# Association between Sleep Duration and Injury from Falling among Older Adults: A Cross-Sectional Analysis of Korean Community Health Survey Data

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**Purpose:** While sleeping problems increase with advancing age, there are inherent differences in sleep between males and females. Previous studies have shown inconsistent results of the relationship between sleep duration and risk of injury from falling. While controlling various sociodemographic and health-related factors, national representative data were used in order to analyze the association between sleep duration and injury from falling among older adults.

**Materials and Methods:** The data were obtained from the Korean Community Health Survey of 2011. A total of 55654 individuals aged 65 years and older participated in the study. Multivariable logistic regression analysis was conducted to identify the factors associated with injury from falling.

**Results:** After adjusting for covariates, such as age, sex, marital status, whether or not an individual is a recipient of benefits from the National Basic Livelihood Act, hypertension, diabetes mellitus, dyslipidemia, stress level, and self-rated health status, those who slept five hours or less per day [odds ratio (OR)=1.26; 95% confidence interval (CI)=1.18–1.34; $p<0.001$] or eight hours or more per day (OR=1.11; 95% CI=1.04–1.17; $p=0.001$) presented significantly higher ORs for injury from falling. A similar result was found when we conducted stratification by sex.

**Conclusion:** The current study supports that there is a relationship between short sleep duration and injury from falling and also identified a marginal risk of long sleep in older adults. Therefore, sleep management in older adults with inadequate sleep duration may be necessary.

**Key Words:** Accidental falls, aged, gender, Korea, sleep

## INTRODUCTION

Modern society is aging rapidly, and the UN World Population Prospects (2012) projects the worldwide older adult population (males and females aged 60 years and over) at 13.7% in 2013, 25.1% in 2050, and 34.6% in 2100.[1] Older adults experience physical changes, including decreased muscular strength and endurance, as well as a decline in ambulatory function and exercise capacity.[2] Together, these things can worsen preexisting conditions, complications, injuries, and social withdrawal, as well as generally decrease quality of life among older adults.[2-5] The most common cause for injuries among older adults is

falls. In the United States, it is estimated that 30% of the older adult population aged 65 years and older are injured due to falling each year.[3] A fall is defined as an unintentional change of body posture in unexpected situations, which causes individuals to trip or lay down on either the floor or somewhere of lower altitude than the current body position.[4] Falls can cause both mental and physical suffering, and it is reported that even individuals who experienced falls without any physical injury might have a fear of falling, which can limit their physical activities and eventually lead them to reside in long-term care facilities and institutions for older adults.[5]

Although falling occurs in all age groups, falling frequently occurs in adults aged 65 years and older, which accounts for one-third of the total cases of falls.[6] Moreover, older adults who have functional disabilities and physical injuries from falls tend to have longer recovery periods, and in severe cases, serious complications that can cause death.[7] Because of the abundant research on the topic, it is well understood that chronic diseases, such as arthritis, as well as socioeconomic factors, including low income status, can increase the risk of falls.[8] In order to prevent or reduce the occurrence of falls, it is necessary to identify the related risk factors, including sociodemographic and health-related contributors to examine their associations with falling.

Recent research highlights that sleep is a risk factor for falling. Studies have found that poorer sleep quality is associated with a higher risk of falling in certain populations.[9] Decreased sleep quality due to insomnia, pain, and noise can cause daytime hypersomnolence, difficulty concentrating, and slowed responses, all contributing to the increased risk of falling.[9] Among older adults, in whom the various physical changes caused by aging greatly impact quality of life, sleep disorders are common complaints.[10] Moreover, even though age does not directly affect sleep disorders,[11] it is reported that more than half of older adults have sleep problems.[12] It is expected that sleep disorders in older adults leads to decreased sleep duration and quality, which can cause problems in concentration and attention, as well as poor judgment, thereby increasing the risk of falling.[13]

Also, sex differences are an important factor to consider when analyzing sleep. Females and males have different sleep tendencies, according to recent studies, which show evidence of some biological differences between sleep in males and females.[14,15] Previous studies have shown that either short or long sleep duration of sleep may be associated with injury from falls, although results have been inconsistent.[16,17] There is also a study that reported that sleep duration was independently associated with falling only among females.[18] This finding may be due to small subject samples or perhaps only a specific population was analyzed in previous studies. There is only limited evidence on the association between sleep duration and falling in the literature. Thus, this study used data from a national representative Korean cohort to examine the association between sleep duration and injury from falling among older males and females, controlling various sociodemographic and health-related factors.

## MATERIALS AND METHODS

### Data and subjects

We used data from the Korean Community Health Survey (KCHS) 2011, which provides detailed information on morbidity, injuries, and the patterns of disease prevalence in Korean adults. The KCHS is a nationwide health interview survey carried out by the Korean Centers for Disease Control and Prevention and public health centers to estimate patterns of disease prevalence and morbidity, as well as to understand the personal lifestyles and health behavior of adults aged 19 years and older. The KCHS has been conducted since 2008 by trained interviewers in annual face-to-face interviews with participants. The survey is based on a protocol and questionnaires consisting of 358 questions in 13 fields across the nation, and is designed to produce community-based comparable health statistics. The KCHS has a two-stage sampling design. The first stage is the process of extracting a sampling area (Tong/Ban/Ri), which is a primary sampling unit, extracted via the number of households in each of the smallest administrative units (Dong/Eup/Myeon), using a probability proportionate to size sampling method. In the second stage, the sample households are extracted in sampling area by systematic sampling methods. All members of a household who were 19 years or older were interviewed. There were 229226 individuals included in the 2011 KCHS. We excluded 172602 individuals who were younger than 65 years of age and 970 who had incomplete records. Finally, a total of 55654 individuals were included in the analysis.

The procedures of this study were reviewed and approved by the Institutional Review Board of the Catholic University of Korea with waiver of the requirement for written informed consent (MC15EISI0013), because the data were obtained from a public database, which is freely accessible online at http://chs.cdc.go.kr, and were analyzed anonymously.

### Variables and measurements

The dependent variable, injury from falling, was assessed by the question, "Did you experience injury from falling this year?" and responses were categorized to either yes or no. In the survey, injuries from falling included not just falling but also included slipping, false stepping, and dropping.

Sleep duration was assessed by the question, "How many hours do you sleep in a day?" We categorized the responses of subjects as quartiles (five hours or less, six hours, seven hours, eight hours or more).[19] Covariates included sociodemographic and health-related factors that were indicated by prior literature and available in the KCHS. In addition, sociodemographic variables included age, sex, marital status, and whether or not the respondent was a recipient of benefits from the National

Basic Livelihood Act (NBLA) was also put into account. Age was treated as a continuous variable, and marital status was classified as married (living with a partner) or unmarried (separated, divorced, widowed, or never married). The NBLA program was launched in October 2000 to support households with less than a designated minimum cost of living per month (approximately 1300 USD for a household with four people as of 2011). The program is often considered a proxy measure of economic status in South Korea, and accordingly, we classified our sample population as recipients or non-recipients of benefits from the program.

Variables representing the health-related characteristics of subjects included the prevalence of chronic diseases, level of stress, and self-rated health status of participants. The analysis model included the prevalence of each of the three chronic diseases with the highest prevalence rate among adults: hypertension, diabetes mellitus, and dyslipidemia.[20,21] Subjects who had been diagnosed with the given disease by a physician and were undergoing treatment were categorized as prevalent. To measure the level of stress, participants were asked, "Do you feel stress in your daily life?" Responses of none, some stress, high stress, and very high stress were classified as low level (none or some stress) or high level (high or very high stress) stress. Self-rated health status was ascertained from the question, "In general, how do you feel about your health?" Self-reported assessments of health as very good, good, fair, poor, or

**Table 1.** Characteristics of the Study Population by History of Falling

| Variable | Falls: no* | | Falls: yes† | | Total‡ | | p value |
|---|---|---|---|---|---|---|---|
| | **Sample size** | **Proportion** | **Sample size** | **Proportion** | **Sample size** | **Proportion** | |
| Age | | | | | | | <0.001 |
| Mean±95% CI | 72.78±0.09 | 0.774 | 73.31±0.16 | 0.226 | 72.90±0.08 | 1.000 | |
| Sex | | | | | | | <0.001 |
| Male | 18925 | 0.448 | 3877 | 0.334 | 22802 | 0.423 | |
| Female | 24833 | 0.552 | 8019 | 0.666 | 32852 | 0.577 | |
| Marital status | | | | | | | <0.001 |
| Married | 27648 | 0.633 | 6587 | 0.556 | 34235 | 0.616 | |
| Unmarried | 16110 | 0.367 | 5309 | 0.444 | 21419 | 0.384 | |
| NBLA recipients | | | | | | | <0.001 |
| No | 41024 | 0.942 | 10828 | 0.911 | 51852 | 0.935 | |
| Yes | 2734 | 0.058 | 1068 | 0.089 | 3802 | 0.065 | |
| Sleep duration | | | | | | | <0.001 |
| 5 hr or less | 9405 | 0.231 | 3236 | 0.290 | 12641 | 0.244 | |
| 6 hr | 10776 | 0.260 | 2792 | 0.246 | 13568 | 0.257 | |
| 7 hr | 11420 | 0.254 | 2646 | 0.216 | 14066 | 0.246 | |
| 8 hr or more | 12157 | 0.254 | 3222 | 0.249 | 15379 | 0.253 | |
| Hypertension | | | | | | | <0.001 |
| No | 22346 | 0.495 | 5703 | 0.473 | 28049 | 0.490 | |
| Yes | 21412 | 0.505 | 6193 | 0.527 | 27605 | 0.510 | |
| Diabetes mellitus | | | | | | | <0.001 |
| No | 36202 | 0.812 | 9442 | 0.776 | 45644 | 0.804 | |
| Yes | 7556 | 0.188 | 2454 | 0.224 | 10010 | 0.196 | |
| Dyslipidemia | | | | | | | <0.001 |
| No | 38671 | 0.848 | 10239 | 0.825 | 48910 | 0.843 | |
| Yes | 5087 | 0.152 | 1657 | 0.175 | 6744 | 0.157 | |
| Stress level | | | | | | | <0.001 |
| Low | 35007 | 0.792 | 8281 | 0.684 | 43288 | 0.767 | |
| High | 8751 | 0.208 | 3615 | 0.316 | 12366 | 0.233 | |
| Self-rated health | | | | | | | <0.001 |
| Good | 9207 | 0.230 | 1553 | 0.149 | 10760 | 0.212 | |
| Fair | 14339 | 0.346 | 3066 | 0.277 | 17405 | 0.330 | |
| Poor | 20212 | 0.424 | 7277 | 0.574 | 27489 | 0.458 | |

CI, confidence interval; NBLA, National Basic Livelihood Act; KCHS, Korean Community Health Survey.
The KCHS as a sample survey was analyzed by research subject and with applied weight calculated in production of the sample design weight and benchmark weight. Strata with single sampling unit centered at overall mean. Values are presented as sample size and weighted proportion, unless otherwise indicated.
*Sample size=43758, weighted=4300338, †Sample size=11896, weighted=1256458, ‡Sample size=55654, weighted=5556795.

very poor in the survey were categorized as good (the category includes very good), fair, or poor (the category includes very poor).

### Statistical analysis

Descriptive analyses were performed to identify the characteristics of the study population according to history of falling and sex, respectively. The statistics were calculated based on a complex sampling design using survey weights and thus provide accurate estimates and ensure the national representativeness. The sample size and weighted proportion were reported. The chi-squared or Student's t-test were performed to identify the difference in distribution. Multivariable logistic regression analysis was conducted to identify factors associated with injury from falling. We reported the adjusted odds ratio (OR) with 95% confidence interval (CI) estimates from the

model. To control for potential gender-related differences in risk of injury from falling, a stratified analysis was also conducted. There is no evidence of significant multicollinearity among the variables when examining the variance inflation factors. Stata/MP 14.2 software (StataCorp, College Station, TX, USA) was used for all the statistical analyses, and the threshold for significance test was $p<0.05$ (two-sided).

## RESULTS

Sociodemographic and health-related characteristics of the study population stratified by history of falling are summarized in Table 1. There were 55654 older adults aged between 65 and 105 years (population mean 72.90, 95% CI=0.08). About one quarter of participants (11896, 22.6%) had a history of fall-

**Table 2.** Characteristics of the Study Population by Sex

| Variable | Male* | | Female† | | p value |
|---|---|---|---|---|---|
| | N | Proportion | N | Proportion | |
| Age | | | | | <0.001 |
| Mean±95% CI | 72.27±0.11 | 0.423 | 73.35±0.10 | 0.578 | |
| Marital status | | | | | <0.001 |
| Married | 19983 | 0.870 | 14252 | 0.430 | |
| Unmarried | 2819 | 0.130 | 18600 | 0.570 | |
| NBLA recipients | | | | | <0.001 |
| No | 21699 | 0.954 | 30153 | 0.921 | |
| Yes | 1103 | 0.046 | 2699 | 0.079 | |
| Sleep duration | | | | | <0.001 |
| 5 hr or less | 4102 | 0.191 | 8539 | 0.283 | |
| 6 hr | 5518 | 0.264 | 8050 | 0.252 | |
| 7 hr | 6047 | 0.262 | 8019 | 0.234 | |
| 8 hr or more | 7135 | 0.283 | 8244 | 0.231 | |
| Hypertension | | | | | <0.001 |
| No | 12620 | 0.526 | 15429 | 0.463 | |
| Yes | 10182 | 0.474 | 17423 | 0.537 | |
| Diabetes mellitus | | | | | 0.344 |
| No | 18743 | 0.804 | 26901 | 0.804 | |
| Yes | 4059 | 0.196 | 5951 | 0.196 | |
| Dyslipidemia | | | | | <0.001 |
| No | 20412 | 0.864 | 28498 | 0.827 | |
| Yes | 2390 | 0.136 | 4354 | 0.173 | |
| Stress level | | | | | <0.001 |
| Low | 18809 | 0.813 | 24479 | 0.733 | |
| High | 3993 | 0.187 | 8373 | 0.267 | |
| Self-rated health | | | | | <0.001 |
| Good | 6033 | 0.284 | 4727 | 0.159 | |
| Fair | 7767 | 0.353 | 9638 | 0.313 | |
| Poor | 9002 | 0.363 | 18487 | 0.527 | |

CI, confidence interval; NBLA, National Basic Livelihood Ac; KCHS, Korean Community Health Survey.
The KCHS as a sample survey was analyzed by research subject and with applied weight calculated in production of the sample design weight and benchmark weight. Strata with single sampling unit centered at overall mean. Values are presented as sample size and weighted proportion, unless otherwise indicated.
*Sample size=22802, weighted=2347797, †Sample size=32852, weighted=3208999.

ing. A significantly higher proportion was identified as those who had a history of falling (0.290), compared to those who did not had a history of falling (0.231) ($p<0.001$) (Table 1).

When stratified by sex, the proportion of history of falling was significantly higher for females (26.1%) than males (17.9%). Regarding sleep duration, the proportion of those with a short sleep duration (five hours or less/day) was higher among female (28.3%) than among male (19.1%) respondents ($p<0.001$) (Table 2).

Table 3 summarizes the results from a multivariable logistic regression model to identify the relationship between sleep duration and injury from falling after controlling for sociodemographics and health-related covariates. After adjusting for covariates (age, sex, marital status, NBLA recipients, hypertension, diabetes mellitus, dyslipidemia, stress level, and self-rated health status), those who slept five hours or less per day (OR=1.26; 95% CI=1.18–1.34) or eight hours or more per day (OR=1.10; 95% CI=1.04–1.17) had higher odds of experiencing an injury from falling ($p<0.001$) (Table 3).

After stratifying by sex, similar associations were found in males and females. The odds of being injured due to falling among both males and females increased significantly among those getting five hours or less sleep per day (male OR=1.27; 95% CI=1.15–1.42; female OR=1.25; 95% CI=1.16–1.35). Eight hours or more sleep per day significantly increased the odds of being injured due to falling among females (OR=1.13; 95% CI=1.05–1.22), but not among males (Table 4).

## DISCUSSION

Injury from falling causes functional impairment and large medical expenses. Prior studies reported that risk of injury from falling, a detrimental event for older adults, is increased in cases of only a short or long sleep duration, which does not show consistent results.[16,17] Moreover, prior studies were significant only among females, which could suggest the existence of a sex difference.[18] Thus, we aimed to identify the relationship between sleep duration and injury from falling among Korean older adults by sex-stratified analysis using national representative data. The risk of injury from falling was significantly associated with short sleep duration and marginally associated with long sleep duration.

Short sleep duration (sleeping five hours or less) may be associated with the risk of falling by reducing awareness and concentration, as pointed out in prior studies.[22,23] Difficulty initiating or maintaining sleep results in short sleep at night, which then results in an increased risk of falling.[22] Sleep problems or sleep disorders are associated with increased risk of falls in older adults.[23] In Korea, there is a growing number of sleep-deprived people. According to a survey from the Organization for Economic Co-operation and Development (OECD), the average sleeping duration for people living in OECD member nations is 502 minutes. The average sleeping time for people in Korea is 469 minutes, ranking Korea the lowest among the 18 countries.[24] In the current sample, we observed that a quarter of Korean older adults sleep five hours or less per day, suggesting that lack of sleep is a serious problem.

The findings from this study indicate that longer sleep duration (sleeping eight hours or more) is related to the risk of falling among older adults (female, $p=0.001$). This could be related to one explanation that longer duration of sleep may be indicative of an underlying sleep disorder, such as sleep-disordered breathing, which leads to excessive daytime sleepiness and may influence risk of falling.[25] Sleeping disorders may contribute to longer sleeping duration to obtain more quality sleep time.[26] A prior study found that reduced sleep efficiency and increased sleep fragmentation (characterized by cycles of waking up during the night) may cause reduced periods of deep sleep and an increased frequency of waking up that contrib-

**Table 3.** Multivariable Logistic Regression Analysis of Injury from Falling among Older Adults

| Variable | OR | 95% CI | p value |
|---|---|---|---|
| Sleep duration | | | |
| 5 hr or less | 1.26 | 1.18–1.34 | <0.001 |
| 6 hr | 1.08 | 1.01–1.14 | 0.018 |
| 7 hr | Ref | | |
| 8 hr or more | 1.11 | 1.04–1.17 | 0.001 |

OR, odds ratio; CI, confidence interval; Ref, reference; NBLA, National Basic Livelihood Act.
Variables adjusted are age, marital status, NBLA recipients, hypertension, diabetes mellitus, dyslipidemia, stress level, and self-rated health through a logistic regression model.

**Table 4.** Multivariable Logistic Regression Analysis of Injury from Falling among Older Adults by Sex

| Variable | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | p value | OR | 95% CI | p value |
| Sleep duration | | | | | | |
| 5 hr or less | 1.27 | 1.15–1.42 | <0.001 | 1.25 | 1.16–1.35 | <0.001 |
| 6 hr | 1.08 | 0.98–1.20 | 0.127 | 1.07 | 1.00–1.16 | 0.068 |
| 7 hr | Ref | | | Ref | | |
| 8 hr or more | 1.07 | 0.97–1.17 | 0.182 | 1.13 | 1.05–1.22 | 0.001 |

OR, odds ratio; CI, confidence interval; Ref, reference; NBLA, National Basic Livelihood Act.
Variables adjusted are age, marital status, NBLA recipients, hypertension, diabetes mellitus, dyslipidemia, stress level, and self-rated health through a logistic regression model.

utes to an increased risk of falling.[27] Another explanation may be that lengthy total sleep duration may be a marker of frailty and ill health. In fact, long sleep durations, which we find to have the highest risk for falling, have been found to be a risk factor for overall health in prior studies, such as cardiovascular, stroke, and coronary heart disease.[28,29] Therefore, sleep management may be needed for older adults to attain the appropriate sleep duration and minimize the risk of falling.

While the current study supports the relationship between sleep duration and falling, it deals exclusively with self-reported sleep duration. Hence, the study is limited by its inability to assess the role of other factors, including actual fall risk, sleep disorders, use of sleep medication, quality of sleep, frequency, or severity of falls experienced by the subjects that were uncollected data on KCHS. In addition, because the KCHS is a cross-sectional survey, our findings may also be caused by reverse-association. There is great diversity in sleep patterns, with some people getting high quality sleep for fewer hours and others suffering from sleep disturbances over the course of more regular hours. In the future, more detailed studies that take into account both sleep duration and quality are necessary to explore the contribution of both factors to the frequency and severity of falling among sample populations. Despite these limitations, with our deeper analysis of a known risk factor for falling, this study shows that inappropriate sleep durations among both older adult males and females are related to increased risks of falling. In other sleep duration-related studies, sex disparity was not considered as a risk factor.[30]

In conclusion, the current study supports that there is a relationship between risk of injury from falling and short sleep among older adults. However, long sleep duration also showed marginal risk. Therefore, further studies are necessary to confirm this outcome. To prevent or reduce the damage caused by falling, sleep management in older adults with inadequate sleeping patterns may be necessary. Rather than trivializing or dismissing sleep disorders as an inevitable part of the aging process, dysfunctional sleep needs to be treated as a health risk factor in older adults.

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