



OPEN Associations of personality traits with actigraphic sleep in middle-aged and older adults

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Although prior studies have examined associations of personality traits with sleep, most have investigated self-reported sleep, been cross-sectional, and focused on younger and middle-aged adults. We investigated associations of personality with actigraphic sleep parameters and changes in sleep in 398 cognitively normal adults aged 40–95 years ($M \pm SD = 70.1 \pm 12.0$) in the Baltimore Longitudinal Study of Aging. Participants completed the Revised NEO Personality Inventory (NEO-PI-R) and 6.61 days ± 1.01 nights of wrist actigraphy at the same study visit. Participants with wrist actigraphy at multiple study visits had actigraphy data at 3.11 ± 1.52 visits (follow-up = 2.35 ± 0.70 years). Adjusting for age, sex, race, education, depressive symptoms, comorbidities and interactions of these variables with time, greater extraversion was associated with higher sleep efficiency. After further adjustment for BMI, sleep medication use, and sleep apnea symptoms, greater extraversion was associated with shorter total sleep time, and greater openness was associated with shorter average wake bout length. We observed numerous interactions of personality with sex and age, with stronger personality-sleep associations generally present at younger ages (i.e., aged 50–60 vs. 70–80) and sex differences in associations. Middle-aged and older adults higher in extraversion and lower in openness may be more vulnerable to poor sleep and may benefit from screening for sleep disturbances.

Keywords Personality, Sleep, Actigraphy, Older adults

Sleep disturbances, including difficulty falling or staying asleep and insufficient or excessively long sleep duration commonly occur in middle-aged and older adults^{1–4} and are associated with numerous adverse health outcomes, including cognitive decline, psychiatric disorders, and premature mortality^{5–11}. Hence, understanding factors that influence the onset or persistence of sleep disturbances is critical to informing interventions that may promote sleep health in these populations.

Personality traits have been linked to numerous health outcomes, including sleep problems^{12–18}. The Five-Factor (or “Big-Five”) model¹⁹ includes five primary dimensions: neuroticism (e.g., propensity to experience distress, especially in response to stressors), extraversion (e.g., inclination towards being sociable), openness (e.g., propensity to be imaginative and have wide interests), agreeableness (e.g., tendency to trust and be altruistic), and conscientiousness (e.g., tendency to be diligent and organized). Prior studies examining associations of personality with sleep have primarily assessed sleep via self-reports and have been cross-sectional in nature.

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For example, higher neuroticism has been cross sectionally associated with reports of poorer sleep quality, short and long sleep duration, and longer sleep onset latency among middle-aged and older adults^{12–14,17,20–22}. Greater extraversion, conscientiousness, and openness have also been cross sectionally linked to higher self-reported sleep quality in middle-aged and older people, whereas agreeableness has generally not been significantly associated with self-reported sleep metrics^{12,13,20,22}. Taken together, cross-sectional studies have consistently linked greater neuroticism and lower extraversion and conscientiousness to poorer self-reported sleep quality.

However, there is a dearth of research that has examined the associations of personality characteristics with objectively measured sleep, particularly among middle-aged and older adults. Self-reported sleep parameters may be influenced by personality characteristics or psychiatric conditions (e.g., depression), and their validity may be undermined by memory problems^{23–26}. Research using objective sleep measures is less subject to these potential sources of bias and can provide additional parameters not readily detectable through questionnaires (e.g., average wake bout length). Limited research that has examined the association of personality with objectively-measured sleep found that higher conscientiousness and lower extraversion were associated with greater objectively-measured total sleep time among younger adults¹⁶. Other work has shown that higher neuroticism and lower extraversion and conscientiousness were associated cross sectionally with greater objectively-measured wake after sleep onset, whereas agreeableness was associated with shorter total sleep time among individuals spanning young adulthood to older adulthood^{18,21}.

To our knowledge, no studies have examined the association of personality traits with longitudinal changes in objectively-measured sleep. One study examined links of personality with repeated self-reported sleep measures and found that higher neuroticism and lower extraversion and conscientiousness at the study baseline predicted greater declines in sleep quality among participants 30–107 years of age¹⁸. Understanding the long-term effects of personality on changes in sleep can help identify individuals who may be at risk for sleep disturbances (and associated poor health outcomes) and may therefore benefit from targeted interventions aimed at promoting sleep health and potentially mitigating the health effects of poor sleep.

In the current study, we build on the limited research that has examined associations of personality attributes with change in sleep over time by examining the extent to which personality characteristics are associated with longitudinal trajectories of objectively measured sleep among middle-aged to older adults. Prior cross-sectional and longitudinal research has consistently linked higher conscientiousness and extraversion to better sleep, and higher neuroticism to poorer sleep cross sectionally and longitudinally^{12–14,16,18,22}; thus, we hypothesized that these personality traits would be more robustly associated with measures reflecting poorer sleep both cross sectionally and over time, and that there would be weaker associations observed involving openness and agreeableness with sleep. In addition, given age is associated with changes in sleep and sex differences in sleep that have been identified (e.g., insomnia is more prevalent in women than men)²⁷, we explored whether age and sex moderated personality-sleep associations.

Method

Participants

Participants were from the Baltimore Longitudinal Study of Aging (BLSA), an observational study focused on understanding physical and cognitive changes that occur with aging²⁸. The BLSA is an ongoing study that recruits participants aged ≥ 20 years that are free of medical conditions (with the exception of previous history of skin cancer or controlled hypertension), mobility challenges, cognitive impairment, and were not using H2 blockers, corticosteroids, immunosuppressants, or antibiotics. Follow-up visits are scheduled every 4 years for adults <60 years of age, every 2 years for adults aged 60–79 years old, and annually for adults ≥ 80 years of age.

We studied participants aged ≥ 40 years. Our study baseline was the first assessment with available data on personality and wrist actigraphy. Although our original analytic sample included 408 adults, we excluded 10 participants who, at our study baseline, had dementia, mild cognitive impairment (MCI), or cognitive impairment not meeting criteria for MCI based on cognitive adjudication²⁹, resulting in a final analytic sample of 398 participants. Follow-up actigraphic sleep data were included in analyses; we did not exclude follow-up data from participants who may have become cognitively impaired during follow-up. BLSA protocols and methods were approved by and performed in accordance with the institutional review boards of the Johns Hopkins University and National Institutes of Health Intramural Research Program. All participants provided written informed consent.

Personality

Participants completed the 240-item Revised NEO Personality Inventory (NEO-PI-R), which assesses the five personality domains of the Five-Factor model including neuroticism, extraversion, openness, agreeableness, and conscientiousness³⁰. Items were rated on a 5-point Likert scale ranging from “strongly agree” to “strongly disagree.” Raw personality composites were standardized as orthogonalized factor t-scores and then transformed into z-scores. The NEO-PI-R has demonstrated high test-retest reliability and internal reliability in the BLSA sample^{31,32}.

Wrist actigraphy

Participants were asked to wear an actigraph (Actiwatch-2, Philips-Respironics, Bend, OR) for seven 24-hour periods on their non-dominant wrist. During that period, participants were asked to fill out a sleep diary and record the time they got out of bed in the morning to start their day and the time they got into bed with the intention of sleeping (i.e., “lights out”). At these times, participants were also asked to press an event-marker button on the watch. Participants also documented nap times and removal of the actigraph in diaries and via event marker button presses. Data from sleep diaries, event-marker presses, light levels (from the light sensor

on the Actiwatch-2) were used to identify the period during which participants were trying to sleep. We applied a validated algorithm to these intervals to derive sleep parameters³³ using Actiware 6.0.9 software (Philips-Respiromics). We included observations with ≥ 3 days of actigraphic data and derived multiple sleep parameters, including: total sleep time (TST; total minutes spent asleep while in bed), sleep onset latency (SOL; number of minutes from “lights out” until sleep onset), wake after sleep onset (WASO; total minutes spent awake after sleep onset); sleep efficiency (SE; % of time in bed spent asleep); and average wake bout length (AWB; average number of minutes awake divided by the number of wake bouts). The mean of each sleep parameter was calculated across nights.

Other measures

Demographic information including age, sex, race, and years of education were obtained from participants. Response options for race were White, Black or African American, Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, or two or more races. We created a binary race variable reflecting individuals who identified as White or Other (i.e., Asian, American Indian, Alaska Native, or two or more races) vs. Black. Participants’ height and weight were obtained at each study visit and used to calculate body mass index (BMI; kg/m²). Sleep medication use was assessed using the item, “In the past month, how often did you take sleeping pills or other medications to help you sleep?” Response options were “never”, “<1/week”, “1–2/week”, “3–4/week” and “5 + times a week.” We assessed sleep apnea symptoms based on participant responses to three questions: “In the past month, how often did you have loud snoring at night?; In the past month, how often did you have choking or gasping while sleeping?; and “In the past month, how often did you have excessive daytime sleepiness? Response options were “never”, “<1/week”, “1–2/week”, “3–4/week” and “5 + times a week.” We created a summed score by summing responses on these three items together. Participants were asked about prior medical diagnoses, including hypertension, Parkinson’s disease, diabetes, congestive heart failure, stroke, peripheral artery disease, angina, cancer, and heart attack. Responses were used to compute the percentage of these nine comorbidities for which participants had a positive history. Depressive symptoms were assessed using the Center for Epidemiological Studies Depression Scale (CES-D), a 20-item measure of depressive symptoms³⁴. We excluded the sleep item (“My sleep was restless”) when computing CES-D scores.

Statistical analyses

We calculated descriptive statistics (e.g., means, standard deviations) for study variables. We also report the intra-class correlation (ICC) for each sleep parameter, which reflects the within-person reliability of these metrics over time. To examine cross-sectional and longitudinal associations of baseline personality characteristics with longitudinal trajectories of sleep parameters, we used linear mixed effects models with each sleep parameter as separate outcomes. Model 1 included a single personality dimension, baseline age, race, sex, years of education, comorbidities, depressive symptoms (minus the sleep item), and time in follow-up years, and interactions between personality and time. Model 1 also included interactions between the covariates (e.g., sex) and time to account for the potential longitudinal effect of the covariates on change in sleep outcomes. Model 2 included all the terms in Model 1 and added BMI, sleep medication use, sleep apnea symptoms, and interactions of these covariates with time. All continuous variables were mean-centered. We report results reflecting unstandardized regression coefficients.

The main effect of the personality attribute estimates the cross-sectional association between the baseline personality characteristic and baseline sleep metrics adjusting for covariates, whereas the personality X time interaction estimates the longitudinal association between the personality attribute and change over time in the sleep outcomes adjusting for covariates. Random effects included the intercept and time with an unstructured covariance matrix.

Exploratory analyses were conducted to examine sex and age as moderators of the cross-sectional and longitudinal associations of personality characteristics with sleep outcomes adjusted for the covariates in Model 2. A two-way interaction (predictor X moderator) and a three-way interaction (predictor X time X moderator) were entered into the models. All lower-order terms were included in models involving 3-way interactions. For significant age interactions that yielded a *p*-value of <0.05, we examined associations between personality and sleep parameters using model-derived estimates at ages 50, 60, 70, and 80. This approach does not involve stratifying the sample into subgroups by age, but rather estimates the strength and significance of the association of personality with sleep parameters at a given age (e.g., age 50). For significant sex interactions, we similarly obtained sex-specific estimates. We present results from significant interactions only. Results with *p*-values <0.05 were considered statistically significant across analyses. Linear mixed effects models were fit using `lme()` function from `nlme` package in R Version 4.0.4 (R Core Team, 2021).

Results

Demographic information and descriptive statistics for the whole sample and by sex can be found in Table 1. Among the 398 participants, 109 (27%) participants had ≥ 2 actigraphy assessments; the mean number of visits of individuals with more than 1 visit was 3.11 (standard deviation (SD)=1.52) (range 2–7), and mean follow-up time was 2.35 years (0.70) (range 2–5). Participants completed an average of 6.61 nights of actigraphy wear (SD=1.01 days, range 1–8 days). The within-person reliability of the sleep metrics ranged from low to high depending on the sleep metric (total sleep time ICC=0.76; sleep onset latency ICC=0.49; sleep efficiency ICC=0.76; wake after sleep onset=0.58; and average wake bout length ICC=0.38).

Time was regressed on each of the sleep parameters to determine whether, on average, a given sleep metric was increasing, decreasing, or stable over time. Sleep efficiency ($B=0.23$, 95% CI=0.002, 0.46) and sleep onset latency ($B=0.58$, 95% CI=0.02, 1.14) significantly increased over time, and although total sleep time increased,

Characteristic	
Follow-up time, in years, M (SD) (range)	1.59 (0.84) (1–7)
Number of visits for participants with more than one visit, M (SD) (range)	3.11 (1.52) (2–7)
Follow-up time for participants with more than one visit, M (SD) (range)	2.35 (0.70) (2–5)
Age, in years, M (SD)	70.1 (12.00)
Sex, N (%)	
Men	190 (47.7%)
Women	208 (52.3%)
Race, N (%)	
White and other race	305 (76.6%)
Black	93 (23.4%)
Baseline BMI, M (SD)	27.11 (4.49)
Baseline depressive symptoms*, M (SD)	3.82 (4.4)
Baseline physical health comorbidities, M (SD)	1.0 (1.07)
Baseline sleep apnea symptoms, M (SD)	1.46 (2.03)
Baseline sleep medication use, M (SD)	0.33 (0.95)
Personality characteristics, M (SD)	
Neuroticism	45.07 (8.91)
Extraversion	48.66 (9.85)
Openness	54.03 (10.64)
Agreeableness	53.13 (9.67)
Conscientiousness	52.76 (10.32)
Actigraphic sleep parameters ^a , M (SD)	
Total sleep time (minutes)	401.14 (58.65)
Sleep efficiency (%)	83.86 (6.8)
Wake after sleep onset (minutes)	46.77 (20.03)
Sleep onset latency (minutes)	12.34 (11.05)
Average wake bout length (minutes)	1.74 (0.72)

Table 1. Participant characteristics ($N = 398$). *CES-D: Center for Epidemiologic Studies Depression Scale score with the sleep item; 2 participants were missing data on the CES-D (minus the sleep item) and 2 individuals were missing data on comorbidities at baseline. ^aMeans and standard deviations of participants' actigraphic sleep parameters across all visits.

the slope was not statistically significant ($B = 1.86$, 95% CI = -0.18, 3.90). Wake after sleep onset ($B = -1.66$, 95% CI = -2.55, -0.77) and average wake bout length ($B = -0.12$, 95% CI = -0.14, -0.09) significantly decreased over time.

Total sleep time (TST)

Greater extraversion was cross sectionally associated with shorter actigraphic TST at baseline in Model 1, which adjusted for demographics (i.e., baseline age, race, sex, years of education), depressive symptoms, comorbidities, and interactions between these covariates and time ($B = -0.84$, 95% CI: -1.46, -0.22); this association remained significant in Model 2, which additionally adjusted for BMI, sleep apnea symptoms, and sleep medication use ($B = -0.68$, 95% CI: -1.32, -0.05) (Table 2). No other significant associations of the personality attributes with TST were observed.

Sex moderated the cross-sectional association of neuroticism with TST (p -value for interaction = 0.011) and agreeableness with TST (p -value for interaction = 0.042) (Table 3). Regression coefficients indicate that greater agreeableness is associated with greater increases in TST among men, but not women. In addition, greater neuroticism was associated with greater increases in TST among women, but not men.

Sleep efficiency (SE)

After adjusting for participant demographics and comorbidities, greater extraversion was cross sectionally associated with lower SE at baseline in Model 1 ($B = -0.07$, 95% CI: -0.15, -0.001) (Table 2). There were no other significant main effect cross-sectional or longitudinal associations of personality characteristics with SE.

Sex significantly modified the effect of agreeableness on change in SE (p -value for interaction = 0.049) (Table 3). Among women, greater agreeableness was associated with greater increases in SE, but smaller increases in SE in men, although point estimates were not significant.

Wake after Sleep Onset (WASO)

There were no significant cross-sectional or longitudinal main effect associations of the personality attributes with WASO. However, age moderated the association between extraversion and change over time in WASO (p -

	Model 1				Model 2			
	Baseline Cross-Sectional Associations		Effect on Sleep Change		Baseline Cross-Sectional Associations		Effect on Sleep Change	
	b	95% CI	b	95% CI	b	95% CI	b	95% CI
<i>Total sleep time</i>								
Neuroticism	0.68	-0.05, 1.40	0.03	-0.29, 0.36	0.73	-0.02, 1.48	0.13	-0.21, 0.47
Extraversion	-0.84*	-1.46, -0.22	-0.05	-0.29, 0.19	-0.68*	-1.32, -0.05	-0.03	-0.27, 0.22
Openness	0.30	-0.28, 0.89	0.11	-0.10, 0.33	0.41	-0.19, 1.00	0.11	-0.11, 0.34
Agreeableness	0.25	-0.41, 0.90	0.15	-0.09, 0.38	0.20	-0.48, 0.87	0.17	-0.09, 0.42
Conscientiousness	0.48	-0.12, 1.08	-0.08	-0.28, 0.13	0.37	-0.24, 0.97	-0.10	-0.31, 0.11
<i>Sleep efficiency</i>								
Neuroticism	0.02	-0.07, 0.10	0.013	-0.02, 0.05	0.04	-0.05, 0.13	0.02	-0.02, 0.06
Extraversion	-0.07*	-0.15, -0.001	-0.003	-0.03, 0.02	-0.05	-0.13, 0.02	-0.004	-0.03, 0.02
Openness	0.05	-0.02, 0.12	-0.02	-0.04, 0.01	0.06	-0.01, 0.13	-0.02	-0.05, 0.01
Agreeableness	0.04	-0.04, 0.11	0.02	-0.01, 0.04	0.05	-0.03, 0.13	0.01	-0.02, 0.04
Conscientiousness	0.07	-0.01, 0.14	-0.02	-0.04, 0.003	0.05	-0.02, 0.12	-0.02	-0.05, 0.001
<i>Wake after sleep onset</i>								
Neuroticism	0.06	-0.21, 0.33	0.004	-0.13, 0.14	0.05	-0.24, 0.33	0.01	-0.13, 0.14
Extraversion	0.13	-0.10, 0.36	-0.08	-0.17, 0.02	0.09	-0.15, 0.32	-0.06	-0.16, 0.04
Openness	-0.11	-0.32, 0.11	0.05	-0.04, 0.14	-0.13	-0.35, 0.10	0.05	-0.05, 0.14
Agreeableness	-0.11	-0.35, 0.14	-0.002	-0.10, 0.10	-0.12	-0.37, 0.13	0.001	-0.11, 0.11
Conscientiousness	-0.19	-0.41, 0.03	0.06	-0.03, 0.15	-0.17	-0.39, 0.06	0.07	-0.02, 0.16
<i>Sleep onset latency</i>								
Neuroticism	0.001	-0.15, 0.15	-0.04	-0.13, 0.05	-0.05	-0.20, 0.10	-0.06	-0.16, 0.03
Extraversion	0.08	-0.05, 0.20	0.01	-0.05, 0.08	0.05	-0.08, 0.18	-0.004	-0.07, 0.07
Openness	-0.06	-0.18, 0.06	0.02	-0.04, 0.08	-0.09	-0.21, 0.03	0.04	-0.03, 0.10
Agreeableness	-0.04	-0.17, 0.10	0.01	-0.06, 0.07	-0.08	-0.21, 0.06	0.01	-0.06, 0.09
Conscientiousness	-0.09	-0.21, 0.04	0.04	-0.02, 0.09	-0.08	-0.20, 0.04	0.05	-0.01, 0.11
<i>Average wake bout length</i>								
Neuroticism	-0.002	-0.01, 0.01	-0.0003	-0.004, 0.004	-0.003	-0.01, 0.01	-0.0002	-0.01, 0.01
Extraversion	0.003	-0.01, 0.01	-0.001	-0.004, 0.002	0.001	-0.01, 0.01	0.001	-0.003, 0.01
Openness	-0.01*	-0.02, -0.001	0.002	-0.001, 0.01	-0.01*	-0.02, -0.003	0.003	-0.0001, 0.01
Agreeableness	-0.002	-0.01, 0.01	0.000	-0.003, 0.003	-0.001	-0.01, 0.01	-0.0001	-0.004, 0.004
Conscientiousness	-0.01	-0.02, 0.002	0.001	-0.001, 0.004	-0.01	-0.01, 0.002	-0.0001	-0.003, 0.003

Table 2. Cross-sectional and longitudinal associations of personality characteristics with Sleep Metrics, estimated beta (95% CI) ($N = 398$). Notes. * $p < .05$. Model 1 adjusted for baseline age, sex, race, years of education, comorbidities, depressive symptoms (minus the sleep item), time, baseline age*time, sex*time, race*time, years of education*time, comorbidities*time and depressive symptoms*time. Model 2 included Model 1 covariates, in addition to BMI, sleep apnea symptoms, sleep medication use, BMI*time, sleep apnea symptoms*time, and sleep medication use*time. Significant values are in bold.

value for interaction = 0.009) (Table 4). Greater extraversion was significantly associated with greater decreases in WASO at ages 50 and 60, but not at ages 70 or 80.

Sleep onset latency (SOL)

No significant cross-sectional or longitudinal main effects of personality dimensions on SOL were observed (Table 3); nor were there any age or sex interactions.

Average Wake Bout length (AWB)

Greater openness was cross sectionally associated with shorter AWB length in Model 1 ($B = -0.01$, 95% CI: -0.02, -0.001) and Model 2 ($B = -0.01$, 95% CI: -0.02, -0.003) (Table 2). Age moderated the longitudinal association of extraversion with AWB (p -value for interaction = 0.041) (Table 4). Greater extraversion was associated with greater decreases in AWB at ages 50 and 60, but smaller decreases in AWB at ages 70 or 80; however, these regression coefficients were not statistically significant.

Discussion

We investigated associations of the Big-5 personality dimensions with objectively measured sleep parameters and subsequent change in sleep over time in middle-aged and older adults. Our findings suggest important personality-sleep links and age- and sex- interactions with personality on sleep, and extend the existing literature by focusing on older adults, objective sleep measures, and employing a longitudinal design³⁵. In the sections that

Longitudinal Associations	Women * time	Men * time	Interaction <i>p</i> -value
Total sleep time			
Neuroticism	0.50* (0.05, 0.95)	-0.35 (-0.83, 0.13)	0.011
Agreeableness	-0.03 (-0.35, 0.28)	0.47* (0.09, 0.86)	0.042
Sleep efficiency			
Agreeableness	-0.01 (-0.04, 0.03)	0.05 (0.01, 0.09)	0.049

Table 3. Significant longitudinal interactions of sex and personality on Sleep Metrics, estimated beta (95% CI). Notes. * $p < .05$. Models adjusted for baseline age, sex, race, years of education, comorbidities, depressive symptoms (minus the sleep item), BMI, sleep apnea symptoms, sleep medication use, time, baseline age*time, sex*time, race*time, years of education*time, comorbidities*time, depressive symptoms (minus sleep item)*time, BMI*time, sleep apnea symptoms*time, and sleep medication use*time. Significant values are in bold.

Longitudinal Associations	50 years * time	60 years * time	70 years * time	80 years * time	Interaction <i>p</i> -value
Wake after sleep onset					
Extraversion	-0.27* (-0.45, -0.09)	-0.17* (-0.29, -0.05)	-0.07 (-0.17, 0.03)	0.03 (-0.09, 0.15)	0.009
Average wake bout length					
Extraversion	-0.01 (-0.01, 0.002)	-0.002 (-0.007, 0.003)	0.001 (-0.003, 0.005)	0.004 (-0.001, 0.01)	0.041

Table 4. Significant longitudinal interactions of age and personality on Sleep Metrics, estimated beta (95% CI). Notes. * $p < .05$, ** $p < .01$. Baseline age was modeled as continuous variable. Estimates of associations at specific ages of 50, 60, 70, and 80 were model-derived. Models adjusted for baseline age, sex, race, years of education, comorbidities, depressive symptoms (minus the sleep item), BMI, sleep apnea symptoms, sleep medication use, time, baseline age*time, sex*time, race*time, years of education*time, comorbidities*time, depressive symptoms (minus sleep item)*time, BMI*time, sleep apnea symptoms*time, and sleep medication use*time. Significant values are in bold.

follow, organized by sleep parameter outcome variables, we discuss our findings and place them in the context of the existing literature.

TST

Although we found that total sleep time increased over time, the slope was not statistically significant. We also found that greater extraversion was positively associated with shorter actigraphic TST, consistent with work linking higher extraversion to shorter actigraphic sleep duration among college students (Allen et al., 2016). Older adults higher in extraversion may be more socially and physically active, and this may impinge on time that may otherwise be spent sleeping^{16,36}. Adults higher in extraversion are at risk for attention problems and are generally more susceptible to distractions, including those that could result in a later bed time and subsequently a shorter total sleep time³⁷.

Participant sex moderated the cross-sectional association of actigraphic TST with neuroticism and agreeableness, with point estimates suggesting that higher neuroticism and lower agreeableness are associated with shorter actigraphic TST among women, and longer TST among men. Although previous studies have found that sex did not moderate associations between personality traits and self-reported sleep²², we are unaware of prior studies of sex differences in links between personality and objectively measured TST. Regarding the finding that higher neuroticism was associated with longer TST among men compared to women, some research has shown that women have fewer sleep disturbances following a stressor compared to men, which may contribute to longer TST³⁸; however, other work has shown that the association between distress and poor sleep is not influenced by participant sex³⁹, and a meta-analysis found no moderation effects of the association of pre-stress induction and sleep by sex⁴⁰. Our finding that agreeableness is associated with greater increases in TST among men, but not women, is likely due to the fact that women tend to be higher in agreeableness⁴¹. Scoring higher in agreeableness is linked with having larger social networks and greater average emotional closeness with members of these networks⁴², and perceptions of stronger social support have been linked with longer TST⁴³. Future research is needed to evaluate sex differences in neuroticism-TST and agreeableness-TST associations and the mechanisms explaining these differences.

SE

With regard to sleep efficiency, we observed very small (~2.3% every 10 years) but significant increases over time. This is unexpected, but again, effects were small, and this may be due to the inclusion/exclusion criteria for BLSA participants, which results in a very healthy sample on enrollment. After adjustment for participant demographic characteristics and comorbidities, greater extraversion was cross sectionally associated with worse sleep efficiency. Higher extraversion has been linked to higher levels of arousability and the propensity to seek

out environmental stimuli (e.g., environments with higher levels of noise or light)^{44,45}, which may contribute to lower sleep efficiency. In addition, adults higher in extraversion may engage in various social activities that may contribute to irregular sleep schedules or sleep routines, which may also lead to lower sleep efficiency.

WASO

Although older adults tend to exhibit more WASO than younger adults in line with recently published work in this cohort⁴⁶, the finding that WASO decreased over time is consistent with some work showing that WASO decreases with age⁴⁷. While we observed no main effects of personality with regard to wake after sleep onset, age and extraversion interacted to predict changes in wake after sleep onset over time. At younger ages (i.e., ages 50 and 60), but not older ages (i.e., ages 70 or 80), greater extraversion was associated with greater declines in wake after sleep onset, paralleling our finding of more robust associations of extraversion with average wake bout length and changes therein at younger, but not older ages. Significant associations of extraversion with sleep at younger ages compared to older ages may be because of changes in physical health or lifestyle factors that occur with aging that may better account for sleep^{20,48}. For example, higher extraversion is associated with a lower risk for depression⁴⁹, higher levels of social support⁵⁰, and greater physical activity among adults⁵¹, all of which are associated with better sleep^{52–54}. However, compared to younger adults, older adults may experience more comorbidities and other health conditions that may overshadow the benefits of extraversion later in life. Future research is needed to better understand factors (e.g., physical health comorbidities, physiological aging) that may account for stronger personality – sleep associations observed in younger adults compared to older adults.

AWB

Consistent with previous literature conducted among older adults, we found that average wake bout length significantly decreased over time⁵⁵. We also found that greater openness was cross sectionally associated with shorter AWB, consistent with a study linking openness to better self-reported sleep quality among Black older adults¹³. Higher openness has been associated with greater positive affect, lower reactivity to stressors⁵⁶, life satisfaction⁵⁷ and better physical health⁵⁸, all of which may reduce wake bout durations.

Limitations

Our study has several strengths, including a robust personality measure, objective sleep measures, and a large sample; however, it also has limitations. The sample was limited to adults who were likely healthier at enrollment than the general population and had high mean levels of education. Thus, results may not generalize to other populations of older adults. In addition, the follow-up time of participants with more than one visit was relatively short (M time = 2.35 years). Research investigating associations of personality with subsequent change in sleep over a longer period is needed. Moreover, although this is one of few studies to examine the association between personality traits and actigraphic sleep, we did not examine associations of personality traits with variability in objectively-measured sleep metrics, an important area for future research. In addition, we did not examine mediators that may underlie the observed associations. Personality may drive affective states, behaviors (e.g., substance use), and lifestyle choices (e.g., diet, exercise) that affect sleep. Studies examining such mechanisms are needed to inform the development of interventions to promote health in individuals whose personality profiles place them at elevated risk for poor outcomes. Further, we did not have access to gold-standard measures of sleep-disordered breathing. Although we adjusted for responses to questions about snoring and excessive daytime sleepiness, studies including measures of sleep-disordered breathing would enhance understanding of personality-sleep links. An additional limitation is that data were not collected on health care utilization or adherence to treatment regimens for sleep disturbances. There is evidence that women are more likely to seek out medical care and adhere to pharmacological treatments, including sleep medications^{59,60}, which may have contributed to the observed sex differences in personality associations with sleep health over time. Indeed, further research in this area is needed. In addition, to reduce the risk of type-one errors, we opted to not examine associations of personality facets with sleep. Our previous work has linked various personality facets (e.g., anxiety, anger hostility) cross sectionally to insomnia symptoms in this cohort⁶¹. Future work should consider examining the associations of personality facets of the Big-5 personality domains in relation to objectively measured sleep. Last, we did not adjust for multiple testing. Thus, our results should be interpreted with caution and replication of our findings is needed.

Conclusions

In conclusion, we found multiple links between personality dimensions and objectively measured sleep metrics in older adults, and observed that some of these associations differed by sex, and were stronger in middle-aged than in older adults. Additional research is needed to determine potential mechanisms and pathways that may account for the associations of personality traits with sleep. Future research is also needed to determine factors (e.g., potential hormonal effects, psychosocial changes) that may account for observed sex and age differences in personality-actigraphic sleep associations. Such work will help inform future interventions aimed at promoting sleep health in specific populations of middle-aged and older adults.

Data availability

The data underlying this study are available upon request from the BLSA website (<https://www.blsa.nih.gov>). All requests undergo a review process performed by the BLSA Data Sharing Proposal Review Committee. Requests to access the datasets should be directed to <https://www.blsa.nih.gov>.

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Author contributions

JAR took a lead role in writing the manuscript. YZ conducted the literature review and drafted the introduction. YY and DC assisted with conducting the analyses, and YA provided support regarding the statistical approach and methods. SW was involved in exporting the actigraphic data and pre-processing of the actigraphic data, and VZ oversaw the processing and cleaning of the actigraphic data. DMR, AT, and PC provided their expertise regarding personality. EMS, LF, and AS edited the manuscript. All authors provided intellectual input and feedback on the manuscript.

Declarations

Competing interests

Adam Spira received payment for serving as a consultant for Merck, received honoraria from Springer Nature Switzerland AG for guest editing special issues of *Current Sleep Medicine Reports*, and is a paid consultant to Sequoia Neurovitality, BellSant, Inc. and Amissa, Inc. The other authors declare no competing interests.

Additional information

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