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Association Between Social and Physical Activities and Insomnia Symptoms Among Community-Dwelling Older Adults

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Abstract

Objective—To examine the association between organized social activity, walking exercise, and insomnia symptoms.

Material and Method—Data for analysis are derived from the National Health Aging Trends Study (NHATS). At baseline, demographic characteristics, socioeconomic status, health-related behaviors, sleep-related problems, and health status were assessed using questionnaires.

Results—Data for 7,162 community-dwelling older adults were available for analysis. Difficulty falling asleep, trouble staying asleep, and both insomnia symptoms were reported by 12%, 5%, and 11% of the participants, respectively. The proportion of participants who reported engaging in organized social activity, walking exercise, and both activities were 11%, 35%, and 26%, respectively. Participants who reported engaging in organized social activity and/or walking exercise were significantly less likely to report insomnia symptoms.

Conclusion—These results have important implications for future studies that plan to implement nonpharmacological interventions for management of insomnia among older adults.

Keywords

organized social activity; walking exercise; insomnia symptoms

Insomnia symptoms are prevalent among older adults and are associated with increased risk of physical and psychiatric morbidities, poor quality life, and increased health care utilization (Foley et al., 1995; Ford & Kamerow, 1989; Ganguli, Reynolds, & Gilby, 1996; Maggi et al., 1998; Murphy et al., 2002; Newman, Enright, Manolio, Haponik, & Wahl, 1997; Schubert et al., 2002; Sivertsen, Krokstad, Mykletun, & Overland, 2009). Currently, the status of clinical management of insomnia remains less than optimal (NIH State-of-the-Science Conference Statements, 2005). In a significant proportion of adults, sleep-related complaints remain underreported, and reported sleep complaints remain undertreated

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Declaration of Conflicting Interests

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(Winkelman & Pies, 2005). Furthermore, pharmacological therapy with sleep promoting medications remains the main modality of treatment for insomnia symptoms (Bertisch, Herzig, Winkelman, & Buettner, 2014; Moloney, Konrad, & Zimmer, 2011), and long-term use of sleep promoting medications is associated with adverse effects such as falls, fractures, persistent fatigue, and even cognitive impairment (Basu, Dodge, Stoehr, & Ganguli, 2003; Endeshaw, 2015; Hogan, Maxwell, Fung, & Ebly, 2003; Tinetti, Speechley, & Ginter, 1988; Wagner et al., 2004; Wang, Bohn, Glynn, Mogun, & Avorn, 2001). For these reasons, nonpharmacological treatment is the preferred modality of treatment. Cognitive behavioral therapy (CBT) for sleep-related complaints has been shown to be efficacious among older adults (Morgenthaler et al., 2006; Morin et al., 2006); however, shortage of trained professionals who can deliver CBT limits application of this form of therapy to the majority of older adults. Because of these factors, there is a growing interest in nonpharmacological interventions that could be performed by older adults and require minimal training or supervision; organized social activity and walking exercise are two such interventions.

Several mechanisms have been proposed to explain the positive impact of physical exercise and social activity on sleep quality. Both photic and nonphotic stimuli are reported to have a positive impact on the activity of the circadian timing system (CTS), one of the two processes that regulate sleep-wake cycle (Dijk, 2002; Saper, 2005), and both social and physical activities that are performed on a regular basis can entrain the circadian rhythm to the environment. For example, social as well as physical activities have been reported to be associated with a deeper nocturnal dip in body temperature, indicating a more robust CTS and hence better sleep quality (Grandin, 2006; Monk, 1994). Regular social activity in the form of interaction with other individuals and playing games has also been associated with higher proportion of slow-wave sleep among older adults (Naylor et al., 2000). In addition, if physical activity is performed outdoors, exposure to the outside light could act as photic stimuli to the suprachiasmatic nucleus neurons, and this influences the timing and consolidation of sleep and wake (Cao et al., 2015). Furthermore, both physical exercise and social activities could have a positive impact on physical, cognitive, and emotional functions of older adults, and may also provide a sense of purpose and accomplishment, and this positive influence may have a favorable impact on sleep quality (Perkinson-Gloor, 2013).

Previous randomized controlled trials have examined the effect of social activity and physical exercise on sleep quality among older adults (King et al., 2008; Reid et al., 2010; Tworoger et al., 2003); however, these studies have several limitations including younger age of study participants (mean age of below 65 years) and limited sample size. For these reasons, whether results from these studies can be applicable to older adults in general and adults above 75 years old in particular is debatable. In a more recent study, in which community-dwelling older adults participated, sleep-wake disturbances were not significantly associated with physical inactivity (Vaz Fragoso et al., 2014). However, participants in this study were “sedentary older adults with functional limitations,” and these results may not be applicable to all community-dwelling older adults. To our knowledge, whether the relationships between social and physical activities and insomnia symptoms are independent of demographic, socioeconomic, and health status factors has not been well documented among a representative sample of older adults.

The present cross-sectional study examines the association between organized social activity, walking exercise, and insomnia symptoms among a nationally representative, multiracial community-dwelling older adults. It is hypothesized that older adults who engage in organized social activity and/or walking exercise are less likely to report insomnia symptoms in comparison with those who do not engage in these activities, independent of racial/ethnic origin, education status, annual family income, and health status of study participants. In addition, we also postulate that participants who report engaging in both social activity and walking exercise would be less likely to report insomnia symptoms in comparison with those who report engaging in only one of these activities. As stated above, this is a cross-sectional study and the results do not infer cause and effect relationship. However, these results would have important implications for future studies that plan to investigate the cause and effect relationships between social and physical activities and sleep quality and studies that plan to implement nonpharmacological interventions for the management of insomnia among older adults.

Method

The present study uses data 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 participated. Baseline data collection was completed in 2011, and at this time, 96% of adults 65 years of age living in the United States were enrolled in Medicare. The NHATS is designed to study trends and dynamics of late life functioning at baseline and during follow up (Kasper, 2014). Using a three-stage sampling design, 12,411 older adults were randomly selected, out of which 8,245 participants completed the face-to-face interview at baseline (2011; Figure 1). Based on the sampling design and nonresponse rate, appropriate sampling weights were developed and will be used in the current analysis (Kasper, 2014). Variables used in the current analysis are shown below.

Sleep-Related Variables

In NHATS, sleep quality at baseline was assessed using the following questions: (a) “How often does it take you more than 30 minutes to fall asleep at night?” and (b) “How often do you have trouble falling back to sleep on nights after waking up from sleep?” Responses to these questions include *every night*, *most nights*, *some nights*, *rarely*, and *never*. For the purpose of this analysis, participants who reported more than 30 minutes to fall asleep *most nights* or *always* were defined to have difficulty falling asleep, and those who reported trouble falling back to sleep after waking up from sleep *most nights* or *always* were defined to have difficulty maintaining sleep. Based on the distribution of these insomnia symptoms, four categories were created as follows: (a) no insomnia symptoms, (b) difficulty initiating sleep only, (c) difficulty maintaining sleep only, (d) and both insomnia symptoms.

Participation in organized social activity and walking exercise were assessed with the following questions respectively. “In the last month, besides religious services, did you ever participate in clubs, classes, or other organized activities?” and “In the last month, did you ever go walking for exercise?” and participants provided “Yes” or “No” or “Don't know”

response. Based on these responses, participants were categorized into four groups as follows: (a) no activities, (b) social activities only, (c) walking exercise only, and (d) both activities.

Demographic, Social, and Economic Factors

These include age in years, gender, race and ethnicity (“White, non-Hispanic”; “Black, non-Hispanic”; “Hispanic”; “Other, which included American Indian, Asian, Native Hawaii, mixed race”), marital status (currently married and not married status), years of formal education (less than 12 years, 12 years, 13 or more years), and total family income. Total family income was obtained from participant's response to the question “How much was your and your spouse/partner's total income before taxes for last year (i.e., for the 12 months ending in December)?” Income data were available for only 45% of participants, and to account for missing data, hot deck imputation was performed by NHATS, and the mean of five income imputation values were used in place of missing income data. Four categories were created based on participant's income quartile, and used in the analysis. Neighborhood characteristics were determined based on observation of the home environment by the interviewers and their response to the following question: “When standing in front of the study participant's home/building, and looking around in every direction, how much of the following did you see?” (a) Litter, broken glass, or trash, on sidewalks and streets; (b) graffiti on buildings and walls; (c) vacant or deserted houses or storefronts; and (d) houses with foreclosure signs. For the purpose of this analysis, neighborhood is considered “desirable” if none of these items were observed around the home, and “not desirable” if one or more of these items were observed.

Because health status and physical functional status could have an impact on whether a person is able to participate in both social and physical activities and on sleep quality, self-reported health status and results of short physical performance battery (SPPB) were included in the analysis. 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 as follows: (a) excellent or very good, (b) good, and (c) fair or poor. The SPPB included balance, walking speed, and the repeated chair stands tests as previously described (Guralnik et al., 1994), but the cut points were modified to reflect the quartiles of the NHATS sample distribution (Kasper, Freedman, & Niefeld, 2012).

Statistical Analysis

Pearson chi-squared statistics is used to describe the relationship between demographic, social, economic, and morbidity characteristics of study participants by insomnia symptom categories. Given the complex study design, oversampling of selected populations and nonresponse, weighted estimates are reported. Multinomial logistic regression (MLR) analysis was used to determine the association between organized social activity, walking exercise, and insomnia symptoms, with insomnia symptoms as the dependent variable. Three regression models were created as follows: Model 1 included social activities and walking exercise only and Model 2 included variables in Model 1 and demographic variables (age, sex, race, marital status) and indicators of socioeconomic status (years of

education, family income, and neighborhood characteristics). Model 3 included variables in Model 2 and self-reported health status and SPPB score. Interaction terms that included age by physical/social activity, gender by physical/social activity, health status by physical and social activity, and SPPB score by physical/social activity were included in Model 3 one at a time and these interaction terms were considered significant at the $p < .1$ level. Because 1,028 participants had missing values or more of the predictor variables, only 6,134 participants were included in Model 3. Of those with missing values, a total of 947 participants (92%) did not complete SPPB for various reasons. Participants were not eligible to perform the test if (a) they use a mobility device and were unable to walk a short distance by self, or (b) they were not able to stand without holding anyone or anything, or (c) it was felt unsafe to perform the activities by the participant or interviewer, or (d) the participant did not understand the instruction, or (e) there was not enough space to perform the test. Participants with missing values were significantly older, more likely to belong to “Black” and “Other” racial groups, and more likely to report lower socioeconomic status (lower years of education, lower income, and lived in “undesirable neighborhood”). Participants with missing values were also more likely to report fair/poor health status. To account for missing data, multiple imputations by chained equations was performed and MLR was repeated using imputed data. Stata survey data software version 13 was used for analysis and p value $< .05$ is considered to indicate statistical significance.

Results

Out of a total of 8,245 participants who completed the study at baseline, 1,048 participants were living in residential care facilities and 7,197 were living in the community. Because important factors such as living environment and burden of disease impact sleep quality, and the prevalence of these factors is significantly different between older adults living in the community and those who live in residential care facilities (Alessi, 2000), only community-dwelling older adults were included in the present study. Thirty-five of the 7,197 community-dwelling participants did not provide adequate response to the sleep questions, leaving 7,162 participants for the current analysis (Figure 1). Overall, 28% of study participants reported one or both insomnia symptoms with 12%, 5%, and 11% reporting difficulty falling asleep, trouble staying asleep, and both insomnia symptoms, respectively. The proportions of participants who reported engaging in organized social activity, walking exercise, and both activities were 11%, 35%, and 26%, respectively. Distribution of insomnia symptoms by demographic characteristics, education and income levels, and neighborhood status is shown in Table 1. Results indicate that there was no significant difference in the proportions of study participants with insomnia symptoms among the different age groups, while the proportion of study participants with insomnia symptoms was higher among women and among Black and Hispanic participants. Proportion of study participants with insomnia symptoms was also higher among those with lower education level, lower income, and those who reside in “not desirable” neighborhood. Insomnia symptoms were reported less frequently among participants who engage in organized social activity and/or walking exercise. Table 2 shows insomnia symptoms by health and functional status, and as expected, the proportion of participants with insomnia symptoms was higher among those with poor health status and those with lower physical performance test scores.

Results of MLR analysis show that the risk of insomnia symptoms was lower among participants who reported engaging in both organized social activity and walking exercise in comparison with those who did not engage in these activities, even after controlling for demographic and socioeconomic factors as well as self-reported health status and SPPB score (Table 3, Model 3). Results also indicate that the risk of insomnia symptoms was lower among those who engaged in both activities than among those who engaged only in one of the activities, suggesting additive beneficial effect of these two activities. For example, participants who reported participating in both activities were 40% less likely to report both insomnia symptoms while participants who reported engaging in organized social activity and walking exercise were 30% and 22% less likely to report both insomnia symptoms, respectively (Table 3, Model 3). None of the interaction terms included in the full model showed significance at $p < .1$ level. Results of MLR after multiple imputations yielded similar results and are shown in Table 3, column 4 (model after imputation).

It is notable that the relationship between race and insomnia symptoms observed in bivariable analysis was no longer significant in the MLR model that included socioeconomic, health, and functional status as covariates, suggesting that the association observed during bivariable analysis could be explained by social-economic and health status factors.

Discussion

Results of the present study indicate significant association between organized social activity, walking exercise, and insomnia symptoms. Furthermore, this association is stronger among study participants who reported engaging in both social activity and walking exercise in comparison with those who reported participating in only one of these two activities, and this may suggest a dose-response association. Because this is a cross-sectional study, cause and effect relationship cannot be inferred and directionality of this association should be investigated by future studies.

The findings in the present study is in agreement with previous reports that examined the effect of physical exercise and social activity on sleep quality among older adults (King et al., 2008; Reid et al., 2010; Tworoger et al., 2003) although these studies were limited by younger age of study participants (mean age of below 65 years) and limited sample size as mentioned above. A more recent study did not find significant association between physical inactivity and sleep quality among “sedentary older adults with functional limitations” (Vaz Fragoso et al., 2014); however, whether these findings can be generalizable to all community-dwelling older adults is debatable as mentioned above. Other studies that examined the effect of physical and social activities on sleep quality among older adults residing in long-term care facilities reported conflicting results with two studies reporting beneficial effect (Richards et al., 2011; Naylor et al., 2000), while two other studies reporting minimal positive effect if any (Alessi et al., 2005; Ouslander et al., 2006). However, participants in these studies were residents of long-term care facilities and sleep quality among long-term care facility residents could be affected by factors related to the facility as well (Schnelle, Alessi, Al-Samarrai, Fricker, & Ouslander, 1999), and this may have accounted for these conflicting results.

Mechanisms that can explain the association between social activity/physical exercise and sleep quality have been described above. In short, physical exercise if performed outdoors could function as photic stimuli of the CTS and both organized social activity and walking exercise performed on a regular basis could serve as nonphotic stimuli to the CTS. The positive impact on the CTS would result in consolidation of the sleep-wake system and improved sleep quality. Furthermore, these activities would have a positive impact on emotional function of older adults, and this may positively influence sleep quality. Actually, the association between social and physical activities and insomnia symptoms could be bidirectional (Kahn, 2013) with social and physical activities lowering the risk of insomnia symptoms by improving sleep quality, and improved sleep quality in return increasing the likelihood of participating in these activities. Future studies would be needed to determine the strength of this possible bidirectional association between social and physical activities and sleep quality among a representative sample of older adults.

The present study uses data derived from a well-designed and well- executed epidemiological study in which a representative sample of Medicare beneficiaries participated, implying that the results could be applicable to older adults living in the contiguous United States. However, the present study also has several limitations and these limitations should be taken in to consideration while interpreting the results. Data on insomnia symptoms were limited to two questions related to time to fall asleep and difficulty going back to sleep. Although these two symptoms address two of the most common night time sleep complaints of individuals with insomnia disorder (American Psychiatric Association, 2013; Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008), it is not possible to make a diagnosis of insomnia disorder based only on these symptoms. However, previous studies have reported significant association between these insomnia symptoms and lower quality of life and persistent severe fatigue among older adults (mean age 69.3 years), indicating the importance of these symptoms in this group of the population (Endeshaw, 2015; Schubert et al., 2002). Another limitation is the lack of objective data related to measures of sleep quality and quantity. However, previous studies have reported only a modest association between self-reported sleep quality and sleep quality measures derived using results of polysomnography (Unruh et al., 2008); this suggests that subjective and objective sleep quality measures may represent different dimensions of sleep. As stated above, given the cross-sectional design of the present study, cause and effect relationship cannot be inferred between social/physical activities and insomnia symptoms and reverse causality cannot be excluded. Future studies would be needed to ascertain the direction of this association.

In conclusion, the present study reports significant association between organized social activity, walking exercise, and insomnia symptoms. Given that these activities can be performed by older adults with minimal supervision and training, these results could have important implications for future interventional studies that aim to improve sleep quality among older adults.

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Figure 1.
Diagram showing flow of participants included in the study.

Table 1
Demographic and Socioeconomic Characteristics of Study Participants by Insomnia Symptoms.

	No sleep symptoms (<i>n</i> = 5,172) (<i>N</i> = 24,314,790)	DIS (<i>n</i> = 832) (<i>N</i> = 3,776,434)	DMS (<i>n</i> = 399) (<i>N</i> = 1,787,885)	Both symptoms (<i>n</i> = 7,59) (<i>N</i> = 3,357,522)	Total (<i>n</i> = 7,162) (<i>N</i> = 33,233,632)	Statistics
Age						
65-74	2,137 (56)	335 (53)	146 (50)	309 (53)	2,927 (55)	
75-84	2,070 (33)	316 (33)	177 (38)	308 (34)	2,871 (34)	<i>p</i> = .060
85	965 (11)	181 (14)	76 (12)	142 (12)	1,364 (11)	
Sex						
Male	2,290 (46)	309 (38)	164 (43)	271 (36)	3,034 (44)	<i>p</i> < .0001
Female	2,882 (54)	523 (62)	235 (57)	488 (64)	4,128 (56)	
Race						
White	3,553 (81)	560 (80)	269 (81)	459 (72)	4,841 (80)	
Black	1,121 (8)	186 (8)	93 (9)	187 (10)	1,587 (8)	<i>p</i> < .0001
Hispanic	282 (6)	60 (8)	24 (7)	78 (12)	444 (7)	
Other	216 (5)	26 (4)	13 (3)	35 (6)	290 (5)	
Married	2,756 (61)	384 (54)	211 (61)	347 (50)	3,698 (59)	
Not married	2,410 (39)	447 (46)	188 (39)	412 (50)	3,457 (41)	<i>p</i> < .0001
Education						
>12 years	2,476 (54)	315 (43)	156 (47)	254 (36)	3,201 (51)	
12 complete	1,366 (26)	262 (33)	104 (26)	211 (29)	1,943 (27)	<i>p</i> < .0001
<12 years	1,270 (19)	245 (24)	137 (27)	284 (35)	1,936 (22)	
Income						
Fourth quartile	1,589 (38)	173 (25)	93 (30)	130 (20)	1,985 (34)	
Third quartile	1,435 (28)	237 (31)	97 (26)	190 (26)	1,959 (28)	
Second quartile	1,340 (22)	243 (27)	139 (30)	232 (29)	1,954 (24)	<i>p</i> < .0001
First quartile (lowest)	808 (12)	179 (17)	70 (14)	207 (25)	1,264 (14)	
Neighborhood						
Good	4,436 (89)	670 (84)	332 (87)	601 (82)	6,039 (88)	<i>p</i> < .0001
Not good	693 (11)	151 (16)	65 (13)	151 (18)	1,060 (12)	
No activity	1,446 (24)	310 (34)	151 (34)	340 (43)	2,247 (28)	
Organized Social Activity	578 (11)	86 (10)	46 (12)	77 (10)	787 (11)	<i>p</i> < .0001

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	No sleep symptoms ($n = 5,172$) ($N = 24,314,790$)	DIS ($n = 832$) ($N = 3,776,434$)	DMS ($n = 399$) ($N = 1,787,885$)	Both symptoms ($n = 7,59$) ($N = 3,357,522$)	Total ($n = 7,162$) ($N = 33,233,632$)	Statistics
Walking activity	1,797 (35)	291 (37)	145 (36)	245 (33)	2,478 (35)	
Both activities	1,349 (30)	145 (19)	57 (18)	97 (14)	1,648 (26)	

Note. n = number of observations; N = weighted counts; DIS = difficulty initiating sleep; DMS = difficulty maintaining sleep. Results in the table are reported as number of observations, n , and (percentage of weighted counts).

Health Status and Physical Performance Characteristics of Study Participants by Insomnia Symptoms.

Table 2

	No sleep symptoms (<i>n</i> = 5,172) (<i>N</i> = 24,314,790)	DIS (<i>n</i> = 832) (<i>N</i> = 3,776,434)	DMS (<i>n</i> = 399) (<i>N</i> = 1,787,885)	Both symptoms (<i>n</i> = 759) (<i>N</i> = 3,357,522)	Total (<i>n</i> = 7,162) (<i>N</i> = 33,233,632)	Statistics
Health status						
Excellent or very good	2,273 (50)	277 (37)	125(36)	139 (20)	2,814 (45)	
Good	1,707 (31)	243 (30)	119 (29)	208 (27)	2,277 (30)	
Fair/Poor	1,189 (19)	311 (34)	155 (35)	412 (53)	2,067 (25)	<i>p</i> < .0001
SPPB score						
(0-12)	6.4 (3.4) ^{†‡}	5.7 (3.4) [*]	5.7 (3.5) [†]	4.8 (3.3) [‡]	6.1 (3.4)	<i>p</i> < .0001
Mean (<i>SE</i>)						
SPPB score						
>7	1,899 (52)	239 (42)	116 (44)	151 (29)	2,405 (48)	
7	2,626 (48)	476 (58)	228 (56)	480 (71)	3,810 (52)	<i>p</i> < .0001

Note. Results in the table are reported as number of observations (*n*) and (percentage of weighted counts), *n* = number of observations; *N* = weighted counts; DIS = difficulty initiating sleep; DMS = difficulty maintaining sleep. SPPB = short physical performance battery score ranges between 0 and 12 with higher score indicating better physical performance; *SE* = standard error.

[†] *p* = .001.

[‡] *p* < .0001.

^{*} *p* < .0001.

Table 3
Results of Multinomial Logistic Regression Models Showing the Association Between Social and Physical Activities and Insomnia Symptoms in Unadjusted and Adjusted Models.

	Model 1 (unadjusted) $n = 7,160$ Odds ratio [CI]	Model 2 (partially adjusted) $n = 7,025$ Odds ratio [CI]	Model 3 (fully adjusted) $n = 6,134$ Odds ratio [CI]	Model after imputation (fully adjusted) $n = 7,162$ Odds ratio [CI]
Difficulty initiating sleep (DIS)				
No activities	Reference	Reference	Reference	Reference
Social activities	.65 [0.50, 0.85], $p = .002$	.71 [0.54, 0.93], $p = .015$	.78 [0.58, 1.04], $p = .089$	.80 [0.61, 1.04], $p = .097$
Walking exercise	.74 [0.60, 0.92], $p = .008$	.81 [0.65, 1.00], $p = .053$	.86 [0.67, 1.08], $p = .200$	.89 [0.72, 1.13], $p = .346$
Both activities	.45 [0.35, 0.57], $p < .001$	.54 [0.42, 0.70], $p < .001$	.61 [0.47, 0.79], $p < .001$	.64 [0.50, 0.81], $p = .001$
Difficulty maintaining sleep (DMS)				
Social activities	.76 [0.50, 1.16], $p = .204$	.80 [0.51, 1.24], $p = .307$	.90 [0.56, 1.45], $p = .654$	.91 [0.58, 1.43], $p = .679$
Walking exercise	0.73 [0.57, 0.93], $p = .012$	.77 [0.58, 1.00], $p = .055$	.80 [0.58, 1.10], $p = .169$	.85 [0.64, 1.13], $p = .254$
Both activities	.42 [0.29, 0.62], $p < .001$	.45 [0.31, 0.66], $p < .001$	.51 [0.33, 0.76], $p = .002$	.56 [0.37, 0.86], $p = .008$
Both symptoms				
Social activities	.49 [0.36, 0.66], $p < .001$	.59 [0.43, 0.80], $p = .001$	.70 [0.49, 1.00], $p = .048$	.77 [0.57, 1.03], $p = .078$
Walking exercise	.52 [0.43, 0.64], $p < .001$	.56 [0.46, 0.68], $p < .001$	.78 [0.61, 0.99], $p = .040$	.76 [0.61, 0.95], $p = .017$
Both activities	.26 [0.29, 0.33], $p < .001$	0.36 [0.28, 0.45], $p < .001$	.60 [0.44, 0.82], $p = .002$	.57 [0.43, 0.76], $p < .001$

Note. Model 2: Adjusted for age, sex, race, marital status, education level, family income and neighborhood status. Model 3: Model 2 + health status and SPPB score. Other variables that showed significant association with insomnia symptoms in the full model (Model 3) are as follows: DIS: RR (CI): Female sex 1.24 [1.03, 1.48], $p = .023$; "Not desirable" neighborhood: 1.38 [1.01, 1.89], $p = .042$; Health status fair/poor: 1.91 [1.42, 2.56], $p < .0001$. DMS: RR (CI): Hispanic race 0.66 [0.43, 1.01], $p = .054$; Health status fair/poor: 2.50 [1.74, 2.50], $p < .0001$. Both insomnia symptoms: RR (CI): Age 85: 0.69 [0.47, 1.00], $p = .051$; Female sex: 1.47 [1.21, 1.79], $p < .001$; Income (lowest quartile): 1.46 [0.98, 2.29], $p = .065$; Health status good: 1.76 [1.33, 2.34], $p < .0001$; Health status fair/poor: 4.62 [3.40, 6.27], $p < .0001$; NHATS SPPB score: 0.95 [0.91, 1.00], $p = .036$.

CI = confidence interval; SPPB = short physical performance battery; DIS = difficulty initiating sleep; DMS = difficulty maintaining sleep.