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AGE-RELATED DIFFERENCES IN SLEEP-WAKE SYMPTOMS OF ADULTS UNDERGOING POLYSOMNOGRAPHY

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Abstract

OBJECTIVES—To evaluate age-related differences in sleep-wake symptoms.

DESIGN—Cross-sectional.

SETTING—Technologist-attended, laboratory-based polysomnography (PSG).

PARTICIPANTS—201 community-dwelling adults aged 20–89, including 52 aged 18–39, 72 aged 40–59, and 77 aged 60.

MEASUREMENTS—1) Medical burden: Charlson Comorbidity Index, medications, and health status; 2) PSG-defined sleep disorders: sleep-disordered breathing (SDB), sleep-associated hypoxemia, and periodic limb movements in sleep (PLMS); 3) sleep-wake symptoms: Epworth Sleepiness Scale (ESS), Insomnia Severity Index (ISI), and fatigue (Facit-F Scale).

RESULTS—Medical burden increased significantly across the age groups of 18–39, 40–59 and 60 ($p < .001$ for Charlson Comorbidity Index and number of medications; $p = .005$ for reduced health status). In addition, the severity of sleep disorders increased significantly across the age groups of 18–39, 40–59 and 60 ($p < .001$ for SDB and hypoxemia; $p = .008$ for PLMS). Conversely, significant reductions were observed for sleep-wake symptoms across the age groups of 18–39, 40–59 and 60 ($p = .020$ for daytime drowsiness [ESS 10]; $p = .036$ for insomnia [ISI 8]; $p < .001$ for fatigue). In adjusted models, a 1-year increase in age was significantly associated with a 4% decrease in the odds of having daytime drowsiness (odds ratio: 0.96 [0.93, 0.98]). Similarly, but only in those with mild SDB, a 1-year increase in age was significantly associated with a 5% decrease in the odds of having insomnia (odds ratio: 0.95 [0.92, 0.99]).

CONCLUSION—In our PSG-based sample, advancing age was characterized by a decrease in sleep-wake symptoms (daytime drowsiness, insomnia and fatigue), despite an age-related increase in disease severity (medical burden and sleep disorders). Because the increase in disease severity included well-established risk factors for having sleep-wake symptoms, we posit that the age-related decrease in sleep-wake symptoms may reflect reduced symptom awareness.

Keywords

sleep-disordered breathing; periodic limb movements; sleep-wake symptoms; driving capacity

INTRODUCTION

Advancing age may be associated with reduced symptom awareness. Prior work has shown that, relative to younger persons, older persons have milder respiratory symptoms in response to methacholine-induced bronchoconstriction, have decreased autonomic and neuroglycopenic symptoms in response to hypoglycemia, and have higher rates of silent myocardial ischemia (in the absence of chest pain).^{1–3}

Age-related reductions in symptom awareness may also occur in response to sleep-disordered breathing (SDB). The Wisconsin sleep cohort previously established a significant association between SDB and daytime drowsiness at age 40, but not at age 60.⁴ In a separate study of persons aged 71–87, there was a poor correlation between SDB and symptoms of insomnia and daytime drowsiness.⁵ Individuals who have SDB, but reduced symptom awareness, may not undergo diagnostic evaluation or may be deemed ineligible for specific therapies. In particular, because the prevalence of SDB increases with advancing age, but is potentially less symptomatic, a polysomnography (PSG) or the institution of positive airway pressure may not be considered in older persons.^{4–7} Importantly, untreated SDB, even when asymptomatic, is associated with adverse cardiovascular outcomes.^{8–10}

In a clinic-based population at risk of having SDB, we have further evaluated age-related differences in sleep-wake symptoms among 201 community-dwelling adults aged 20–89 who were undergoing their first PSG. Although our primary study outcome was to prospectively evaluate age-related differences in adherence to positive airway pressure in those with newly confirmed SDB, the baseline assessment included: 1) sleep-wake symptoms: insomnia (Insomnia Severity Index), daytime drowsiness (Epworth Sleepiness Scale), fatigue (Facit-F Scale), and restless legs syndrome;^{11–15} 2) driving history: self-reported driver ratings, driving mileage, and adverse driving events in the prior year; 3) medical burden: Charlson Comorbidity Index, medications, and health status; and 4) PSG-defined sleep disorders: SDB, sleep-associated hypoxemia, and periodic limb movements in sleep (PLMS). Accordingly, because aging is associated with increased disease prevalence,^{16–18} but potentially reduced symptom awareness,^{1–5} we evaluated whether older study participants would have milder sleep-wake symptoms, despite having a higher medical burden and more severe sleep disorders. Similarly, as a secondary aim, we evaluated whether older participants would have better self-reported driver ratings, despite having more adverse driving events.

METHODS

Study Population

Our study sample was drawn from a clinic-based, referral population at the Yale Center for Sleep Medicine and the Veterans Affairs Connecticut (VA-CT) Sleep Center. In particular,

our study sample included community-dwelling adults aged 18 who were undergoing their first PSG, with the clinical indication being the evaluation of SDB. The PSG was technologist-attended and performed at the Yale or VA-CT sleep laboratories. The Institutional Review Boards of the corresponding centers approved study procedures and participants gave informed consent.

Our enrollment of study participants involved a prospective but non-probability sampling that occurred sequentially over a two-year period, with the goal of having similar sample sizes for the age groups of 18–39 (young age), 40–59 (middle age), and 60 (old age). The age cutpoints approximated age-related trends in sleep efficiency and sleep architecture across the adult lifespan.¹⁹ Exclusion criteria included non-English speaking, pregnancy, prior PSG or diagnosis of SDB, oxygen dependency, and moderate-to-severe cognitive impairment (Mini-Mental State Examination [MMSE] <18).²⁰ Of the 235 patients who met eligibility criteria and were invited to participate in the current study, 8 declined, 13 did not complete the PSG, and 13 were not interviewed due to scheduling conflicts, yielding a final analytical sample of 201 participants (85.5%).

Demographic and Clinical Characteristics

The baseline demographic and clinical characteristics included age, sex, race, chronic conditions, cognition, depressive symptoms, medications, health status, and sedentary status. Chronic conditions were ascertained by the self-reported Charlson Comorbidity Index.¹¹ Cognition was evaluated by the MMSE.²⁰ Depressive symptoms were evaluated by the Center for Epidemiologic Studies Depression Scale (CES-D).²¹ Medications were defined as the total number and whether participants reported a medication with potential central nervous system (CNS) effects, including anticonvulsants, antidepressants, antihistamine, antipsychotics, barbiturates, benzodiazepines, muscle relaxants, or opiates. To assess health status, participants were asked, “Would you say your health in general is excellent, very good, good, fair, or poor?” Reduced health was defined as a rating of fair-to-poor. Sedentary status was established by a response of never or <2 hours to the following: “During a typical week in the last month, how often did you engage in moderate sports or recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball, or other similar activities?”

Polysomnography (PSG)

Participants underwent a technologist-attended PSG, as per protocols from the American Academy of Sleep Medicine (AASM).²² Arterial oxygen saturation was measured using pulse oximetry (SpO₂), and reported as the lowest value during sleep and on ambient air (SpO₂nadir). Nasal pressure transducer and oral thermistor monitored airflow. Inductance plethysmography monitored ribcage and abdominal excursions. AASM criteria were used to score respiratory events. In particular, an apnea was defined as an 80% or greater reduction in airflow lasting at least 10 seconds. A hypopnea was defined as at least a 30% reduction in thoracoabdominal movement or airflow as compared to baseline, lasting at least 10 seconds, and with 4% oxygen desaturation. A respiratory-effort related arousal (RERA) was defined as a sequence of breaths lasting at least 10 seconds that is characterized by increasing respiratory effort or flattening of the nasal pressure waveform, leading to an arousal from

sleep, but not meeting criteria for apnea or hypopnea. The sum of apneas, hypopneas, and RERAs averaged per hour of sleep yielded the respiratory disturbance index (RDI), with values >15 defining moderate-to-severe SDB. As a metric for SDB and in the evaluation of sleep-wake symptoms, the RDI is preferred over the Apnea Hypopnea Index (includes only apneas and hypopneas), because RERAs are associated with sleep-wake symptoms and their treatment with positive airway pressure can improve objective sleepiness.²³

Lastly, AASM criteria were also used to score PLMS, and their sum was averaged per hour of sleep to yield the periodic limb movement index (PLM-Index). A PLM-Index >15 established a sleep-related movement disorder, which is often due to a medical or neurological condition, a medication or substance use, but may also occur as a primary sleep disorder termed periodic limb movement disorder.²³

Sleep-Wake Symptoms

Insomnia symptoms were evaluated by the Insomnia Severity Index (ISI). The ISI is a 7-item questionnaire based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for insomnia.¹² The response to each item is scored on a 0–4 scale, yielding an ISI score ranging from 0–28, with higher scores signifying more severe symptoms. An ISI ≥ 8 established a diagnosis of insomnia.¹²

Daytime drowsiness was evaluated by the Epworth Sleepiness Scale (ESS).¹³ The ESS measures the chance of dozing on a scale of 0–3, as experienced during eight different activities. The ESS score ranges from 0–24, with higher scores signifying more severe symptoms. To establish clinically-meaningful daytime drowsiness, we opted for an ESS ≥ 10.^{4,5,24–26} The ESS also established drowsy driving if a participant reported a chance of dozing when “in a car, while stopped for a few minutes in traffic” (item 8 of the ESS).¹³

Other symptoms included fatigue and restless legs syndrome (RLS). Fatigue was established if participants responded “I feel tired—quite a bit or very much” (Facit-Fatigue Scale).¹⁴ RLS was established when all diagnostic criteria were met, including 1) urge to move the legs, usually accompanied or caused by uncomfortable/unpleasant sensations in the legs; 2) begins/worsens during periods of rest or inactivity such as lying or sitting; 3) partially or totally relieved by movement, such as walking or stretching, at least as long as the activity continues; and 4) worse in the evening or night than during the day or only occur in the evening or night.¹⁵

Driving History

Driving history included self-reported driving mileage, driver self-ratings, and self-reported adverse driving events.^{25,26} The driving mileage was expressed as the average number of miles per day. Driving self-ratings included overall and night-time, using a discrete visual analog scale of 0–100 (higher values indicated better-perceived capacity). Adverse driving events included crashes, near-crashes, or getting lost in the prior year. Adverse drowsy driving events were established by a Yes response to: “In the past year, have you had any car accident or near misses (almost accidents) because you were sleepy or drowsy while driving?”

Statistical Analysis

The clinical characteristics of study participants, as well as their PSG measures, sleep-wake symptoms, and driving history, were first summarized as means accompanied by standard deviations (SD) [normal distribution] or medians accompanied by interquartile ranges (IQR, 25th–75th percentiles) [non-normal distribution], or as counts accompanied by percentages. All results were stratified by the age groups of 18–39, 40–59, and ≥60.

Unadjusted comparisons were then made between the three age groups using Mantel-Haenszel chi-square tests or Fisher exact tests for categorical variables, and Kruskal-Wallis tests for continuous variables lacking normal distributions. Next, using multivariable logistic regression models, the associations between age and the outcomes of insomnia (ISI ≥8) and daytime drowsiness (ESS ≥10) were evaluated. The age variable was expressed as a 1-year increment and covariates included established risk factors for sleep-wake disorders, ^{6,16–18} which differed significantly across the three age groups — as noted in the Results section, these were an RDI ≥15, PLM-index ≥15, sleep-associated hypoxemia (nadir SpO₂), Charlson Comorbidity Index, and number of medications used. The goodness of fit of the regression models was assessed with residual analysis, influence diagnostics, and goodness-of-fit statistics.

The amount of missing data was modest and noted; complete case analyses were therefore performed. All statistical analyses used SAS v9.3 (SAS Institute; Cary, NC), and results were interpreted as statistically significant according to a level of 0.05 for two-sided tests.

RESULTS

The study population included 201 participants aged 20–89; 143 were male and 46 were non-white. Table 1 shows the clinical characteristics of study participants, stratified by the age groups of 18–39 (young age), 40–59 (middle age), and ≥60 (old age). The old age group had the highest medical burden, as defined by the Charlson Comorbidity Index (median 3.0), number of medications used (median 7.0), and prevalence of reduced health status (39.0%). Of the chronic conditions, the old age group had the highest frequency of arthritis (69.7%), cardiac disease (41.6% had angina, heart failure, or coronary artery disease), and diabetes (32.5%). Otherwise, across the three age groups, there were no statistically significant differences in MMSE, CES-D, CNS medication use, and sedentary status.

Table 2 shows PSG measures of SDB, hypoxemia, and PLMS by age group. The old age group had: 1) highest RDI (median 19.0), including highest proportion of participants having RDI ≥15 (57.1%); 2) most severe hypoxemia (median SpO₂nadir of 84.0%); and 3) highest proportion of participants having a PLM-index ≥15 (23.4%). These results were statistically significant across the three age groups, with the young age group having a milder RDI, SpO₂nadir, and PLM-Index, whereas the middle age group had intermediate severity.

Table 3 shows sleep-wake symptoms by age group. The old age group had: 1) lowest ISI score (median of 11.0), including lowest proportion of participants having insomnia (72.7%); 2) lowest proportion of participants having daytime drowsiness (36.4%); and 3)

lowest proportion of participants having fatigue (35.1%). These results were statistically significant across the three age groups, with the young and middle age groups having more severe insomnia (ISI score and ISI 8), daytime drowsiness (ESS 10), and fatigue. Otherwise, no statistically significant differences were seen regarding the ESS score and proportion of participants having RLS and drowsy driving, respectively, across the three age groups.

Table 4 shows adjusted odds ratios of having insomnia (ISI 8) and daytime drowsiness (ESS 10), using multivariable logistic regression models. The only significant associations were for age, as follows: 1) a 1-year increase in age yielded adjusted odds ratios of having insomnia of 0.95 (0.92, 0.99) and 1.01 (0.96, 1.05) at RDI <15 and ≥15, respectively (p value for the age x RDI interaction was 0.0499); and 2) a 1-year increase in age yielded adjusted odds ratio of having daytime drowsiness of 0.96 (0.93, 0.98) — there were no interactions. In the insomnia model, among those with an RDI <15, the adjusted odds ratio of 0.95 signified that a 1-year increase in age was associated with a 5% decrease in the odds of having insomnia, averaged across the age range. In the daytime drowsiness model, the adjusted odds ratio of 0.96 signified that a 1-year increase in age was associated with a 4% decrease in the odds of having daytime drowsiness, averaged across the age range.

Table 5 shows driving history by age group. The proportion of participants who reported an adverse driving event in the prior year was high across all age groups, but with the young age group having a higher proportion (69.8%) than the middle and older age groups (46.9% and 46.3%, respectively). This result was statistically significant across the three age groups. Otherwise, no statistically significant differences were shown regarding miles driven per day, driver self-ratings (overall and night-time), and adverse drowsy driving events across the three age groups. Importantly, despite the high frequency of having an adverse driving event in the prior year across all age groups, the median overall driver self-rating was “good” at value of 90 (visual analog scale of 0–100) in each of the three age groups.

DISCUSSION

In a PSG-based sample of adults aged 20–89, we found that disease severity, including medical burden and sleep disorders, increased significantly across the age groups of 18–39, 40–59, and ≥60. In particular, the oldest age group had the highest medical burden, characterized by a median Charlson Comorbidity Index of 3, high rates of chronic conditions (arthritis [69.7%], cardiac disease [41.6%], diabetes [32.5%], and stroke [5.7%]), frequent medication use (median number was 7), and reduced health status (39%). The oldest age group also had the highest rate of sleep disorders, including having an RDI >15 (57.1%), a PLM-index >15 (23.4%), and more severe sleep-associated hypoxemia (median SpO₂nadir 84%). These results are consistent with prior work showing that older persons have a high medical burden, in general and in combination with sleep disorders.^{6,8–10,16–18,27}

Conversely, the sleep-wake symptoms of insomnia, daytime drowsiness, and fatigue decreased significantly across the age groups of 18–39, 40–59, and ≥60. In particular, we found that a 1-year increase in age was associated with a statistically significant 4% decrease

in the adjusted odds of having daytime drowsiness. Similarly, but limited to those with milder levels of SDB (RDI <15), a 1-year increase in age was associated with a statistically significant 5% decrease in the adjusted odds of having insomnia. Accordingly, we posit that the age-related decrease in sleep-wake symptoms likely reflected a reduction in symptom awareness, given that the age-related increase in disease severity included well-established risk factors for having sleep-wake symptoms.^{6,8–10,16–18,27} This observation is consistent with prior work showing age-related reductions in the awareness of respiratory, hypoglycemic, and anginal symptoms.^{1–3}

The mechanism underlying the age-related reduction in sleep-wake symptoms cannot be established by the current study, but is likely to be multifactorial in origin.¹⁸ For example, the experience of sleep-wake symptoms may attenuate with advancing age because older persons typically adjust activity patterns as a compensatory response to impairments,²⁵ or because of the “paradox of well-being.”²⁸ The latter refers to the high level of life satisfaction among older persons, and may include lower health expectations.²⁸ CNS-based mechanisms may also alter the experience of sleep-wake symptoms, including age-related changes in the homeostatic and circadian regulation of sleep-wake cycles.^{29,30}

Clinically, sleep-wake symptoms inform medical decisions regarding PSG evaluation and CPAP prescription.^{7,13,18} Hence, we posit that an age-related reduction in the awareness of sleep-wake symptoms could be a potential barrier to medical care. This observation has high relevance in older persons, given that their high rate of SDB may adversely affect important chronic conditions (cardiac disease, diabetes, and stroke), including in the absence of sleep-wake symptoms.^{6,8–10,16–18}

The current study also highlights discordance between self-reported driving capacity and driving safety.³¹ In each of the three age groups, the median overall driver self-rating was “good” at a value of 90 (visual analog scale of 0–100), which is unexpected given the frequent reporting of a prior adverse driving event across all three age groups (range of 46.3%–69.8%). The discordance may reflect age-related mechanisms. In particular, because of reductions in symptom awareness, we posit that our older study participants who had a high medical burden and more severe sleep disorders were less likely to adjust driving practices, potentially increasing driving risk. In our young age group, because they reported the highest frequency of having a prior adverse driving event (69.8%) but had otherwise very mild disease severity, we posit that their driving performance was more vulnerable to adverse effects—prior work has shown that, in response to chronic sleep loss, reductions in performance across wakefulness is especially severe in younger persons.^{30,32–34}

Our study has several strengths, having enrolled participants with a wide age range, having included PSG-defined sleep disorders, and having evaluated a broad clinical presentation, including medical burden, sleep-wake symptoms, and driving history. The results of our study are preliminary, however, given four limitations. First, our study sample was modest in size and clinic-based, representing a high risk population rather than a random sampling of community-based individuals.¹⁰ Moreover, female sex (58/201), the oldest-old (the old age group had a mean age of 69 years), and those with cognitive impairment (median MMSE was 29) were under-represented. These limitations in study enrollment may have impacted

the prevalence of sleep-wake symptoms.^{16–19,35–37} Second, we did not include objective measures of daytime drowsiness (multiple sleep latency test), nor home-based evaluation of insomnia (actigraphy). Third, driving capacity and adverse driving events were by self-report.³¹ Fourth, SDB may have night-to-night variability. For example, prior work has shown that the severity of SDB may differ across two consecutive nights of PSG, termed a first-night effect (13–15% of patients had more severe SDB on the second PSG).^{38,39} It is unknown, however, whether age-related differences exist in the first-night effect. To address these limitations, future studies will need to enroll a larger number of participants, with greater community-based representation, including females, the oldest-old, and those with cognitive impairment; objectively confirm daytime drowsiness, insomnia, and driving capacity; and evaluate age-related differences concerning the PSG-based first-night effect.^{16–19,23,31,35–40}

In conclusion, we found that advancing age was characterized by a decrease in sleep-wake symptoms, including insomnia, daytime drowsiness, and fatigue, despite an age-related increase in disease severity, including medical burden, SDB, PLMS, and sleep-associated hypoxemia. Because the increase in disease severity included well-established risk factors for having sleep-wake symptoms, we posit that the age-related decrease in sleep-wake symptoms may reflect reduced symptom awareness.

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Financial/Personal Conflicts	Vaz Fragoso	Van Ness	Araujo	Iannone	Yaggi
	No	No	No	No	No
Employment/Affiliation	X	X	X	X	X
Grants/Funds	X	X	X	X	X
Honoraria	X	X	X	X	X
Speaker Forum	X	X	X	X	X
Consultant	X	X	X	X	X
Stocks	X	X	X	X	X
Royalties	X	X	X	X	X
Expert Testimony	X	X	X	X	X
Board Member	X	X	X	X	X
Patents	X	X	X	X	X
Personal Relationship	X	X	X	X	X

Author Contributions: Dr. Vaz Fragoso had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors made substantial contributions to study concept and design, to data acquisition, analysis and interpretation, and to drafting the submitted article.

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Table 1

Clinical characteristics by age group

Variable ^a	Age 18–39 Young Age N=52	Age 40–59 Middle Age N=72	Age 60 Old Age N=77	P value
Age, mean (SD)	30.8 (4.7)	51.1 (5.6)	69.0 (7.7)	----
Charlson Comorbidity Index, median (IQR)	0 (0, 1)	1 (0.3)	3 (1.5)	<.001 ^h
Arthritis, No. (%)	6 (11.8)	32 (45.7)	53 (69.7)	<.001 ⁱ
Cardiac disease, No. (%) ^b	2 (3.9)	8 (11.4)	32 (41.6)	<.001 ^j
Diabetes, No. (%)	0 (0.0)	9 (12.9)	25 (32.5)	<.001 ^j
Digestive, No. (%)	8 (15.4)	15 (21.4)	20 (26.0)	.154 ⁱ
Chronic lung disease, No. (%) ^c	9 (17.3)	10 (14.3)	14 (18.2)	.838 ⁱ
Stroke, No. (%)	1 (1.9)	4 (5.7)	10 (13.0)	.060 ^j
Cancer, No. (%) ^d	1 (1.9)	2 (2.9)	6 (7.8)	.282 ^j
Liver disease, No. (%)	1 (1.9)	3 (4.3)	4 (5.2)	.744 ^j
Kidney disease, No. (%)	0 (0.0)	3 (4.3)	2 (2.6)	.374 ^j
HIV, No. (%)	0 (0.0)	2 (2.9)	1 (1.3)	.625 ^j
MMSE, median (IQR)	29.0 (29.0, 30.0)	29.0 (28.0, 30.0)	29.0 (28.0, 30.0)	.085 ^h
CES-D, median (IQR)	12.5 (8.0, 19.0)	12.0 (8.0, 20.0)	10.0 (5.0, 20.0)	.744 ^h
Number of medications, median (IQR)	2.0 (0.0, 3.0)	5.0 (2.0, 8.0)	7.0 (4.0, 11.0)	<.001 ^h
CNS medication use, No. (%) ^e	22 (44.0)	45 (64.3)	46 (59.7)	.122 ⁱ
Reduced health status, No. (%) ^f	8 (15.4)	22 (31.4)	30 (39.0)	.005 ⁱ
Sedentary status, No. (%) ^g	46 (88.5)	64 (91.4)	73 (94.8)	.190 ⁱ

Abbreviations: CES-D, Center for Epidemiologic Studies Depression Scale; CNS, central nervous system; HIV, human immunodeficiency virus; IQR, interquartile range (25th, 75th percentiles); MMSE, MiniMental State Examination; SD, standard deviation.

^a Missing data: Charlson Comorbidity Index (n=2); MMSE (n=1), CES-D (n=26), medications (n=4), CNS medication (n=4), and sedentary status (n=2).

^b Angina, congestive heart failure, or coronary artery disease.

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^c Asthma, emphysema, or chronic bronchitis.
^d Skin cancers are included, but only if melanoma.

^e Use of any of the following medications having a CNS effect: anticonvulsants, antidepressants, antihistamines, antipsychotics, barbiturates, benzodiazepines, muscle relaxants, or opiates.

^f Fair-to-poor health status.

^g Response of never or <2-hours to the following: “during a typical week in the last month, how often did you engage in moderate sports or recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball, or other similar activities?”

^h Kruskal-Wallis Test.

ⁱ Mantel-Haenszel Chi-Square Test.

^j Fisher’s Exact Test.

Polysomnography measured sleep-disordered breathing and periodic limb movements in sleep by age group

Table 2

Sleep Disorders ^a	Age 18–39 Young Age N=52	Age 40–59 Middle Age N=72	Age 60 Old Age N=77	P value
RDI, median (IQR)	6.0 (3.0, 16.0)	13.0 (6.0, 27.0)	19.0 (11.0, 41.0)	<.001 ^d
RDI 15, ^b No. (%)	13 (26.5)	32 (45.1)	44 (57.1)	<.001 ^e
SpO2nadir (%), median (IQR)	89.0 (85.0, 94.0)	86.0 (81.0, 90.0)	84.0 (81.0, 88.0)	<.001 ^d
PLM-Index, median (IQR)	0.0 (0.0,0.0)	0.0 (0.0,5.0)	0 (0.0, 13.0)	.008 ^d
PLM-Index>15, ^c No. (%)	1 (2.0)	8 (11.3)	18 (23.4)	.002 ^f

Abbreviations: IQR, interquartile range (25th, 75th percentiles); PLM-Index, Periodic Limb Movement Index (sum of periodic limb movements averaged per hour of sleep); RDI, Respiratory Disturbance Index (sum of apneas, hypopneas, and respiratory effort related arousals averaged per hour of sleep); SpO2nadir, lowest oxygen saturation during sleep and while on ambient air.

^aMissing data: RDI (n=4), SpO2nadir (n=4), PLM-Index (n=4), RLS (n=5).

^bDefines moderate-to-severe sleep-disordered breathing.

^cDefines a sleep-related movement disorder.

^dKruskal-Wallis Test.

^eMantel-Haenszel Chi-Square Test.

^fFisher's Exact Test.

Table 3

Symptom burden by age group

Symptoms ^a	Age 18–39 Young Age N=52	Age 40–59 Middle Age N=72	Age 60 Old Age N=77	P value
Sleep-Wake Symptoms				
ISI, median (IQR)	14.5 (11.0, 19.0)	15.0 (10.0, 19.0)	11.0 (7.0, 15.0)	<.001 ^e
Insomnia (ISI ≥ 8), No. (%)	45 (86.5)	61 (85.9)	56 (72.7)	.036 ^f
ESS, median (IQR)	10.0 (6.0, 14.0)	11.0 (6.0, 14.0)	8.0 (5.0, 12.0)	.101 ^e
Daytime drowsiness (ESS ≥ 10), No. (%)	29 (55.8)	39 (55.7)	28 (36.4)	.020 ^f
Drowsy driving, No. (%) ^b	17 (34.0)	25 (35.7)	19 (25.0)	.236 ^f
Fatigue, No. (%) ^c	34 (65.4)	33 (47.1)	27 (35.1)	<.001 ^f
RLS, No. (%) ^d	11 (21.2)	25 (36.8)	10 (13.2)	.163 ^f

Abbreviations: ESS, Epworth Sleepiness Scale; IQR, interquartile range (25th, 75th percentiles); ISI, Insomnia Severity Index; RLS, restless legs syndrome.^aMissing data: ESS (n=2), ISI (n=1), RLS (n=5), frequently tired (n=2), drowsy driving (n=5), fair-to-poor health status (n=2).^bParticipants reported a chance of dozing when “in a car, while stopped for a few minutes in traffic”.^cFacit-Fatigue Scale (“I feel tired — quite a bit or very much”)^dYes response to all four diagnostic criteria of RLS.^eKruskal-Wallis Test.^fMantel-Haenszel Chi-Square Test.

Adjusted odds ratios of having insomnia and daytime drowsiness, using multivariable logistic regression models (N=192)

Table 4

Predictor	Insomnia Model ISI 8	Daytime Drowsiness Model ESS 10
	Adjusted Odds Ratio (95% Confidence Interval)	
Age, year	Age x RDI interaction ^c	0.96 ^e (0.93, 0.98)
RDI 15 ^a	At RDI <15: 0.95 ^d (0.92, 0.99)	1.32 (0.58, 2.98)
	At RDI 15: 1.01 (0.96, 1.05)	
PLM-Index >15 ^b	0.67 (0.24, 1.85)	0.92 (0.32, 2.61)
SpO2	0.98 (0.92, 1.04)	0.96 (0.90, 1.02)
Charlson Comorbidity Index	0.72 (0.50, 1.04)	1.09 (0.76, 1.56)
Total number of medications	1.06 (0.97, 1.16)	1.02 (0.93, 1.11)

Abbreviations: ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index.

^aDefines moderate-to-severe sleep-disordered breathing.^bDefines a sleep-related movement disorder.^cP-value of 0.0499 for age x RDI interaction.^dThe adjusted odds ratio of 0.95 signifies that a 1-year increase in age is associated with a 5% decrease in the odds of having an ISI 8, among those who had an RDI <15 and averaged across the range of ages.^eThe adjusted odds ratio of 0.96 signifies that a 1-year increase in age is associated with a 4% decrease in the odds of having an ESS 10, averaged across the range of ages.

Table 5Driving history by age group^a

Driving History	Age 18–39 Young Age N=43	Age 40–59 Middle Age N=64	Age 60 Old Age N=67	P value
Miles/day, median (IQR) ^b	20.0 (10.0, 50.0)	25.0 (15.0, 50.0)	20.0 (10.0, 40.0)	.451 ^g
Overall driver self-rating, median (IQR) ^c	90.0 (80.0, 95.0)	90.0 (80.0, 95.0)	90.0 (80.0, 95.0)	.965 ^g
Night-time driver self-rating, median (IQR) ^d	90.0 (80.0, 99.0)	90.0 (75.0, 100.0)	85.0 (75.0, 95.0)	.427 ^g
Adverse driving event, No. (%) ^e	30 (69.8)	30 (46.9)	31 (46.3)	.026 ^h
Adverse drowsy driving event, No. (%) ^f	8 (18.6)	4 (6.3)	5 (7.5)	.096 ⁱ

Abbreviations: ESS, Epworth Sleepiness Scale; IQR, interquartile range (25th, 75th percentiles); ISI, Insomnia Severity Index.^a Only included those individuals who drove at least once a week (n=174).^b Based on response to: How many miles do you drive in a typical day?^c Based on response to: How would you currently rate yourself as a driver? Visual analogue scale from 0–100 (0 meaning poor and 100 meaning excellent).^d Based on response to: How confident are you driving at night? Within the context of the past month, using a visual analogue scale from 0–100 (0 meaning 'Not at all confident' and 100 meaning 'Completely confident').^e Based on self-report and included at least one of the following in the past year: crash, near-crash, or getting lost.^f Yes response to: In the past year, have you had any car accident or near misses (almost accidents) because you were sleepy or drowsy while driving?^g Kruskal-Wallis Test.^h Mantel-Haenszel Chi-Square Test.ⁱ Fisher's Exact Test.