to develop frailty (27). The strong association between the severity of depressive symptoms and frailty was due to comorbid diseases or lifestyle factors (27). Therefore, we included comorbid diseases and lifestyle factors as confounders of the relationship between depression and frailty. Nevertheless, similar results were found when we included depression only. Thus, older people living alone suffering from severe depression need particular attention from nurses in National Health Service. It is necessary to develop frailty improvement interventions to enhance their quality of life.

Association between Frailty and Falls ("b" Path)

Older people living alone who were frail had a higher risk of falling (OR=15.68, 95% CI=10.69-23.01) than their non-frail counterparts. This association became stronger when age, sex, BMI, current smoking status, drinking alcohol, physical activity, and comorbid diseases were adjusted (OR=15.59, 95% CI=10.98-22.14). This finding is in line with previous studies showing consistent findings for the association between frailty and falls, but the risk level was notably different (2, 19, 30). A study of community-dwelling older Koreans aged 65 years or older reported negative consequences of frailty on falls (OR=2.09, 95% CI=1.14-3.81). The prevalence of falls they reported was 17.1% (2). Another study of elderly adults aged 70–84 years in China reported that frailty significantly increased the risk of falls (OR=2.25, 95% CI=1.54–3.28), and the prevalence of falls they reported was 17.6% (30). Although the prevalence of falls in our study (18.1%) was similar to previous reports, the comprehensive frailty assessment we used was remarkably strongly associated with falls. One explanation for why frailty was strongly associated with falls is that the previous studies used the validated Korean version of FRAIL and frailty phenotype scale, respectively, which consisted of five components. However, the frailty measurement (KC20-K) used in this study was more comprehensive, including

domains of daily life, physical ability, nutrition, oral conditions, outdoor activities, and cognitive status. Another explanation is that other study populations were all community-dwelling elderly individuals, whereas study targeted older people living alone. Therefore, the present results provide evidence that frailty is an important predictor of falls and older adults living alone who are should urgently receive fall interventions. However, we recommend additional studies to generalize this result and confirm these results for older people living alone.

The Mediating Effects of Frailty on the Links between Severe Depression and Falls ("a×b" Path)

Confirming our hypothesis, frailty explained the mediating role between severe depression and fall showing a full mediating effect. Severe depression showed a 1.5 times higher association with falls than mild depression in older people living alone. This evidence suggests that severe depression in older people living alone increases their likelihood of being frail, which in turn increases the probability of falls. Since frailty is reversible by reducing negative health factors through specific interventions (11, 17), it could be a valuable target for fall intervention among severely depressed older people living alone. Thus, frailty assessments and interventions in severely depressed older people living alone should be considered an important component of home visiting care services. Visiting nurses should have a sufficient knowledge of depression, frailty, and falls to better recognize frailty in older people living alone suffering from deep depression. Due to the absence of an international consensus on the definition of frailty, various frailty indexes index. Frailty is generally evaluated by grip strength, walking speed, exhaustion, physical activity, and unintentional body weight loss in the frailty phenotype instrument (5). Frailty is also evaluated by fatigue, resistance, ambulation, illness, and unintentional loss of weight in the FRAIL instrument (4). However, in older people living alone, frailty should be identified in a more comprehensive and multidomain way (8, 12-14), as done in this study, and not confined to mobility and weight loss.

Mild depression showed a nonsignificant association with frailty, although it remained associated with falls. These results imply that an intervention program to control mild depression is needed to prevent falls in older people living alone. Antidepressants increased the fall risk by 3.6 times (15). In this study, we did not consider antidepressants when evaluating the mediating effect; therefore, we recommend future studies.

The limitations of this study are as follows. First, although the visiting nurses measured hypertension, diabetes, and hypercholesterolemia, information on other chronic diseases was obtained by a self-reported questionnaire. Second, we did not monitor fall frequency in a certain period. Therefore, individuals might have also been frail when they experienced falls. Finally, no functional assessments were conducted to obtain verified information on physical capabilities, including physical strength, postural way, gait speed, or other variables of interest. Overall, these findings from older South Korean adults living alone may enrich our understanding of the mediating mechanism of frailty in the association between depression and falls, which was evaluated in a comprehensive frailty context.

Conclusion

This study explored the mediating role of frailty in the relationship between depression and falls based on Baron and Kenny's three-step criteria for mediation. Frailty showed a full mediating effect in the relationship between severe depression and falls. It showed the same results when age, drinking alcohol, osteoarthritis, physical activity, and comorbid diseases were adjusted. Although the total effect of mild depression on falls was significant, mild depression was not associated with frailty. Therefore, it is necessary to approach fall interventions according to the classification of depression when providing home visiting care services for older people living alone. For severely depressed older people living alone, it is important

to assess frailty in a comprehensive context to prevent falls.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interest.

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