RESEARCH PAPER

Self-reported insomnia symptom, sleep duration and the risk of recurrent falls among older men and women

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Key Summary Points

Aim To examine the risk of recurrent falls among older adults with insomnia symptoms and abnormal sleep duration.
Findings The risk of falls was significantly higher among older women who reported insomnia symptoms along with short sleep duration.
Message Insomnia symptoms along with a measure of sleep duration may be a more accurate indicator of risk for falls among older women than insomnia symptoms or sleep duration alone.

Abstract

Background/objectives Previous studies have reported conflicting results on the association between sleep disturbance and recurrent falls. The objective of the current study was to examine the risk of recurrent falls among community-dwelling older adults who reported one or more insomnia symptoms along with normal, short and long sleep durations in comparison with those who reported no insomnia symptom and normal sleep duration.
Design Secondary data analysis of a prospective cohort study.
Setting Community.
Participants 2198 community-dwelling older adults who participated in the National Health and Aging Trends Study at round 3 and round 4 follow-up visits.
Measurements Data on self-reported sleep characteristics, demographic characteristics, health and memory status, and depression symptom collected at round 3 and round 4 follow-up visits, and corresponding data on falls that was collected at round 4 and round 5 follow-up visits.
Results Risk of recurrent falls significantly increased among women who reported insomnia symptom with short sleep duration. No significant association was observed among men.
Conclusion One or more insomnia symptoms with a measure of sleep duration may be a more accurate indicator of adverse outcomes associated with sleep disturbance than either insomnia symptom or sleep duration alone. The mechanism underlying gender-specific association reported in the current study merits further investigation.

Keywords Insomnia symptom · Sleep duration · Recurrent falls

Introduction

Falls and associated injuries are a major cause of morbidity, hospital admissions, disability, nursing home placement and death among older adults [1–4]. Etiology of falls is multifactorial and interrelated, and includes decreased muscle strength, gait and balance abnormalities, comorbidities, polypharmacy and use of central nervous system-active medications, impaired sense of vision and hearing as well as environmental factors which increase the risk of tripping [1–4]. Previous studies have examined the association

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between sleep disturbance and the risk of falls [5–8]; however, results of these studies have not been consistent, with some studies reporting significant association between sleep disturbance and one or more falls [5, 6] and others finding no significant association between sleep disturbance and two or more falls [7]. Similar conflicting results were reported with regard to the association between sleep duration and falls. Among studies that included only older adults ≥ 65 years old, increased risk of one or more falls was associated with short sleep duration in some [8, 9] and long sleep duration [6, 10] in others. Studies that examined the association between sleep duration and recurrent falls also reported inconsistent results. For example, two studies in which 8000 older women [mean (sd) age 77(5) years] [11] and 3101 older men [mean (sd) age: 76.4 (5.5) years] [7] living in the United States participated failed to show independent association between self-reported short or long sleep duration and recurrent falls in the subsequent year. In contrast, results of a study from Spain in which 1542 older men and women [mean (sd) age: 77.4 (6.3) years] participated showed independent association between long sleep duration and recurrent falls in the previous year [10]. Another study from Korea in which 206,382 adults ranging in age from 19 to 109 years participated, subgroup analysis of data indicated that both short sleep duration and long sleep duration were associated with increased risk of recurrent falls among adults ≥ 61 years old [12]. A recently reported meta-analysis reported significant association between both short sleep and long sleep durations, and recurrent falls [13]; however, as the authors indicated, results of this meta-analysis may be influenced by one study with a large sample size ($n = 206,382$) [12].

One explanation for these conflicting results could be that sleep measures such as sleep disturbance and sleep duration may be broad and do not portray a single entity. With regard to this issue, several studies have reported a significant association between insomnia symptom with short sleep duration and higher morbidity burden [14–16] as well as higher mortality rate [17], suggesting that co-existence of insomnia with short sleep duration may present a 'distinct phenotype'. For this reason, categorizing individuals with sleep disturbance into those with normal sleep duration, short sleep duration or long sleep duration may provide a more precise estimate when determining association between sleep disturbance and outcome of interest. To the knowledge of the author, previous studies that examined the association between sleep disturbance and falls or sleep duration and falls among older adults did not take this issue into account. The current study addresses this issue and examines the risk of recurrent falls among community-dwelling older adults who reported insomnia symptom and normal, short or long sleep duration, in comparison with those who reported no insomnia symptom and normal sleep duration.

Methods

Study participants

Data for this secondary data analysis are derived from the National Health Aging Trends Study (NHATS), an epidemiological study in which a nationally representative sample of Medicare beneficiaries ≥ 65 years old living in contiguous United States (US) participated. The NHATS study design and recruitment strategies have been described previously [18], but in brief, a three-stage sampling design was used to recruit 12,411 randomly selected older adults living in contiguous United states, out of which 8245 participants completed a face-to-face interview at baseline in 2011 (round 1). Participants were followed up annually and questions about sleep duration were added at round 3 and round 4 follow-up visits. Participants who reported their sleep duration were included in the current study. This secondary data analysis project was approved by Institutional Review Committee, Morehouse School of Medicine.

Insomnia symptom

The presence or absence of insomnia symptom at round 3 and round 4 was determined based on responses to the following three questions: (1) "In the last month, how often did it take you more than 30 min to fall asleep at night?", (2) "In the last month, on nights when you woke up before you wanted to get up, how often did you have trouble falling back asleep?" Responses to these questions include every night, most nights, some nights, rarely and never. Participants who reported more than 30 min to fall asleep most nights or always were defined to have difficulty falling asleep, and those who reported trouble falling back to sleep most nights or always were defined to have difficulty maintaining sleep. (3) "How would you rate the overall quality of your sleep in the last month? Would you say it was very good, good, fair, poor, or very poor?" Participants with difficulty falling asleep and/or trouble falling back to sleep and/or those who reported their sleep quality as poor or very poor were described as having insomnia symptom.

Sleep duration

Questions about sleep duration were randomly assigned to one-third of study participants at round 3, and one-third of study participants at round 4 that were not included at round 3. The following question was used to determine sleep duration: "In the last month, how many hours of actual sleep did you usually get at night?" and participants are asked to enter the number of hours of sleep. In the current study, normal sleep duration was defined as 6–8 h of sleep per night,

while ≤ 5 h of sleep and ≥ 9 h of sleep per night were defined as short sleep duration and long sleep duration, respectively.

Based on insomnia symptom described above and self-reported sleep duration, participants were categorized into five categories as follows: (1) "no insomnia symptom and normal sleep duration (NISNSD)"; (2) "no insomnia symptom and short sleep duration (NISSSD)"; (3) "insomnia symptom and normal sleep duration (ISNSD)"; (4) "insomnia symptom and short sleep duration (ISSSD)"; (5) "long sleep duration (LSD)".

Recurrent falls (primary outcome)

Information on falls was obtained at each annual visit and falls are defined as "any fall, slip or trip in which you lose your balance and land on the floor or ground at a lower level" [19]. Participants were asked the following question: "During the last 12 months, have you fallen down more than one time?" and participants who responded "Yes" to the question were determined to have recurrent falls.

For participants who reported sleep duration at study round 3, fall data collected at subsequent follow-up visit (round 4) were used as outcome, and similarly, for participants who reported sleep duration at round 4, fall data collected at round 5 annual visit were used as outcome.

Covariates

Data collected on covariates at round 3 or round 4, corresponding to the time at which data on sleep duration were obtained, were used in the analysis. These variables included demographic and socio-economic factors, use of sleep-promoting medications, daytime sleep status, self-reported health and memory status, and depression symptom. Demographic, social and economic factors included age in years, sex, race and ethnicity ("Caucasian, non-Hispanic"; "African American, non-Hispanic"; "Hispanic", "Other which included American Indian, Asian, Native Hawaii, mixed race"), marital status (currently married or living with a partner, and not married), and years of formal education (less than 12 years, 12 years, 13–15 years or 16 or more years).

Use of sleep-promoting medications at year 3 or year 4 was determined based on response to the following question: "In the last month, how often did you take medication to help you sleep? Would you say every night, most nights, some nights, rarely or never?" Daytime sleep status was determined based on responses to the following questions: (1) In the last month, how often did you have trouble staying awake at times during the day when you wanted to be awake? Would you say every day, most days, some days,

rarely, or never ? (2) In the last month, how often did you take naps during the day? Would you say every day, most days, some days, rarely, or never?

Health status was determined based on the response to the question "Would you say that in general your health is excellent, very good, good, fair, or poor? Based on participant's response, three categories were created which are (1) "excellent or very good", (2) "good" and (3) "fair or poor". Self-reported memory status was determined based on response to the question: "How would you rate your memory at the present time? Would you say it is excellent, very good, good, fair, or poor?". Participants were also asked if they were ever told to have dementia or Alzheimer's disease by their health care provider. Screening for depression symptom was performed using Patient Health Questionnaire-2 (PHQ-2), and participant who scored 3 or more was considered to manifest depression symptom. History of fear of falling was collected at years 3 and 4 using the following two questions: "In the last month, did you worry about falling down?" and "Did this worry ever limit your activities?". Based on these responses, three categories were created: (1) No worry about falling down; (2) Worry but no limitation of activities; (3) worry and limitation of activities. History of one or more falls in the previous data collection period (at round 3 for participants who reported multiple falls in round 4 and at round 4 for participants who reported multiple falls in round 5) was also included in the analysis.

Statistical analysis

Chi-square statistics was used to describe the characteristics of study participants by recurrent falls. Logistic regression (LR) analysis was conducted to determine the association between insomnia–sleep duration and recurrent falls, with recurrent falls as the dependent variable. Covariates that showed significant association with recurrent falls on bivariable analysis or those that were considered to have biological relevance based on results of previous studies were included in the LR model. Interactions terms were included in the final model and these included insomnia–sleep duration and sex, insomnia–sleep duration and race. Significant interactions were observed between insomnia–short sleep duration and sex ($p = 0.013$); hence, LR analysis was redone after stratification by gender and this result is reported. There were no significant interactions between insomnia–sleep duration and race. LR analysis was repeated after excluding participants who reported poor memory status and those who were told to have dementia by their provider. Statistical significance was determined at two-sided p value ≤ 0.05. Stata statistical software (version 14, College Station, TX) was used in the current analysis.

Table 1 Descriptive statistics showing demographic and selected clinical characteristics of study participants with normal, short and long sleep durations

	Normal sleep duration [n = 1903 (74%)]	Short sleep duration [n = 351 (14%)]	Long sleep duration [n = 306 (12%)]	Total participants (n = 2560)
Age in years (%)**				
65–74 years	701 (37)	141 (40)	67 (22)	909
75–84 years	834 (44)	146 (42)	119 (39)	1099
≥ 85 years	368 (19)	64 (18)	120 (39)	552
Sex*				
Male	800 (42)	122 (35)	131 (43)	1053
Female	1103 (58)	229 (65)	175 (57)	1507
Race/ethnicity***				
Caucasian	1402 (74)	202 (58)	223 (73)	1827
African American	352 (18)	98 (28)	51 (27)	501
Hispanic	88 (5)	26 (7)	26 (8)	140
Other	61 (3)	25 (7)	6 (2)	92
Marital status**				
Married	950 (50)	142 (41)	140 (46)	1232
Not married	953 (50)	207 (59)	166 (54)	1326
Education in years***				
≥ 16	547 (29)	46 (13)	76 (25)	669
12–115	485 (26)	98 (24)	64 (21)	634
12 complete	476 (25)	104 (30)	65 (22)	645
< 12	385 (20)	113 (33)	98 (32)	596
Health status***				
Excellent/very good	884 (46)	92 (26)	90 (29)	1066
Good	623 (33)	129 (34)	105 (34)	848
Fair	396 (21)	137 (39)	111 (36)	644
Poor				
Memory status**				
Excellent/very good	752 (41)	105 (32)	91 (35)	948
Good	737 (40)	117 (36)	94 (37	948
Fair	292 (16)	93 (28)	61 (24)	446
Poor	51 (3)	15 (6)	10 (4)	76
Depression score (PSQ-2)***				
< 3	1678 (89)	265 (77)	238 (79)	2181
≥ 3	209 (11)	77 (23)	65 (21)	351

*< 0.05; ** < 0.01 *** < 0.001

Results

Data on sleep duration were collected from 2820 participants at study round 3 and round 4, and out of these 63 reported that their sleep hours were different (variable) in different days and did not have any usual hours of sleep, and were excluded from the study. Of the remaining 2757 participants, 197 were living in long-term care facilities at the time of data collection, leaving 2560 community-dwelling older adults who reported their sleep duration who were included in the current analysis. There were 1053 (41%) men and 1507 (59%) women, and the mean (SD) age was 76.3 (7.2) years for the group. Of these 2560 participants, 1903 (74%), 351 (14%) and 306 (12%) reported normal, short and long sleep durations, respectively.

Table 1 shows selected characteristics of these participants with normal sleep, short sleep and long sleep durations.

Data on insomnia symptom and sleep duration were available for 2550 community-dwelling study participants and of these, 1459 (57%) reported "no insomnia symptom and normal sleep duration (NINSD)", 115 (5%) reported "no insomnia symptom and short sleep duration (NISSD)", 436 participants (17%) reported "insomnia symptom and normal sleep duration (ISNSD)", 234 (9%) reported "insomnia symptom and short sleep duration (ISSSD)", 259 (10%) reported "no insomnia symptom and long sleep duration (NILSD)" and 47 (2%) reported "insomnia symptom and long sleep duration (ISLSD)". Because insomnia symptom was reported by only 47 of the 306 (15%) participants with long sleep duration, participants with

long sleep duration with and without insomnia symptom were combined together into one group [long sleep duration (LSD)].

Data on recurrent falls at study rounds 4 and 5 were available for 2204 participants and recurrent falls were reported by 16% and 15% of men and women, respectively. Data for insomnia symptom–sleep duration at study rounds 3 and 4, and corresponding data on recurrent falls at subsequent follow-up visits (round 4 and round 5), respectively were available on 2198 community-dwelling participants and these participants were included in the final analysis. There were 909 males [mean (sd) age = 75.3 (6.8) years] and 1289 females [mean (sd) age = 76.2 (7.2) years]. Data were missing for 352 participants and participants with missing data were more likely to be older ($p < 0.001$), more likely to report fewer years of education ($p < 0.001$), poor health status r ($p < 0.001$), insomnia symptom (0.038), less likely to report normal sleep duration (0.023).

Demographic and selected clinical characteristics of study participants by recurrent falls among male and female study participants are shown in Table 2. Participants in the older age group were more likely to report recurrent falls among men, while those with not married status and lower education were more likely to report recurrent falls among women. In both men and women, participants who reported poor health status, poor memory, higher depression score (≥ 3), history of falls in the previous year and those who worry about falling were more likely to report recurrent falls.

Bi-variable relationships between recurrent falls and self-reported sleep related symptoms are depicted in Table 3. It is notable that statistically significant relationships between these sleep-related symptoms (i.e., insomnia symptom, sleep duration, sleep medication use, difficulty staying awake during the day) and recurrent falls were observed among women only.

Table 3 shows results of LR analysis before and after adjustment for possible confounding variables, respectively. As shown in the fully adjusted model, insomnia symptom with short sleep duration significantly predicted recurrent falls during the subsequent follow-up visit among women [OR(CI): 1.99 (1.16–3.41)], while no significant association was observed among men. LR analysis was repeated after excluding participants who reported poor memory status ($n = 64$) and those who were told to by their doctor to have dementia ($n = 108$), and insomnia symptom with short sleep duration significantly predicted recurrent falls [OR (CI): 1.83 (1.03–3.27), $p = 0.041$] among women only (Tables 4, 5).

Discussion

Results of the current study demonstrate two important findings. First, self-reported insomnia symptom with short sleep duration independently predicted higher risk of recurrent falls. As described above, previous studies have described a significant association between insomnia with objective short sleep duration, and adverse metabolic and cardiovascular outcomes, suggesting that insomnia with short sleep duration may represent a distinct phenotype. [14–17] The current study reports a similar pattern of association in that it is only insomnia symptom with short sleep duration that independently predicted recurrent falls. As mentioned above, previous studies have failed to show consistent significant association between insomnia and falls as well as short sleep duration and falls among older adults; and it is possible that examining the association between insomnia and falls without taking sleep duration into consideration or vice versa may have diluted the association between these sleep-related symptoms and falls.

Second, a significant association between short sleep duration with insomnia symptom and recurrent falls was observed among women only, indicating a gender-specific association. Although previous studies have reported a similar gender-specific association between self-reported sleep duration and one or more falls [9], the current study extends knowledge in the field by describing significant association between insomnia symptoms with short sleep duration and recurrent falls among older women. Several explanations have been forwarded to explain the association between sleep disturbance and adverse outcomes in general, and these include disturbance of cardio-metabolic function and poor physical functional status. [20–23]. However, it is not clear if these adverse outcomes are gender specific. It is possible that adverse effects of sleep disturbance may be different among men and women, as previous studies have reported a stronger association between sleep disturbance and inflammatory response [23], as well as cardiovascular morbidity and mortality [24] among women than among men. It is also possible that the gender difference observed in the current study may be reflective of differences in reporting of sleep disturbance among men and women as previously reported. [25].

The current study has several limitations. Diagnostic criteria for insomnia disorder based on the Diagnostic and Statistical Manual-5 (DSM-5) were not met as only difficulty initiating or maintaining sleep and sleep quality were used in the current study to categorize participants into those with and without insomnia symptom. However, these aforementioned insomnia symptoms are considered essential features of insomnia disorder and have also been shown to negatively impact the functional status of older adults [26]. This indicates the significance of these symptoms in this group of the population. Another limitation is that sleep duration was determined by self-report and self-reported sleep duration may not have a strong correlation with objectively derived sleep duration [27, 28]. However, self-reported sleep duration has been reported to be associated with adverse

Table 2 Descriptive statistics showing demographic and clinical characteristics of study participants who reported (yes) and did not report (no) recurrent falls stratified by sex

Recurrent falls	Male ($n=909$)			Female ($n=1289$)			Total ($n=2198$)		
	No ($n=768$) n (%)	Yes ($n=141$) n (%)	Total P value n	No ($n=1098$) n (%)	Yes ($n=191$) n (%)	Total P value n	No ($n=1866$) n (%)	Yes (332) n (%)	Total P value n
Age in years*									
65–74	314 (41)	46 (33)	360	388 (35)	69 (35)	457	702 (37)	115 (35)	817
75–84	335 (44)	61 (43)	396	480 (44)	73 (39)	553	815 (44)	134 (40)	949
≥ 85	119 (15)	34 (24)	153	230 (21)	49 (26)	279	349 (19)	83 (25)	432
			0.026			0.242			0.029
Race/ethnicity									
Caucasian	569 (74)	106 (75)	675	775 (71)	137 (72)	912	1344 (72)	243 (73)	1587
African American	138 (18)	22 (15)	160	228 (21)	34 (18)	262	366 (20)	56 (17)	422
Hispanic	34 (4)	9 (6)	43	63 (6)	12 (6)	75	97 (5)	21 (6)	118
Other	27 (4)	4 (3)	31	32 (3)	8 (4)	41	59 (3)	12 (4)	71
			0.677			0.644			0.571
Education years*									
≥ 16	274 (36)	45 (32)	319	243 (22)	39 (21)	282	517 (28)	84 (25)	601
13–15	165 (21)	30 (21)	195	308 (28)	54 (28)	362	473 (25)	84 (26)	557
12	146 (19)	35 (25)	181	317 (29)	42 (22)	359	463 (25)	77 (23)	540
< 12	181 (24)	30 (21)	212	223 (20)	54 (29)	277	404 (22)	84 (26)	488
			0.427			0.050			0.459
Married**	530 (69)	89 (63)	619	408 (37)	49 (26)	457	940 (50)	138 (41)	1076
Not married	238 (31)	52 (37)	290	689 (63)	142 (74)	831	932 (50)	198 (59)	1121
			0.168			0.002			0.003
Health status***									
Excellent/VG	368 (48)	46 (33)	414	478 (43)	51 (27)	529	846 (45)	97 (29)	943
Good	260 (34)	39 (27)	299	382 (35)	56 (29)	438	642 (35)	95 (29)	737
Fair/poor	140 (18)	56 (40)	196	237 (22)	84 (44)	321	377 (20)	140 (42)	517
			<0.001			<0.001			<0.001
Memory status**									
Excellent/VG	299 (42)	42 (32)	341	425 (40)	56 (32)	481	724 (40)	98 (32)	822
Good	301 (41)	51 (40)	352	415 (39)	61 (35)	476	716 (40)	112 (36)	828
Fair	117 (16)	32 (24)	149	198 (19)	47 (27)	245	315 (17)	79 (26)	394
Poor	22 (3)	7 (5)	29	24 (2)	11 (6)	35	46 (3)	18 (6)	64
			0.033			0.001			<0.001
Depression score***									
< 3	693 (91)	114 (81)	807	964 (88)	138 (73)	1102	1657 (89)	252 (77)	1909
≥ 3	69 (9)	27 (19)	96	128 (12)	50 (27)	178	197 (11)	77 (23)	274
			<0.001			<0.001			0.001
Fall history***									
No	576 (75)	48 (34)	624	804 (73)	62 (32)	866	1380 (74)	110 (33)	1490
Yes	192 (25)	93 (66)	285	294 (27)	129 (68)	423	486 (26)	222 (67)	708
			<0.001			<0.001			<0.001
Worry about									
Falling***	614 (80)	79 (56)	693	764 (70)	86 (45)	850	1378 (74)	165 (50)	1543
No	103 (13)	37 (26)	140	226 (20)	53 (28)	279	329 (18)	90 (27)	419
Yes/no limitation	51 (7)	25 (18)	76	107 (10)	52 (27)	159	158 (8)	77 (23)	235
Yes/limitation			<0.001			<0.001			<0.001

VG very good, *Yes/No limitation* Yes but no limitation of activity. *Yes/Limitation* Yes and limitation of activity

* = <0.05; ** = < 0.01; *** = < 0.001

Table 3 Descriptive statistics showing sleep-related characteristics of study participants who reported and did not report recurrent falls stratified by sex

	Recurrent falls (Male (n=909))			Recurrent falls (Female (n=1289)			Recurrent falls Total (2198)		
	No (n=768) n(%)	Yes (n=141) n(%)	Total P value n	No (n=1098) n(%)	Yes (n=191) n(%)	Total P value	No (n=1866) n(%)	Yes (332) n(%)	Total P value
Sleep duration**									
6–8 h	602 (78)	102 (72)	704	830 (76)	120 (63)	950	1432 (77)	222 (67)	1654
≤5 h	81 (11)	16 (11)	97	151 (14)	44 (23)	195	232 (12)	60 (18)	292
≥9 h	85 (11)	23 (16)	108	117 (10)	27 (14)	144	202 (11)	50 (15)	252
			0.183			0.001			0.001
Difficulty falling*** asleep									
No	646 (84)	114 (81)	760	878 (80)	126 (66)	1004	1524 (82)	239 (72)	1763
Yes	121 (16)	26 (19	147	220 (20)	65 (34)	285	341 (18)	91 (28)	432
			0.409			<0.001			<0.001
Difficulty maintaining sleep**									
No	671 (87)	126 (89)	797	950 (87)	146 (77)	1096	1621 (87)	272 (82)	1893
Yes	96 (13)	15 (11)	111	148 (13)	45 (23)	193	244 (13)	60 (18)	304
			0.532			<0.001			0.015
Sleep quality***									
Very good	203 (26)	26 (18)	229	273 (25)	37 (20)	310	476 (26)	63 (19)	539
Good	349 (45)	68 (48)	417	514 (47)	69 (36)	583	863 (46)	137 (41)	1000
Fair	170 (22)	31 (22)	201	247 (22)	56 (29)	303	417 (22)	87 (26)	504
Poor/very poor	46 (6)	16 (11)	62	64 (6)	29 (15)	93	110 (6)	45 (14)	155
			0.041			<0.001			<0.001
Insomnia/duration***									
NIND	479 (62)	77 (55)	556	644 (59)	82 (43)	726	1123 (60)	159 (48)	1282
NSD	31 (4)	6 (4)	37	59 (5)	7 (4)	66	90 (5)	13 (4)	103
IND	123 (16)	25 (17)	148	186 (17)	38 (19)	224	309 (17)	63 (19)	372
ISD	50 (7)	10 (7)	60	92 (8)	37 (19)	129	142 (8)	47 (14)	189
LD	85 (11)	23 (16)	108	117 (11)	27 (14)	144	202 (11)	50 (15)	252
			0.377			<0.001			<0.001
Sleep medication use**									
Rarely/never	629 (82)	116 (82)	745	866 (79)	124 (65)	990	1495 (80)	240 (72)	1735
Sometimes	38 (5)	5 (4)	43	77 (7)	16 (8)	93	115 (6)	21 (6)	136
Often/always	99 (13)	20 (14)	119	153 (14)	51 (27)	204	252 (14)	71 (21)	322
			0.723			<0.001			0.001
Daytime naps									
Rarely/never	534 (69)	91 (64)	625	857 (78)	139 (71)	996	1391 (74)	230 (68)	1621
Some days	147 (19)	32 (23)	179	142 (13)	32 (16)	174	289 (15)	64 (19)	353
Often/always	89 (12)	18 (13)	107	103 (9)	24 (12)	127	192 (10)	42 (13)	234
			0.512			0.140			0.082
Difficulty staying awake**									
Rarely/never	493 (64)	79 (56)	572	706 (64)	103 (54)	809	11,199 (64)	182 (55)	1381
Some days	182 (24)	45 (32)	227	284 (26)	57 (30)	341	466 (25)	102 (31)	568
Often/always	92 (12)	17 (12)	109	107 (10)	31 (16)	138	199 (11)	48 (14)	247
			0.107			0.006			0.004

*p < 0.05; ** p < 0.01; ***p < 0.001

Table 4 Unadjusted logistic regression model showing associations between insomnia symptom–sleep duration status and recurrent falls stratified by sex

	Male (N = 909) OR(CI), p value	Female (N = 1289) OR(CI), p value	Total (2198) OR(CI), p value
No IS* and normal SD**	Reference	Reference	Reference
IS* and normal SD**	1.20 (0.49–2.98), 0.688	0.93 (0.41–2.11), 0.805	1.02 (0.56–1.87), 0.948
No IS* and short SD**	1.26 (0.77–2.07), 0.351	1.60 (1.06–2.44), 0.027	1.44 (1.05–1.98), 0.025
IS* and short SD**	1.24 (0.61–2.56), 0.552	3.16 (2,02–4.93), < 0.001	2.34 (1.62–3.38), < 0.001
Long SD**	1.68 (1.00–2.83), 0.050	1.81 (1.12–2.92), 0.015	1.75 (1.23–2.48), 0.002

Dependent variable: recurrent falls

Table 5 Adjusted logistic regression model showing associations between insomnia symptom–sleep duration status and recurrent falls stratified by sex

	Male (N = 863) OR(CI), p value	Female (N = 1222) OR(CI), p value	Total (2085) OR(CI), p value
No IS* and normal SD**	Reference	Reference	Reference
IS* and normal SD**	0.98(0.33 –2.94), 0.974	1.00 (0.42–2.41), 0.996	0.92 (0.47–1.81), 0.826
No IS* and short SD**	0.96 (0.55–1.70), 0.902	1.21 (0.74–1.96), 0.446	1.07 (0.75–1.54), 0.707
IS* and SHORT SD**	0.62(0.26–1.50), 0.290	1.99 (1.16–3.41), 0.013	1.31 (0.84–2.05), 0.237
Long SD**	0.87 (0.45–1.67), 0.670	1.23 (0.70–2.17), 0.461	1.04 (0.68–1.58), 0.852
Age in years			
65–74	Reference	Reference	Reference
75–84	0.88(0.55–1.41), 0.591	0.61(0.40–0.92), 0.020	0.73 (0.54–0.99), 0.044
≥ 85	1.20 (0.66–2.17), 0.554	0.71 (0.43–1.17), 0.174	0.88 (0.61–1.29), 0.524
Sex			
Male	–	–	Reference
Female			0.70 (0.52–0.94), 0.017
Race/ethnicity			
Caucasian	Reference	Reference	Reference
African American	0.83 (0.44–1.57), 0.572	0.63 (0.37–1.06), 0.082	0.75(0.50–1.10), 0.144
Hispanic	1.11 (0.42–2.92), 0.833	0.40 (0.17–0.96), 0.040	0.63 (0.33–1.18), 0.150
Other	0.24 (0.05–1.31), 0.100	1.10 (0.33–3.66), 0.869	0.61 (0.23–1.59)
Marital status			
Married	Reference	Reference	Reference
Not married	1.48 (0.94–2.34), 0.094	1.59 (1.05–2.41), 0.028	1.48 (1.10–1.99), 0.009
Education in years			
≥ 16 years	Reference	Reference	Reference
13–16 years	0.90 (0.51–1.60), .727	0.84(0.51–1.39)	0.86 (0.59–1.24), 0.405
12 years	0.98 (0.55–1.75), 0.950	0.55(0.32–0.96), 0.034	0.72 (0.49–1.07), 0.105
< 12 years	0.66 (0.34–1.25), 0.203	0.93(0.52–1.65), 0.797	0.82 (0.54–10.25)
Use of sleep aids			
No	Reference	Reference	Reference
Sometimes	0.60 (0.21–1.74), 0.350	1.04 (0.55–1.97), 0.547	0.89 (0.52–1.52), 0.673
Often/always	0.66 (0.35–1.25), 0.203	1.39 (0.89–2.19), 0.147	1.06 (0.74–1.51), 0.755
Health status			
Excellent/very good	Reference	Reference	Reference
Good	1.04 (0.62–1.75), 0.785	1.09 (0.67–1.73), 0.706	1.04 (0.74–1.47), 0.673
Fair/poor	2.59 (1.39–4.82), 0.003	1.69 (1.01–2.84), 0.044	1.93 (1.31–2.85)
Self-rated memory			
Excellent/very good	Reference	Reference	Reference
Good	1.07 (0.65–1.76), 0.785	1.01(0.66–1.56), 0.959	1.06(0.77–1.46), 0.735
Fair	1.22 (0.67–2.34), 0.517	1.60 (0.96–2.66), 0.069	1.41(0.96–2.06), 0.077
Poor	1.35 (0.46–3.94), 0.579	1.70(0.68–4.23), .256	1.48 (0.75–2.92), 0.256

Table 5 (continued)

	Male ($N = 863$) OR(CI), p value	Female ($N = 1222$) OR(CI), p value	Total (2085) OR(CI), p value
Depression score (PHQ-2)			
< 3	Reference	Reference	Reference
≥ 3	1.50(0.78–2.90), 0.228	1.40 (0.86–2.28), 0.181	1.41 (0.96–2.07)
Daytime naps			
Rarely/never	Reference	Reference	Reference
Sometimes	1.09 (.65–1.86), 0.727	1.0 (0.57–1.74), 0.989	1.05 (0.72–1.52), 0.813
Often/always	0.74 (0.37–1.46), 0.386	0.89 (0.47–1.68), 0.711	0.80 (0.51–1.26)0.345
Difficulty staying awake			
Rarely/never	Reference	Reference	Reference
Sometimes	1.30 (0.82–2.07),0.269	0.92 (0.60–1.41),0.688	1.04 (0.76–1.42),0.805
Often/always	0.66(0.32–1.37),0.266	1.09 (0.60–1.99),0.781	0.853 (0.54–1.34),0.494
Fall history			
No	Reference	Reference	Reference
Yes	4.93 (3.21–7.58), < 0.001	3.86(2.65–5.61), < 0.001	4.42 (3.35–5.82), < 0.001
Fear of falling			
No	Reference	Reference	Reference
Yes but no limitation	1.85 (1.10–3.10),0.020	1.32(0.86–2.04), 0.204	1.48 (1.07–2.06), 0.019
Yes with limitation	1.84 (.93–3.65), 0.082	1.98 (1.18–3.34), 0.010	1.86 (1.24 –2.80), 0.003
	Pseudo R2 = .17 Hosmer–Lemeshow chi square: $p = 0.272$	Pseudo R2 = .16 Hosmer–Lemeshow chi square: $p = .591$	Pseudo R2 = .15 Hosmer–Lemeshow chi square $p = .106$

Dependent variable: recurrent falls

*IS insomnia symptoms, **SD sleep duration

outcomes indicating that this subjective sleep measure could have important clinical significance [29]. A third limitation is the lack of data on specific central nervous system-active medications, such as specific sedative hypnotic, antidepressant and antipsychotic medications in the current data set, as these medications have been reported to be associated with falls among older adults [30]. In the current study, "use of medications to promote sleep" was used as proxy for sedative hypnotics, and as this term is not specific for any group of medications and this may have undermined the impact of central nervous system-active medications on recurrent falls.

In summary, results of the current study indicate higher risk of recurrent falls among women who reported insomnia symptom with short sleep duration. This result indicates that insomnia symptom with a measure of sleep duration may be a more accurate marker of risk for recurrent falls than insomnia symptom or sleep duration alone. The finding of significant association between these sleep-related symptoms and recurrent falls only among women is intriguing and merits further investigation to determine the mechanism underlying this gender-specific association.

Compliance with ethical standards

Conflict of interest No conflicts of interest declared by the author.

Ethical approval This is a secondary data analysis of de-identified data and the study was approved by Institutional Review Board of Morehouse School of Medicine.

Informed consent This is a secondary data analysis of de-identified data and no contact was made with the study participants.

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