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# Association of Falls and Fear of Falling with Mortality in Korean Adults: The Dong-gu Study

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This study evaluated the association between falls and the fear of falling (FOF) with the risk of all-cause mortality in Korean adults. The study enrolled 4,386 subjects aged 50 years and over who participated in the Dong-gu Study. Falls in the past year were categorized as yes or no. Injurious falls were defined as falls that resulted in fractures, head injuries, sprains or strains, bruising or bleeding, or other unspecified injuries. FOF was classified as low or high. The associations of falls and fall-related characteristics with mortality were assessed using Cox proportional hazards models. The average follow-up was 7.8 years. During this period, 255 men and 146 women died. In a fully adjusted model, falls in the past year were not associated with an increased risk of all-cause mortality (hazard ratio [HR] 1.16, 95% confidence interval [CI] 0.85-1.58), but a history of injurious falls was associated with an increased risk of mortality (HR 1.36, 95% CI 1.04-1.79). Compared with subjects without a FOF, subjects who were moderately or very afraid of falling had a higher mortality rate (HR 1.26, 95% CI 0.97-1.63). In conclusion, injurious falls and a high FOF increased the risk of all-cause mortality in Koreans. This study suggests that injurious falls and FOF can predict mortality in the general population.

**Key Words:** *Accidental Falls; Cohort Studies; Risk; Cause of Death*

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## INTRODUCTION

Falls are a major public health concern and a leading cause of morbidity and mortality in the elderly worldwide.[1] Falls affect one in five adults over the age of 65 years annually,[2] and they cause 25% of serious injuries[3] and 40% of all injury-related deaths.[4] Fear of falling (FOF) is a high level of anxiety regarding falling while standing or walking, which can lead to limitations in daily life. FOF is not only an index reflecting a history of falling[5] or poor health status in older adults;[6,7] it can also occur in people without a history of falling, and it is associated with health problems such as stroke[8] and cardiovascular diseases.[9] In Korea, according to the 2011 Community Health Survey, 19.4% of people aged 65 or older experience falls annually.[2] In addition, the prevalence of FOF in Korea is 76.6%,[10] higher than the 36.5% reported in Japan[7] and 36.2% in the United States.[11]

Few studies have examined the association between FOF and falls and mortality. In previous studies, FOF was associated with increased mortality in the general population[12] and in populations with hip fracture.[13] However, the association between a history of falling and mortality is inconsistent across studies.[12,14] In addition, no study has examined the effects of the interaction between FOF and falls on mortality. Therefore, we conducted this prospective study to evaluate the association of falls and FOF with mortality in Korean adults. We also evaluated the effects of the interaction of FOF and previous falls on mortality.

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## MATERIALS AND METHODS

### 1. Subjects

This study enrolled participants in the Dong-gu Study, a population-based cohort study seeking to identify the risk factors of chronic diseases.[15] The baseline survey for this study was conducted from 2007 to 2010, and 9,260 people aged 50 years or older participated in the survey. Fall questionnaires were included only in the baseline surveys in 2009-2010, when 4,997 subjects were examined. Of these, 241 participants with a history of stroke, 288 with missing values in the fall questionnaire, and 82 with missing values for covariates were excluded. Ultimately, 4,386 participants were included in our study. The Dong-gu Study protocol was approved by the institutional review board of Chonnam National University Hospital (IRB No. I-2008-05-056), and all participants provided informed consent.

### 2. Falls characteristics

A history of falls in the past year was defined as a "yes" answer to the question "During the past 12 months, have you fallen and landed on the floor or ground, or fallen and hit an object like a table or chair?" Subjects who experienced falls were asked about fall-related injuries and were classified into those who experienced fall-related injuries and those who did not. Injurious falls were defined as falls that resulted in a fracture, head injury, sprain or strain, or bruising or bleeding. FOF was assessed using the question, "Are you afraid of falling?" Subjects were asked to classify their degree of fear as "not afraid," "slightly afraid," "moderately afraid," or "very afraid." For analysis purposes, the responses were grouped as "not or slightly afraid" and "moderately or very afraid."

### 3. Covariates measurements

Body mass index (BMI) was calculated by dividing body weight by height squared, and classified as underweight (<18.5), normal (18.5-24.9), overweight (25.0-29.9), or obese ($\geq$30). Marital status was categorized as living alone or living with a spouse or partner. Educational attainment was classified as not having completed elementary school, not having completed high school, or having attended college or higher. Smoking status was classified as non-smoker, ex-smoker, or current smoker. Heavy drinking was defined as drinking more than seven drinks per month for men and more than five drinks per month for women. Physical activity was defined as moderate physical activity for at least 30 minutes, five times per week or vigorous physical activity for at least 20 minutes three times per a week. Moderate physical activity referred to swimming at a slow pace or playing table tennis, badminton, or tennis doubles, and vigorous physical activity referred to swimming at a fast pace, climbing, cycling, squash, and tennis singles. Histories of diabetes mellitus, hypertension, or coronary heart disease were self-reported. Blood pressure was measured three times at 1-minute intervals after resting for 5 minutes, and the mean value was used. Glycated hemoglobin was measured with an HPLC analyzer (Bio-Rad, Hercules, CA, USA). Total cholesterol was measured by an enzymatic method using blood collected after 8 hours' fasting.

### 4. Ascertainment of death

The date and causes of death were ascertained by linkage with the death records of the National Statistical Office. The date of death was ascertained until December 31, 2017.

### 5. Statistical analysis

The general characteristics are presented according to gender, using the mean and standard deviation for continuous variables and number and percentage for categorical variables. The associations between fall-related characteristics and mortality were assessed using Cox proportional hazards models. Model 1 adjusted for age, sex, marital status, educational attainment, smoking, alcohol consumption, and physical activity. Model 2 was further adjusted for diabetes medication, hypertension medication, history of coronary heart disease, systolic blood pressure, glycated hemoglobin, and total cholesterol. The statistical analyses were performed using Stata 14.0 (StataCorp, College Station, TX, USA), and statistical significance was set at 0.05.

## RESULTS

Table 1 shows the baseline characteristics of the study population. In the baseline survey, the average age was 65.5 years for men and 63.8 years for women. The average follow-up was 7.8 years. During this period, 255 men and 146 women died. Women experienced falls more often than men. Women had higher BMI and cholesterol levels than men. Women were less likely to live with a partner or be married and had lower education levels. They also had lower blood pressure levels and lower rates of smoking, high-risk drinking, and diabetes medication. In men, 11.3% had a history of falls, 8.6% had a history of injurious falls, and 6.6% had a FOF; these values in women were 19.2%, 15.6%, and 22.5%, respectively.

Table 2 gives the hazard ratios (HR) of injurious falls, falls, and FOF. The incidence of falls in the past year and FOF were not statistically associated with an increased risk of all-cause mortality. The risk of death in subjects with a history of falls and FOF was attenuated by adjustment for covariates. The HR of falls was 1.27 (95% confidence interval [CI] 0.99-1.62) in crude model, 1.23 (95% CI 0.96-1.58) in model 1, and 1.17 (95% CI 0.90-1.51) in model 2. The HR of FOF was 1.38 (95% CI 1.09-1.76) in crude model, 1.33 (95% CI 1.02-1.72), and 1.26 (95% CI 0.97-1.63) in model 2. However, a history of injurious falls was associated with an increased risk. The HR of injurious falls was 1.31 (95% CI 1.00-1.71) in crude model, 1.41 (95% 1.07-1.84) in model 1, and 1.36 (95% CI 1.04-1.79) in model 2.

Fig. 1 shows the HRs and 95% CIs according to FOF and a history of injurious falls. Compared to subjects with no a history of injurious falls or FOF, the HR for subjects with

only FOF and that for subjects with only a history of injurious falls were 1.14 (95% CI 0.80-1.63) and 1.08 (95% CI 0.79-1.48), respectively. In comparison, subjects with both a FOF and a history of injurious falls had a significantly higher risk of mortality (HR 1.87, 95% CI 1.26-2.77). However, the interaction between FOF and a history of injurious falls was not significant (p-value=0.152).

**TABLE 1.** Baseline characteristics of study population according to sex

| | Men (N=1,860) | Women (N=2,526) | p-value |
|---|---|---|---|
| Death | 255 (13.7) | 146 (5.8) | <0.001 |
| Age (years) | 65.5±8.1 | 63.8±8.2 | <0.001 |
| Falls in past year | 218 (11.3) | 486 (19.2) | <0.001 |
| Injurious falls | 160 (8.6) | 395 (15.6) | <0.001 |
| Fear of falling (moderately or very afraid of falling) | 122 (6.6) | 567 (22.5) | <0.001 |
| BMI (kg/m$^2$) | 24.0±2.8 | 24.7±3.0 | <0.001 |
| Underweight | 40 (2.1) | 27 (1.1) | <0.001 |
| Normal | 1,138 (61.2) | 1,358 (53.8) | |
| Overweight | 639 (34.3) | 1,024 (40.5) | |
| Obese | 43 (2.3) | 117 (4.6) | |
| Partnered | 1,672 (89.9) | 1,805 (71.5) | <0.001 |
| Education | | | <0.001 |
| Uneducated/elementary | 462 (24.8) | 1,326 (52.5) | |
| Middle school/high school | 962 (51.7) | 1,036 (41.0) | |
| More than college | 436 (23.4) | 164 (6.5) | |
| Smoking | | | <0.001 |
| Non-smoker | 469 (25.2) | 2,441 (96.6) | |
| Former-smoker | 895 (48.1) | 43 (1.7) | |
| Current smoker | 496 (26.7) | 42 (1.7) | |
| Heavy drinking | 735 (39.7) | 141 (5.6) | <0.001 |
| Physical activity | 471 (25.3) | 325 (13.3) | <0.001 |
| Hypertension | 624 (33.5) | 883 (35.0) | 0.332 |
| Diabetes mellitus | 275 (14.8) | 282 (11.2) | <0.001 |
| Coronary heart diseases | 120 (6.4) | 123 (4.9) | 0.024 |
| Systolic blood pressure (mmHg) | 126.0±17.2 | 123.8±17.5 | <0.001 |
| HbA1c (%) | 5.8±0.9 | 5.8±0.9 | 0.311 |
| Total cholesterol (mg/dL) | 197.1±38.0 | 215.3±39.8 | <0.001 |

All values were presented as 'N (%)' or 'mean±standard deviation'. The p-values were calculated using Student's *t*-test or chi-square test. BMI: body mass index, HbA1c: Glycated hemoglobin.

## DISCUSSION

In this population-based cohort study, injurious falls in the past year were associated with an increased risk of mortality, whereas falls in the past year were not. FOF was associated with an increased risk of all-cause mortality. Although the effect of the interaction between FOF and previous falls was not significant, mortality was highest in the subjects with both FOF and a history of falls.

Few studies have examined the association of FOF and falls with mortality. In the Shih-Pai Study of elderly Taiwanese,[12] FOF was associated with high mortality, whereas a history of falls was not. By contrast, Dunn et al.[14] reported that recurrent falls were associated with high mortality, and injurious falls were associated with high mortality in our study. After adjusting for chronic diseases, the association between FOF and mortality was attenuated and was borderline significant (HR 1.26, 95% CI 0.97-1.63), although a history of injurious falls was still a risk factor for mortality (HR 1.31, 95% CI: 1.00-1.71).

Fear of falling is a phobic reaction to falling, and the severity of anxiety and FOF were positively correlated.[16] In previous studies, both anxiety[17] and anxiety disorder[18] were associated with high mortality. In the HUNT-2 Study,[17] the HR for anxiety scores was reduced from 1.25 to 1.07 after

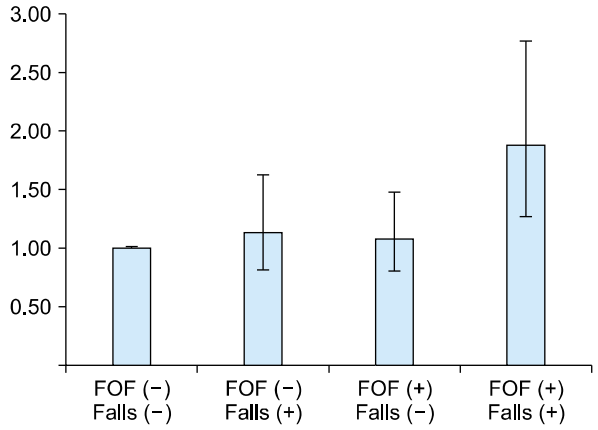


**FIG. 1.** Hazard ratio according to fear of falling (FOF) and history of injurious falls. Error bars showed 95% confidence intervals.

**TABLE 2.** Association of falls, fall-related injuries and fear of falling with all-cause mortality

| | Event/N | Crude model | Model 1 | Model 2 |
|---|---|---|---|---|
| Falls | 323/3,682 | 1.00 | 1.00 | 1.00 |
| | 78/704 | 1.27 (0.99-1.62) | 1.23 (0.96-1.58) | 1.17 (0.90-1.51) |
| Injurious falls | 335/3,831 | 1.00 | 1.00 | 1.00 |
| | 66/555 | 1.38 (1.06-1.79) | 1.41 (1.07-1.84) | 1.36 (1.04-1.79) |
| Fear of falling | 319/3,697 | 1.00 | 1.00 | 1.00 |
| | 82/689 | 1.38 (1.09-1.76) | 1.33 (1.02-1.72) | 1.26 (0.97-1.63) |

Model 1 was adjusted for age, sex, body mass index, marital status, educational attainment, smoking, alcohol consumption, and physical activity. Model 2 was further adjusted for diabetes medication, hypertension medication, history of coronary heart disease, systolic blood pressure, glycated hemoglobin, and total cholesterol.

correcting for smoking history, physical activity, and other factors. This is consistent with previous findings that FOF reduced daily physical activity,[19,20] In our study, although Model 1 adjusted for physical activity, the association between FOF and mortality remained significant.

No study has evaluated the effects of the interaction between FOF and previous falls on mortality, and the interaction was not significant in our study. FOF and falls are closely related.[19,21] These variables share several elements, including associations with old age, poor health status[6,21] and diseases that cause gait disturbance such as stroke[8] or Parkinson's disease.[22] In the Longitudinal Aging Study Amsterdam (LASA),[23] the interaction between FOF and previous falls had an effect on fall risk, and both FOF and fall history were associated with a high fall risk. According to the Salisbury Eye Evaluation (SEE) study,[24] falls and FOF are independent risk factors from each other. Based on our findings and these results, those who had both FOF and a history of injurious falls appeared to be at much higher risk of having poorer physical function and higher risk of death than those with only one of these factors.

Although some studies have reported a prevalence of falls at similar levels as ours,[7,12] many studies have reported a higher prevalence of falls than in our study.[2,5,14,23] In most studies, the age of the study population was higher than that of our study.[2,5,7,12,14,23] Although not presented in the results, the prevalence of falls was 17.5% in subjects aged 65 years or over, and 21.5% in subjects aged 75 years or over, which was similar to the results in other studies.[2,14] In addition, some studies tracked fall history prospectively[23] or reviewed medical records,[5] using this method, more cases could be identified in these studies than those investigated with self-reported questionnaires. The prevalence of FOF in our study was lower than the prevalence reported in other studies.[7,10,12,23] These differences can be partially explained by the definition of FOF and the age difference of the study population. In most previous studies,[7,10,12,23] FOF was defined by the presence of anxiety of falling, but in our study we defined FOF as having moderate-to-severe anxiety of falling.

There are several limitations to this study. First, we measured FOF using the patients' degree of fear, but it can also be measured by how much the FOF limits activity, such as with the Fall Efficacy Scale (FES). To assess how behavioral changes due to FOF affect health outcomes, additional information, such as the degree of activity limitation, needs to be considered. Second, studies involving physical functions related to falls, such as imbalance, are needed. FOF modifies the association between postural imbalance and falls. In the Steps to Avoid Falls in the Elderly (SAFE) trial,[25] postural imbalance and high fall risk were associated in subjects with low FOF, but not with subjects with high FOF. Third, the history of falls was determined through interviews rather than from medical records, and a recall bias may be greater in subjects with poor health status, which would lead to a greater correlation between falls and mortality. Fourth, further evaluation involving variables related to depression is needed. Anxiety and depression are closely related,[26] and the association between FOF, a type of phobic reaction, and health outcomes may vary depending on depression. In the HUNT-2 Study,[17] anxiety had a protective effect on mortality in case-level depression, but when these subjects were excluded, there was a U-shaped association between anxiety score and mortality. Fifth, although many confounders have been considered in this study, there are still some potential confounders such as visual impairments, sarcopenia, and osteoporosis which were not adjusted. Objective physical fitness variables also need to be considered, however, our study only included self-reported physical activity. Sixth, subjects with strokes were excluded from the analyzes, but other diseases that could cause gait disturbance such as Parkinson's diseases, spinal cord diseases, and multiple sclerosis were not investigated.

In conclusion, both injurious falls and high FOF increased the risk of death in Korean. This suggests that both injurious falls and FOF are useful predictors of mortality in the general population.

## CONFLICT OF INTEREST STATEMENT

None declared.

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