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Risk factors of repeated falls in the community dwelling old people

Jae Soon Yoo[1], Chul Gyu Kim[1], Jong Eun Yim[2], Mi Yang Jeon[3,*]

[1]Department of Nursing, Chungbuk National University, Cheongju, Korea
[2]Department of Physical Therapy, Sahmyook University, Seoul, Korea
[3]College of Nursing, Institute of Health Science, Gyeongsang National University, Jinju, Korea

This study aimed to provide evidence for the development of an algorithm to identify older adults with a high risk for repeated falls, along with strategies to prevent repeated falls, by analyzing the known physical, psychological, and environmental factors related to falls in older adults. One hundred fifty-seven community-dwelling older adults aged 65 years or older who experienced a fall within the past year were enrolled in this study. Participants' physical, psychological, environmental, and fall prevention-related characteristics were surveyed using structured questionnaires to identify the risk factors for repeated falls. The use of antidepressants, depression score, and compliance with fall prevention behaviors were found to differ significantly between the two groups, and the use of antidepressants and depression were found to be significant predictors of repeated falls. Depression should be considered as a major variable when developing an algorithm to identify the risk of repeated falls among older adults living at home. Also, the practice of fall prevention behaviors was higher in the repeated-falls group, likely due to that group's efforts to prevent additional falls.

Keywords: Repeated falls, Depression, Fall prevention, Risk factors, Older adults

INTRODUCTION

Falls refer to accidents wherein people fall to the floor or ground due to an unintentional postural change. With decreasing muscle mass due to aging, older adults experience a deterioration of their overall motor capacity, including muscle strength, power, flexibility, agility, and endurance (Spirduso et al., 2005). Such decline of physical functions increases the risk for falls among older adults.

One study reported that 17.2% of older adults above the age of 65 years in Korea have experienced a fall injury in the past year (Ministry of Health, Welfare and Family Affairs, 2009). In particular, about 20% of older adults aged 70 years or older and 35% of older adults aged 75 years or older experience fall accidents (Ministry of Health, Welfare and Family Affairs, 2009), and 62% of trauma inpatients aged 65 years or older and 81% of trauma inpatients aged 85 years or older are admitted to the hospital for a fall injury (Korea Centers for Disease Control and Prevention, 2005). In the United States, over 30% of older adults aged 65 years or older experience a fall. About 40% of all deaths caused by an accident involve a fall (World Health Organization, 2007), and falls account for 85% of hospital admissions and 40% of nursing home admissions among older adults (Donaldson et al., 2005). About 50% of older adults who experience a fall face various other problems; about 10%–15% of them require medical treatment for severe injury, 0.2%–1% experience femoral fracture, 5% experience nonfemoral fracture, and another 5% encounter restrictions in activity due to soft tissue damage (Sattin, 1992; Sjögren et al., 1991).

As stated above, falls have serious health repercussions for older adults, including morbidity, mortality, immobility, hospitalization, and early admission to a long-term care facility (Bulat et al., 2008; Rubenstein and Josephson, 2006). Furthermore, older adults who experience a fall not only suffer from pain and fracture but also develop a fear of falling, which limits their physical activity, thereby deteriorating their physical capacity and ultimately

*Corresponding author: Mi Yang Jeon https://orcid.org/0000-0002-5058-9912
College of Nursing, Gyeongsang National University, 63 Gajwa-gil 29beon-gil, Jinju 52828, Korea
E-mail: myjeon68@gnu.ac.kr
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increasing their vulnerability to falls (Jeon et al., 2017).

Korean studies report that about 44.2%–53.8% of those who experienced a fall were involved in at least two fall incidents (Jeon et al., 2017; Park et al., 2008; Yoo, 2011). In Canada, 33% of community-dwelling older adults experience a fall, and 42.4% of them experience repeated falls (Fletcher et al., 2009). Repeated falls not only lead to a more dependent lifestyle in older adults but also undermine their quality of life and increases society's healthcare costs, calling for strategies to prevent repeated falls among this population.

Factors related to repeated falls in older adults should be identified to develop preventive strategies or programs. However, Korean studies on the topic are limited to those that examined the physical factors related to repeated falls, including studies that compared the physical fitness of older community-dwelling women who have experienced a fall and those who experience repeated falls (Jeon et al., 2017; Park et al., 2008) and a study that analyzed multilateral risk factors for repeated falls using a functional state assessment scale (Fletcher et al., 2009). However, falls are a complex health problem that should be examined in relation to physical, psychological, and environmental factors.

Therefore, this study aimed to provide evidence for developing an algorithm for identifying older adults with a high risk for repeated falls and strategies to prevent repeated falls by analyzing the known physical, psychological, and environmental factors related to falls in older adults.

MATERIALS AND METHODS

Research design

This is a descriptive survey study analyzing the risk factors of repeated falls in community-dwelling older adults (approval number: CIRB-2012-Q02).

Participants

One hundred fifty-seven community-dwelling older adults aged 65 years or older who experienced a fall within the past year were enrolled in this study. The inclusion criteria were older adults without disorientation, capable of understanding and answering the given questions. The required sample size for logistic regression analysis was 140, as 14 independent variables were chosen and 10 participants are needed per predictor. Considering a 20% dropout rate, 164 participants were recruited, but after excluding eight participants for omitting responses, 157 participants were included in the final analysis.

Method

Participants' physical (existing disease, drugs currently being taken, visual impairment, hearing impairment, dizziness, ambulatory discomfort, physical activity), psychological (fear of fall, depression), environmental (cohabiting family, type of residence, home environment safety), and fall prevention-related characteristics (knowledge of falls, compliance with fall prevention behaviors) were surveyed using structured questionnaires.

Measurement of physical activity

The Korean Version of Physical Activity Scale for the Elderly (K-PASE), developed through a process of translation and back translation and modifications of the original scale developed by Washburn et al. (Choe et al., 2010) was used. Each item of this 10-item scale is weighted according to the type of physical activity (leisure activity, household activity, work-related activity) and activity frequency to analyze the risk. Items 1–6 (weekly and daily assessments of leisure activities) comprise two subitems to measure the content and duration of the activity. Items 7–9 assess household activities, and only item 9 comprises four subitems. Item 10 assesses work-related activity, and those who answer "yes" are instructed to answer the five additional items. The degree of physical activity was computed based on the PASE scoring method suggested by Washburn et al. (Choe et al., 2010). In other words, leisure activities were computed by converting the activity frequencies using the "time per day" conversion table, and household activities were computed in percentages based on the degree of participation in the past week. Contribution to the total physical activity score was calculated by multiplying the activity frequency by the PASE weighted value. The total score ranges from 0–360, with a higher score indicating more physical activity. The test-retest reliability at the time of the development was 0.75.

Measurement of fear of falling

Fear of falling was measured by the question "Are you afraid of falling?" which was rated on a 4-point scale, wherein 1 indicates "not at all," 2 indicates "slightly," 3 indicates "very," and 4 indicates "very much." A higher score indicates greater fear of falling.

Measurement of depression

Depression was measured using the Korean short form of Geriatric Depression Scale, developed by Song (Kee, 1996) by translating and standardizing the Geriatric Depression Scale: Short form developed by Sheikh and Yesavage (Kee, 1996). Each item of this 15-item scale is answered with a yes or no. "Yes" and "no"

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to a positive item was given a score of 0 and 1, respectively, and "yes" and "no" to a negative item was given a score of 1 and 0, respectively. Score 0–4 indicates normal, 5–9 indicates mild depression, and 10–15 indicates severe depression, and a higher score indicates more severe depression. The Cronbach α at the time of development was 0.89 and that in this study was 0.79.

Measurement of home environment safety

Home environment safety was measured using the Korean version (developed by Gu et al., 2006) (Hyeon et al., 2010) of the checklist for risk of fall at home in the Merck manual of geriatrics developed by Beers et al. (Hyeon et al., 2010). This scale comprises 25 items, including living room, furniture, lighting, bathroom, kitchen, stairs, and mobility, and each item is answered with a yes (1 point) or no (0 points). The total score ranges from 0–25, and a higher score indicates a safer home environment. The Cronbach α of the scale in this study was 0.77.

Measurement of knowledge of falls

The scale developed by Kim to measure nurses' knowledge of falls was modified by Kim to assess older adult inpatients (Hwang and Shin, 2013), and this scale was again modified by Hwang (Hwang and Shin, 2013) to assess community-residing older adults, which

Table 1. Comparison of general characteristics (n=157)

Characteristic	One-time fall group (n=112)	Repeated falls group (n=45)	χ^2 or t	*P*-value
Age (yr)	78.19±5.66	77.87±7.11	0.27	0.766
Gender				
Male	12 (10.7)	7 (15.6)	0.71	0.423
Female	100 (89.3)	38 (84.4)		
Marital status				
Married	31 (27.7)	12 (26.7)	2.61	0.451
Divorce	4 (3.6)	0 (0)		
Bereaved	75 (67.0)	33 (73.3)		
Single	2 (1.8)	0 (0)		
Education				
Uneducated	74 (66.1)	30 (66.7)	1.02	0.832
Elementary school	27 (24.1)	11 (24.4)		
Middle school	5 (4.5)	3 (6.7)		
Above high school	6 (5.4)	1 (2.2)		
Living standard				
Very bad	16 (14.3)	6 (13.3)	0.83	0.843
Bad	53 (47.3)	20 (44.4)		
Moderate	38 (33.9)	18 (40.0)		
Good	5 (4.5)	1 (2.2)		

Values are presented as mean±standard deviation or number (%).

Table 2. Comparison of physical, psychological, ecological and fall related characteristics (n=157)

Characteristic	One-time fall group (n=112)	Repeated falls group (n=45)	χ^2 or t	*P*-value
Physical factors				
Diagnosis				
Hypertension				
No	29 (26.1)	14 (31.8)	0.51	0.551
Yes	82 (73.9)	30 (68.2)		
Diabetes				
No	69 (62.2)	32 (71.1)	1.12	0.356
Yes	42 (37.8)	13 (28.9)		
Stoke				
No	97 (88.2)	41 (91.1)	0.28	0.779
Yes	13 (11.8)	4 (8.9)		
Arthritis				
No	25 (22.3)	10 (22.2)	0.00	>0.999
Yes	87 (77.7)	35 (77.8)		
Urinary, no	105 (95.5)	39 (86.7)	3.74	0.080
Incontinence, yes	5 (4.5)	6 (13.3)		
Alcoholism				
No	110 (100)	44 (97.8)	2.46	0.290
Yes	0 (0)	1 (2.2)		
Medication				
Antidiuretic				
No	100 (89.3)	42 (93.3)	0.61	0.557
Yes	12 (10.7)	3 (6.7)		
Cardiotonic				
No	105 (93.8)	41 (91.1)	0.34	0.730
Yes	7 (6.3)	4 (8.9)		
Sedatives				
No	103 (97.3)	42 (93.3)	1.39	0.355
Yes	3 (2.7)	3 (6.7)		
Hypnotic				
No	109 (97.3)	44 (97.8)	0.03	>0.999
Yes	3 (2.7)	1 (2.2)		
Analgesic				
No	98 (87.5)	40 (88.9)	0.06	>0.999
Yes	14 (12.5)	5 (11.1)		
Antidepressant				
No	111 (99.1)	41 (91.1)	6.66	0.024
Yes	1 (0.9)	4 (8.9)		
Arthritis drug				
No	77 (68.8)	25 (55.6)	2.46	0.140
Yes	35 (31.3)	20 (44.4)		
Diabetes drug				
No	91 (81.3)	34 (75.6)	0.64	0.511
Yes	21 (18.8)	11 (24.4)		

(*Continued to the next page*)

Table 2. Continued

Characteristic	One-time fall group (n=112)	Repeated falls group (n=45)	χ^2 or t	P-value
Visual disturbance				
No	27 (24.1)	10 (22.2)	0.06	0.839
Yes	85 (75.9)	35 (77.8)		
Hearing defect				
No	46 (41.1)	26 (57.8)	3.61	0.076
Yes	66 (58.9)	19 (42.2)		
Dizziness				
No	14 (12.5)	2 (4.4)	2.28	0.156
Yes	98 (87.5)	43 (95.6)		
Physical activity	56.17±44.54	55.08±42.05	0.14	0.888
Psychological factors				
Fear of fall	2.86±0.75	3.04±0.80	-1.40	0.165
Depression	7.00±3.50	9.00±3.44	-3.25	0.001
Environmental factors				
Living				
Alone	63 (56.3)	25 (55.6)	0.81	0.985
With spouse	29 (25.9)	11 (24.4)		
With offspring	16 (14.3)	6 (13.3)		
With family	1 (0.9)	1 (2.2)		
Other	3 (2.7)	2 (4.4)		
House				
Apartment	33 (29.5)	10 (22.2)	5.64	0.139
Villa, multi-family	9 (8.0)	4 (8.9)		
Single house	70 (62.5)	29 (64.4)		
Other	0 (0)	2 (4.4)		
Safety of home environment	15.66±5.56	16.11±4.38	-0.54	0.592
Fall prevention factors				
Fall prevention activity compliance	11.46±2.81	12.49±1.63	-2.85	0.005
Knowledge of fall	8.99±3.10	8.71±4.57	0.38	0.707

Values are presented as number (%) or mean±standard deviation.

was used for this study. The scale comprises 18 items pertaining to the definition of fall, physical risk factors, and drugs that increase the risk for falls. Each item is answered with a "yes," "no," or "I don't know." Correct answers were given 1 point, while wrong answers and "I don't know" were given 0 point. The total score ranges from 0–18, and a higher score indicates a greater knowledge about falls. The Kuder–Richardson Formula 20 (K-R 20) in Hwang and Shin (2013) was 0.86, and that in this study was 0.76. Measurement of compliance with fall prevention behavior

Fall prevention behaviors were measured using the scale developed by Gu et al. (2006) This scale comprises 14 items, including wearing safe shoes, practicing safe walking habits, limiting alcohol intake, and taking drugs. Each item is answered with a "yes" or "no," which is given a score of 2 and 1, respectively. The total score ranges from 14–28, with a higher score indicating higher compliance with fall prevention behaviors. The reliability (Cronbach α) of the scale in the study of Hyeon et al. (2010) was 0.78 and that in this study was 0.73.

Data analysis

Data were analyzed using IBM SPSS Statistics ver. 21.0 (IBM Co., Armonk, NY, USA). The general, physical, psychological, and environmental characteristics of the single-fall and repeated-fall groups were presented as mean and standard deviation as well as frequencies and percentages. The differences between the two groups were analyzed using the χ^2-test, Fisher exact test, and independent t-test. The risk factors for repeated falls were analyzed by logistic regression, and the goodness of fit of the model was tested using the Hosmer and Lemeshow test. The reliability of each scale was measured by KR-20 or Cronbach alpha, and statistical significance was set at $P<0.05$.

RESULTS

Comparison of the demographic characteristics of the single-fall group and repeated-falls group

A total of 157 participants were included in this study. One hundred twelve (71.3%) were assigned to the single-fall group, while 45 (28.7%) were assigned to the repeated-falls group. The mean ages were 78.19 years and 77.87 years, respectively, showing no significant difference ($t=0.27$, $P=0.766$). The percentage of women in each group was 89.3% and 84.4%, respectively, also showing no significant difference ($\chi^2=0.71$, $P=0.423$). Most of the participants were not educated ($\chi^2=1.02$, $P=0.832$), widowed ($\chi^2=2.61$, $P=0.451$), and had poor economic status ($\chi^2=0.83$, $P=0.843$), and there were no significant differences between the two groups (Table 1).

Comparison of the physical characteristics of both groups

Regarding disease prevention in the single-fall group and repeated-falls group, the prevalence of hypertension was 73.9% and 68.2% ($\chi^2=0.51$, $P=0.551$), respectively, and the prevalence of diabetes mellitus was 37.8% and 28.9% ($\chi^2=1.12$, $P=0.356$), respectively. The prevalence of stroke was 11.8% and 8.9% ($\chi^2=0.28$, $P=0.779$), respectively, and the prevalence of arthritis was 77.7% and 77.8% ($\chi^2=0.00$, $P>0.999$), respectively. The prevalence of urinary incontinence was 4.5% and 13.3% ($\chi^2=3.74$, $P=0.080$), respectively, showing no significant differences between

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Table 3. Factors influencing the repeated falls

Variable	B	SE	Wald	*P*-value	Odds ratio	95% CI
Intercept	-5.36	1.24	18.70	<0.001		
Antidepressant	1.69	0.77	4.76	0.029	5.40	1.187–24.601
Fall prevention activity compliance	0.11	0.07	2.52	0.112	1.12	0.974–1.283
Depression	0.15	0.04	13.15	<0.001	1.17	1.073–1.267

SE, standard error; CI, confidence interval.
$\chi^2 = 22.25$, $P < 0.001$, Nagelkerke $R^2 = 0.117$.

the two groups. Only one person in the repeated-falls group was diagnosed with alcoholism (Table 2). Regarding the drugs being taken, the use of antidepressants significantly differed between the two groups, with 0.9% in the single-fall group and 8.9% in the repeated-falls group ($\chi^2 = 6.66$, $P = 0.024$); there were no significant differences in the use of diuretics ($\chi^2 = 0.61$, $P = 0.557$), cardiotonics ($\chi^2 = 0.34$, $P = 0.730$), sedatives ($\chi^2 = 1.39$, $P = 0.355$), sleeping pills ($\chi^2 = 0.03$, $P > 0.999$), use of sedatives ($\chi^2 = 0.06$, $P > 0.999$), arthritis medication ($\chi^2 = 2.46$, $P = 0.140$), and diabetes medication ($\chi^2 = 0.64$, $P = 0.511$). There were also no significant differences in the prevalence of visual impairment ($\chi^2 = 0.06$, $P = 0.839$), hearing impairment ($\chi^2 = 3.61$, $P = 0.076$), dizziness ($\chi^2 = 2.28$, $P = 0.156$), and physical activities ($t = 0.14$, $P = 0.888$) (Table 2).

Comparison of the psychological characteristics of both groups

The two groups significantly differed in their depression scores ($t = -3.25$, $P = 0.001$) but not in their fear of falling ($t = -1.40$, $P = 0.165$) (Table 3).

Comparison of the environmental characteristics of both groups

Regarding cohabitation, most participants lived alone, with no significant difference between the two groups ($\chi^2 = 0.81$, $P = 0.985$). Home environment safety ($t = -0.54$, $P = 0.592$) was also not significantly different between the two groups (Table 2).

Comparison of the fall prevention-related characteristics of both groups

The two groups did not significantly differ in the knowledge of falls ($t = 0.38$, $P = 0.707$) but did significantly differ in compliance with fall prevention behaviors ($t = -2.85$, $P = 0.005$) (Table 2).

Actors affecting falls in both groups

To identify the risk factors for repeated falls, the use of antidepressants, depression score, and compliance with fall prevention behaviors, which were found to differ significantly between the two groups, were analyzed by logistic regression. Older adults taking antidepressants were 5.40 times more likely to experience repeated falls, and those with a high depression score were 1.17 times more likely to experience repeated falls. The model was found to be significant in the Nagelkerke test ($\chi^2 = 22.25$, $P < 0.001$) with an explanatory power of 11.7% (Table 3).

DISCUSSION

Older adults are at a higher risk for falls due to their reduced sensory functions, musculoskeletal problems, such as reduced lower limb muscle strength and articular contracture, and deteriorated cognitive ability (McGibbon et al., 2001). Those who experience a fall limit their activities due to a fear of falling again (Jeon et al., 2017). Falling is a safety accident in which various physical, psychological, and environmental factors are at play; thus, a comprehensive assessment of these factors is needed to identify the risk factors for falling. Hence, this study divided community-dwelling older adults into those who have only fallen once and those who have experience repeated falls in order to compare their physical characteristics (underlying disease, drugs they take, visual impairment, hearing impairment, dizziness, ambulatory discomfort, physical activities), psychological characteristics (fear of falling, depression), environmental characteristics (cohabiting family member, form of residence, home environment safety), and fall prevention-related characteristics (knowledge of falls, compliance with fall prevention behavior).

In our study, there were no significant differences in the demographic characteristics (age, sex, marital status, education level, economic status) between the single-fall and repeated-falls groups. These results are in line with the previous findings (Jeon et al., 2017; Park et al., 2008; Yoo, 2011). However, according to Woolcott et al. (2009), the risk for falls increases with advancing age. This difference may be attributed to the fact that the mean age of

participants in our study and previous studies (Jeon et al., 2017; Park et al., 2008; Yoo, 2011) was more than 75 years. Although a previous study (Yoo, 2011) reported that older adults living alone show an increased incidence of falls, there was no significant difference in the relation to cohabitation in our study. This may be because a high percentage of participants lived alone (more than 50%) in both the single-fall and repeated-falls groups in our study. Based on these results, older adults aged 75 years or older or those living alone should be weighted additionally when developing an algorithm to identify those with a high risk for repeated falls.

In our study, there was no significant difference in the prevalence of comorbidities between the single-fall group and the repeated-falls group but the two groups significantly differed in their use of antidepressants. This result is in keeping with a previous finding that drug administration is associated with falls (Chen et al., 2014; Woolcott et al., 2009). A meta-analysis of antipsychotic drugs that increase the risk for falls (Woolcott et al., 2009) reported that antipsychotics, antidepressants, and benzodiazepines increase the risk for falls (Chen et al., 2014). In our study, older adults taking antidepressants were 5.40 times more likely to experience repeated falls (95% confidence interval [CI], 1.19–24.60). Antidepressants may increase the risk for falls because the elevated serotonin concentration in the brain not only decreases depression but also induces sedation. Furthermore, antidepressants may have elevated the risk for repeated falls due to their side effects, including extrapyramidal symptoms, such as tremor and ataxia, postural hypotension, anxiety, enuresis, and sleep disturbance (Chen et al., 2014).

In our study, the single-fall group and repeated-falls group did not show a significant difference in their fear of falling score but did have a significant difference in their depression score. This result is consistent with a previous finding that single-fall and repeated-falls groups have significantly different depression scores. In addition, we found that a higher depression score is associated with 1.17 time higher risk for repeated falls (95% CI, 1.07–1.27). Based on these results, depression and the use of antidepressants should be considered as major variables when developing an algorithm to identify older adults with a high risk for repeated falls.

In our study, the practice of fall prevention behaviors was higher in the repeated-falls group than in the single-fall group. This might be a result of the repeated-falls group's effort to prevent additional falls after having experienced several falls.

This study assessed the physical (health status, physical activity, compliance with fall prevention behaviors), psychological (fear of falling, depression), and environmental factors (cohabiting family members, type of residence, and home environment safety) of older adults who had experienced a fall once and those who had experienced multiple falls in order to provide data for developing a program to prevent repeated falls in community-dwelling older adults. The use of antidepressants and depression were found to be significant predictors of repeated falls. Based on these results, depression should be considered as a major variable when developing an algorithm for identifying the risks for repeated falls among older adults living at home.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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