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Objective Measures of Sleep Apnea and Actigraphy-Based Sleep Characteristics as Correlates of Subjective Sleep Quality in an Epidemiologic Study: The Jackson Heart Sleep Study

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Abstract

Objective: Self-reported "sleep quality" often is assessed in epidemiologic studies. However, the bases for variation in sleep quality is not fully understood. We quantified the extent to which subjective sleep quality was related to sleep disorders and sleep characteristics among 795 African American adults.

Method: Between 2012 and 2016, participants underwent home sleep apnea testing and 1-week actigraphy (estimating sleep duration, efficiency, fragmentation, latency). Sleep quality, insomnia and restless legs syndrome symptoms, sleepiness, and physician diagnosis of sleep disorders were self-reported. We fit linear regression models to determine the extent to which subjective and objective sleep measures as well as depressive symptoms and anxiety were related to subjective sleep quality.

Results: After adjustment for covariates, worse sleep quality scores were associated with insomnia and restless legs syndrome symptoms, sleep apnea, physician diagnosis of a sleep disorder, and actigraphy-based fragmented sleep, lower sleep efficiency, and shorter sleep duration. Insomnia symptoms explained the most variance in subjective sleep quality, 21%. Other sleep measures each explained 3% to 7% and psychosocial factors explained 8% to 9% of the variance in subjective sleep quality after adjustment for confounders.

Conclusions: The weak associations of sleep quality with sleep disorders and objectively measured sleep disturbances are consistent with concepts of "sleep health" as a multidimensional

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construct. Sleep quality is a patient-centered outcome that provides unique information over objective measurements of sleep disturbances.

Keywords

sleep quality; Jackson Heart Study; Actigraphy; African American

INTRODUCTION

The National Sleep Foundation's 2014 Sleep Health Index, an annual nationally representative poll of United States adults, reported 35% of Americans endorse a “poor” or “only fair” sleep quality (1). Poor sleep quality is associated with adverse health outcomes including depression, diabetes, hypertension, increased incidence of cardiovascular disease, and mortality (2). Although subjective sleep quality can be measured by validated scales (3,4), epidemiologic studies commonly assess sleep quality by a single-item question such as by asking about satisfaction with sleep (5), overall rating of sleep (good or bad) (6,7), or feeling rested (2).

Researchers have identified the complexity in understanding self-reported sleep quality and challenges in defining this construct (2,3). Although many studies have compared objective and subjective measurements of sleep (8–11), few have explicitly examined how a single-item measurement of subjective sleep quality, as commonly used in epidemiologic studies, maps to more specific sleep characteristics. Participants have self-reported perceptions of sleep quality as feeling tired, rested, or restored on waking as well as the number of awakenings during the night (3,10). In testing the extent to which subjective sleep quality is reflective of sleep disturbances, studies have reported that sleep quality was related to day-to-day variability in sleep duration, total sleep time, sleep efficiency, and sleep latency (11,12). However, this body of literature is limited in the assessment of sleep disorders, sample size, lack of racial diversity, and consistency.

African Americans are more likely to report poorer sleep quality and have poorer overall sleep health compared with other racial/ethnic groups (13,14). Although African Americans have a higher prevalence of poor sleep quality (subjective and objective) and short sleep duration (15), the vast majority of research is conducted among non-Hispanic white populations. Given the disproportionately high burden of poor sleep among African Americans, it is important to better characterize sleep in this population, as well as conduct within-group analyses to investigate the drivers of poor sleep in African Americans. Understanding the determinants and correlates of subjective sleep quality, particularly in African Americans, may improve measurement and help target tailored interventions to improve sleep health.

The goal of this article was to explore the extent to which subjective sleep quality is explained by objective and subjective measurements of sleep. Using data from the Jackson Heart Sleep Study (JHSS), we quantified the extent to which subjective sleep quality is related to underlying sleep disorders measured by self-reported sleep symptoms and physician diagnoses, objective actigraphic measures (sleep latency, wake after sleep onset [WASO], sleep efficiency, sleep fragmentation, sleep duration), and home sleep apnea testing. The variables of interest were selected based on a multidimensional framework for sleep health, which defines optimal sleep according to sleep quality (outcome of interest), sleepiness, timing, efficiency, and duration (5). We hypothesized that objective sleep traits will explain a large portion of the variation in sleep quality. In secondary analyses, we explored the role of psychosocial factors—depression and anxiety—in relation to sleep quality. In addition, we further explored whether the subjective meaning of sleep quality varied by sex, based on the literature, which demonstrates differences in subjective and objective sleep traits by sex (16,17). More specifically, women are more likely to report sleep complaints (17,18), but within African Americans, men have worse objectively measured sleep quality (19). We hypothesized that among men, sleep quality would be most related to sleep disorders or objective measures of sleep, whereas among women, sleep quality would reflect more subjective measures of sleep. A further understanding of the clinical or physiological correlates of self-described poor “sleep quality,” particularly in underrepresented minority populations, may help advance research that addresses sleep health at a population level by helping to clarify the drivers of suboptimal sleep health in the population.

METHODS

The Jackson Heart Study (JHS) is a longitudinal study of 5306 African American adults aged 21 to 95 years from three counties in Jackson, Mississippi (Hinds, Madison, and Rankin). The JHS was designed to prospectively study the etiology of cardiovascular disease among African Americans. Participants were recruited between September 2000 and March 2004, and three follow-up examinations were administered. The details of the JHS design have been previously published (20). The current analyses use data from the JHSS, which was conducted between January 2013 and May 2016. Institutional review board approval was obtained from the University of Mississippi Medical Center and Brigham and Women’s Hospital, and written informed consent was obtained from all participants.

Objective Sleep Measures

Details of the JHSS have been previously published (21). In brief, between 2012 and 2016, participants in the JHS examination 3 were invited to participate in the JHSS, designed to evaluate the associations between sleep disturbances and risk factors for cardiovascular disease, diabetes, and stroke. Participants (n = 913) attended a clinic visit when they underwent fasting venipuncture, anthropometry, blood pressure, and other vascular studies, completed interviewer-administered sleep and health questionnaires, and underwent in-home sleep apnea testing and 1-week wrist actigraphy.

Assessment of sleep-disordered breathing was made with the Embletta-Gold device (Embla, Broomfield, Colorado), used for a single night, which measured nasal pressure, thoracic and abdominal inductance plethysmography, and finger pulse oximetry (to quantify level of oxygen desaturation). The respiratory event index (REI) was derived as the sum of all apneas and hypopneas per hour of estimated sleep, edited to exclude artifact and probable wake epochs as described before (22). Apneas and hypopneas were scored based on complete or nearly-complete reductions in airflow (apneas) or 30% or more decreases in airflow (hypopneas) for 10 or more seconds. Only hypopneas associated with a 4% or more oxygen desaturation were included. Moderate or more severe sleep apnea was defined as REI ≥ 15.

Sleep duration and continuity were assessed for 7 days using the GT3X + Activity Monitor (ActiGraph Corp, Pensacola, Florida) worn on the nondominant wrist, along with completing a sleep diary (23), validated for sleep-wake assessment (24). Actigraphic data during 60-second epochs were scored as sleep or wake by ActiLife version 6.13 analysis software using a validated algorithm (Cole-Kripke) (25). A single trained research assistant manually scored each sleep study using the sleep diary to annotate sleep and wake periods, which was analyzed using the Cole-Kripke algorithm. From valid nocturnal actigraphy data, we computed the average values for sleep duration as total sleep time (<7 hours defined short sleep (26)), sleep midpoint (the average clock time between sleep onset and offset), WASO (minutes awake after sleep onset during the sleep period), sleep efficiency as the total sleep time from lights off to lights on (analyzed continuously and dichotomized at 85% (15)), sleep latency as the minutes between lights off and sleep onset, and sleep fragmentation index, which is a measure of the percent of sleep time spent mobile and the percent of sleep periods ≤1 minute (higher index reflecting more disturbed sleep (27)).

Self-Reported Sleep Symptoms and Disorders

From the sleep questionnaire, we assessed insomnia symptoms, daytime sleepiness, and self-reported physician-diagnosis of sleep disorders (e.g., sleep apnea, insomnia, and restless legs syndrome [RLS]). Insomnia symptoms were assessed by a modified version of the Women's Health Initiative Insomnia Rating Scale (WHIIRS), in which we removed the question regarding sleep quality (28). The items used for assessing insomnia were as follows: trouble falling asleep, waking up several times at night, waking up earlier than planned, and trouble getting back to sleep after waking too early. Responses range from (0) no, not in past 4 weeks, to (4) yes, 5 or more times a week; higher scores indicate more insomnia symptoms. The Cronbach α for WHIIRS was .80. Daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS) using eight scenarios, scored on a 4-point Likert scale from 0 to 3, with the overall score ranging from 0 to 24, with higher scores indicating more sleepiness (29). The Cronbach α for ESS was .77. RLS symptoms were assessed using a modified version of the International Restless Legs Screening Questionnaire, which included the question regarding "the desire to move your legs because of discomfort or disagreeable sensations in your legs" with follow-up questions regarding "relief of symptoms and timing of symptoms," "symptoms worse when at rest," and "symptoms worse later in the day or at night" (30). Indication of RLS required the respondents answer yes to all the questions (30).

Psychosocial Measures

Depressive symptoms and anxiety were included as psychosocial measures. Depressive symptoms were assessed with the Center for Epidemiologic Studies of Depression scale and modeled continuously. The Center for Epidemiologic Studies of Depression is a standardized, 20-item, self-reported instrument that measures the frequency of recently experienced depressive symptoms (31). Anxiety was measured according to the State-Trait Anxiety Inventory for Adults Form Y-2 (32).

Sleep Quality (Outcome)

Subjective quality/satisfaction with sleep was assessed using a single item from the WHIIRS, "overall, was your typical night's sleep during the last 4 weeks?" "very sound or restful," "sound or restful," "average quality," "restless," and "very restless," with responses coded on scale from 1 to 5. In regression models, sleep quality was analyzed as a continuous variable.

Covariates

Covariates selected *a priori* as potential confounders included age, sex, education, income, and employment. Age (date of birth) and sex (male or female) were self-reported. Education was assessed using four categories of formal education completed (less than high school, high school or General Equivalency Diploma, some college, or college degree or higher). Combined family income was a measure of total household income divided into 15 categories and used as a continuous measure that was derived using the midpoints of the categories. Employment was categorized as currently employed or not employed/retired.

To describe the study sample, we reported distributions for smoking status, alcohol consumption, depressive symptoms, anxiety, body mass index (BMI), hypertension, and diabetes. Smoking status was categorized as current smoker versus ever or nonsmoker. Alcohol consumption was categorized as yes or no for currently drinking. BMI was based on measured weight (in kilograms) divided by height (in meter squared). Hypertension was defined as a systolic blood pressure ≥130 mm Hg or a diastolic blood pressure ≥80 mm Hg derived from the last two of three seated blood pressure measurements, use of antihypertensive medications (self-report or identified from a medication inventory), or self-reported history of hypertension (33). Diabetes was defined as fasting glucose ≥126 mg/dl, use of antidiabetic medication, or self-reported diabetes diagnosis (34).

Statistical Analysis

Participants with missing sleep-related measures, symptoms, or diagnosis were excluded from the analysis, yielding a final analytic sample of 795 participants. For descriptive purposes (Table 1 only), comparisons were made by sleep quality categories (good, average, and poor) using the χ^2 and ANOVA tests. Linear regression models were fit to examine the association between validated subjective and objective measures of sleep with sleep quality (Figure S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A602). Each sleep measure was analyzed in separate models with adjustment for demographics (age, sex) and socioeconomic status (education, income, employment). The goal of this article was to explore the extent to which sleep quality is explained by objective and subjective sleep traits; therefore, a minimal model adjustment approach was applied. Furthermore, we determined the proportion of the variance among participant sleep quality scores that is attributable to each subjective and objective sleep measure. In *post hoc* analyses, we included depressive symptoms and anxiety in the regression models. We also applied Benjamini-Hochberg adjustment for multiple comparisons with a false detection rate of 5%. The significance threshold was p values of ≤.310 and ≤.0276 for unadjusted and adjusted estimates, respectively.

Lastly, we tested whether sex or age modified the association between the exposures of interest (sleep disorders, actigraphy-based sleep, sleep characteristics) and sleep quality by testing an interaction term between the sleep exposure and sex or age (defined by <50 or >50 years).

RESULTS

Participants in JHSS were comparable with those in examination 3 in terms of distributions of age, sex, BMI, diabetes, and self-reported sleep duration. However, compared with examination 3 participants not enrolled in JHSS, participants in JHSS (n = 913) had a higher proportion with a college degree (54.2% versus 45.7%), with hypertension (84.7% versus 73.7%), but a lower proportion with very restless or restless sleep (16.7% versus 29.3%).

The overall study sample had a mean (SD) age of 63.1 (10.7) years, and 53.7% were college educated. The sample had a high BMI of 32.0 (6.9) kg/m^2 and a high prevalence of hypertension and diabetes, 85.7% and 26.3%, respectively. Compared with individuals with good sleep quality, those with average or poor sleep quality were more likely to be female, have a lower income, and report more anxiety and depressive symptoms (Table 1).

Sleep characteristics of the sample are also displayed in Table 1. The mean (SD) sleep duration was 6.7 (1.1) hours, and 62.1% had a short sleep duration (<7 hours). The average (SD) sleep efficiency and sleep latency were 86.9% (4.9%) and 6.2 (1.4) minutes. Participants with poor sleep quality had a lower sleep efficiency, were more likely to have a physician diagnosis of insomnia or sleep apnea, and reported more insomnia and RLS symptoms compared with participants with a good or average sleep quality. Sleep duration, sleep latency, physician diagnosis of RLS, daytime sleepiness, or objectively measured sleep apnea (REI) did not differ by categories of sleep quality.

Insomnia symptoms were moderately correlated with self-reported sleep quality, $r = 0.38$ (Table S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A602). A sleep disorder diagnosis, daytime sleepiness, RLS symptoms, sleep efficiency, sleep midpoint, WASO, and REI were weakly correlated with subjective sleep quality; correlations ranged between $r = -0.10$ to 0.17 ($p \leq .05$; Table S1). Depressive symptoms and anxiety were also weakly correlated with sleep quality, $r = 0.23$ and $r = 0.26$, respectively. Sleep duration, fragmentation, and sleep latency were not significantly correlated with sleep quality.

Results from the unadjusted analyses (Table 2) demonstrated that subjective (except daytime sleepiness) and objective sleep measures (except sleep duration and latency) were independently associated with worse subjective sleep quality. In adjusted models, insomnia symptoms, RLS symptoms, REI, physician diagnosis of a sleep disorder, and sleep fragmentation index were each related to a worse sleep quality score. Insomnia symptoms alone explained the highest proportion (20%) of the residual variability in sleep quality. RLS symptoms explained 3% of the variability in sleep quality. After adjustment for multiple comparisons, daytime sleepiness, sleep duration, sleep midpoint, WASO, and sleep latency were not associated with subjective sleep quality in models accounting for demographics and socioeconomic status.

In *post hoc* analyses, both depressive symptoms and anxiety were associated with worse subjective sleep quality. Following insomnia symptoms, these psychosocial factors explained a higher proportion of the residual variability in sleep quality than objective measures of sleep, 6% (depressive symptoms) and 7% (anxiety).

Sex nor age modified the associations between any of the tested sleep exposures (sleep symptoms, sleep disorder, actigraphy-based sleep) and sleep quality ($p_{\text{interaction}} > .10$, all).

DISCUSSION

Subjective sleep quality is commonly assessed using a single-item measure in epidemiologic studies. However, its determinants are poorly understood. We sought to characterize the correlates of subjective sleep quality in African Americans and evaluate whether its variation predominantly reflects objective or subjective sleep disturbances or can be explained by underlying sleep disorders such as insomnia, sleep apnea, or RLS. Similar to the large epidemiologic studies (2,35), we used a single question to assess subjective sleep quality and found that a global measurement of sleep quality is moderately associated with self-reported symptoms of insomnia and only weakly or modestly varies with measurements from other constructs of sleep health such as sleep efficiency, duration, and presence/absence of other sleep disorders. We found that insomnia symptoms were independently associated with reduced sleep quality and accounted for 20% of the variance in sleep quality more than objective measurements of sleep disturbance and other known sleep disorders such as sleep apnea or RLS. These data also suggest that objective and subjective measures of sleep quality may capture different aspects of sleep, and although both are important, each may reflect different underlying pathophysiology of poor sleep or different sleep disorders. It is also important to note that sleep quality may not reflect pathophysiology but may reflect the influences of cultural norms and/or lived experiences that should be considered. In fact, depressive symptoms and anxiety explained a higher proportion of the variability in sleep quality than objective measures of sleep and report of a sleep disorder diagnosis.

Studies have demonstrated that African Americans commonly report poor sleep quality and have a high prevalence of short sleep duration (15,36) and sleep apnea (15) but a lower prevalence of RLS (37). Few studies have simultaneously explored the association between subjective sleep quality and other subjective and objective aspects of sleep health, particularly among African Americans. We found that among our large sample of African Americans, short sleep duration (<7 hours) and sleep disorders such as sleep apnea were highly prevalent and largely undiagnosed, but only explained a small (4%) portion of the variation in reported sleep quality. Although insomnia symptoms are common, data support that insomnia is likely underdiagnosed among African Americans (38). Our results suggest that efforts to screen and treat insomnia may have beneficial effects on sleep quality in African Americans.

Consistent with prior studies (7,39), JHSS study participants who reported low subjective sleep quality were more likely to be female, to have depression, anxiety, and lower socioeconomic status. Furthermore, although symptoms of insomnia were moderately correlated with subjective sleep quality, objective actigraphy-based measures of sleep duration and fragmentation, including WASO, sleep latency, and sleep efficiency, were at most only weakly correlated with self-reported sleep quality. This is consistent with prior literature that demonstrated that subjective sleep quality is not well correlated with objective measures of sleep as measured by either polysomnography (40,41) or actigraphy (42,43). Patients with insomnia report various degrees of daytime and nighttime impairments, likely reflecting variable contributions of dysregulation of wake drive, sleep drive, and sleep perception (44), potentially attenuating associations with objective sleep measurements. We also found that subjective sleepiness measured by the ESS score was not associated with subjective sleep quality, supporting the notion that sleepiness and sleep quality are different constructs (5).

Sleep apnea, which was common in this cohort when assessed using objective measurements, or self-reported sleep apnea, which was uncommon, was each significantly but weakly associated with reduced subjective sleep quality, and again explained a low percent-age of the variation in sleep quality. A physician-reported diagnosis of RLS and symptoms of RLS obtained from questionnaire were uncommon in this cohort, and although weakly associated with subjective sleep quality, RLS symptoms explained about twice or more of the variance in sleep quality than all other sleep measures other than insomnia symptoms, suggesting that when RLS does occur, it has a substantial impact on sleep quality.

The JHSS is a large study aimed at investigating the determinants and consequences of objective and subjective sleep disturbances among African Americans. Strengths of the study include its measurement of multiple sleep-related traits using actigraphy, home sleep apnea testing, and standardized questionnaires that assess multiple domains. Inclusion of an all-African American cohort, a racial group that is understudied despite a high prevalence of sleep disorders, provides new data to the sleep field. However, we cannot assume that the observed patterns in this population would be generalizable to all African Americans, given that JHSS comprises a relatively socioeconomically advantaged Southern community population as reflected by the above-average income and level of education. Future research needs to assess these issues in larger samples of African Americans. Other limitations to the study include use of home sleep apnea testing, which did not allow for assessment of sleep architecture that may provide more insight into understanding neurophysiological correlates of subjective sleep quality. Associations with insomnia symptoms may have been somewhat inflated because of convergent validity between the questions on sleep quality and insomnia from the same instrument. Our study was cross-sectional, which hinders our ability to infer causality; however, this study design allowed us to explore associations with multiple sleep measurements. It is important to note that the goal of this article was not to develop a causal model but was to identify the contributors to variation in sleep quality.

In conclusion, our study suggests that among African American men and women, variation in subjective sleep quality was explained more by insomnia symptoms than by measured sleep disorders or actigraphy-based measurements of sleep continuity or duration. Variation in sleep quality is likely a patient-reported outcome that provides unique information over and beyond objective measurements. Our findings suggest that associations between poor sleep quality and adverse health outcomes may partially reflect risk associated with insomnia, thus, supporting studies designed to evaluate the impact of treating insomnia symptoms are needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Glossary

BMI	body mass index
ESS	Epworth Sleepiness Scale
JHS	Jackson Heart Study
JHSS	Jackson Heart Sleep Study
REI	respiratory event index
RLS	restless legs syndrome
WASO	wake after sleep onset
WHIIRS	Women’s Health Initiative Insomnia Rating Scale

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TABLE 1.

Distribution of Selected Characteristics Across Categories of Sleep Quality in the Jackson Heart Sleep Study (n = 795)

Characteristic	Full JHS Sleep Cohort	Good Sleep Quality (n = 329)	Average Sleep Quality (n = 340)	Poor Sleep Quality (n = 126)
Age, mean (SD), y	63.1 (10.7)	63.5 (10.2)	63.3 (11.4)	61.3 (9.8)
Sex (female), n (%)	527 (66.3)	202 (61.4)	232 (68.2)	93 (73.8)
Education, n (%)				
Less than HS	74 (9.5)	28 (8.6)	32 (9.7)	14 (11.6)
HS or GED	110 (14.2)	36 (11.1)	51 (15.4)	23 (19.0)
Some college/training[a]	175 (22.5)	70 (21.6)	71 (21.5)	34 (28.1)
College degree[b]	417 (53.7)	190 (58.6)	177 (53.5)	50 (41.3)
Income ($10,000), mean (SD)	5.2 (3.3)	5.6 (3.3)	5.1 (3.3)	4.5 (3.6)
Employed, n (%)	379 (47.7)	166 (50.5)	158 (46.5)	55 (43.7)
Anxiety score[c], mean (SD)	30.7 (8.3)	28.8 (7.7)	30.9 (7.9)	34.9 (9.5)
Depressive symptoms score[d], mean (SD)	8.6 (7.8)	6.9 (6.9)	8.7 (7.4)	12.5 (9.6)
Current smoker, n (%)	65 (8.2)	28 (8.6)	22 (6.5)	15 (11.9)
Consume alcohol, n (%)	266 (33.8)	100 (30.8)	124 (36.9)	42 (33.3)
BMI, mean (SD), kg/m^2	32.0 (6.9)	31.5 (6.5)	32.4 (7.3)	32.0 (7.0)
Hypertension, n (%)	673 (85.7)	268 (83.2)	291 (86.1)	114 (91.2)
Diabetes, n (%)	205 (26.3)	80 (25.2)	94 (28.1)	31 (24.6)
Sleep duration, mean (SD), h	6.7 (1.1)	6.7 (1.2)	6.7 (1.1)	6.5 (1.2)
Short sleep (sleep duration <7 h), n (%)	494 (62.1)	200 (60.8)	211 (62.1)	83 (65.9)
Sleep efficiency, mean (SD), %	86.9 (4.9)	87.4 (4.5)	87.0 (4.9)	85.5 (5.3)
Sleep latency, mean (SD), min	6.2 (1.4)	6.2 (1.4)	6.1 (1.4)	6.2 (1.6)
Insomnia diagnosis, n (%)	20 (2.5)	3 (0.9)	10 (2.9)	7 (5.6)
RLS diagnosis, n (%)	8 (1.0)	1 (0.3)	3 (0.9)	4 (3.2)
Sleep apnea diagnosis, n (%)	18 (2.3)	3 (0.9)	8 (2.4)	7 (5.6)
Insomnia symptoms[e], n (%)	116 (14.6)	12 (3.6)	43 (12.6)	61 (48.4)
RLS symptoms, n (%)	200 (25.2)	64 (19.5)	81 (23.8)	55 (43.7)
Daytime sleepiness, mean (SD)	7.1 (4.3)	6.9 (4.5)	6.9 (3.9)	8.0 (4.7)
REI ≥ 15, n (%)	295 (37.1)	112 (34.0)	126 (37.1)	57 (45.2)

Characteristic	Full JHS Sleep Cohort	Good Sleep Quality (*n* = 329)	Average Sleep Quality (*n* = 340)	Poor Sleep Quality (*n* = 126)
REI, mean (SD), events/h	15.8 (15.9)	14.7 (14.3)	16.4 (117.3)	17.2 (16.0)

JHS = Jackson Heart Study; HS = high school; GED = General Equivalency Diploma; BMI = body mass index; RLS = restless legs syndrome; REI = respiratory event index; CESD-20 = 20-item Center for Epidemiologic Studies of Depression; WHIIRS = Women’s Health Initiative Insomnia Rating Scale.

[a] Some vocational or trade school, vocational or trade certificate.

[b] Associates, bachelor’s, graduate, or professional schools.

[c] Anxiety score was the total score of 20-item Trait-Anxiety Inventory, ranging from 0 to 80.

[d] Depressive symptom score was the total score of CESD-20 scale while excluding restless sleep item, with a range from 0 to 57.

[e] Modified WHIIRS.

TABLE 2.

Multivariate Linear Regression Model With Subjective Sleep Quality in the Jackson Heart Sleep Study

	Unadjusted Model			Adjusted Model		
Variable	**β**	**SE**	**Partial R^2**	**β**	**SE**	**Partial R^2**
Insomnia symptoms[a]	0.096	(0.007)**,b	0.20	0.092	(0.007)**,b	0.21
RLS symptoms	0.395	(0.076)**,b	0.03	0.402	(0.081)**,b	0.07
Sleep apnea (REI > 15)	0.138	(0.069)*	0.00	0.213	(0.075)**,b	0.04
Daytime sleepiness	0.015	(0.008)***	0.00	0.014	(0.008)***	0.04
Insomnia Dx	0.606	(0.213)*,b	0.01	0.558	(0.244)*,b	0.04
Sleep apnea Dx	0.576	(0.225)*,b	0.01	0.634	(0.261)*,b	0.04
RLS Dx	0.723	(0.335)*,b	0.00	0.842	(0.381)*,b	0.04
Sleep efficiency	−0.022	(0.007)**,b	0.01	−0.017	(0.007)*,b	0.04
Sleep fragmentation index	0.009	(0.004)*,b	0.01	0.010	(0.004)*,b	0.04
Sleep duration	−0.001	(0)***	0.00	−0.001	(0.001)*	0.04
Sleep midpoint	0.001	(0)*,b	0.01	0.001	(0.001)***	0.04
WASO	0.004	(0.001)*,b	0.01	0.002	(0.002)	0.04
Sleep latency	−0.011	(0.023)	0.00	0.013	(0.025)	0.03
Psychosocial factors						
Depressive symptoms	0.030	(0.004)**,b	0.06	0.026	(0.005)**,b	0.08
Anxiety	0.030	(0.004)**,b	0.07	0.027	(0.004)**,b	0.09

RLS = restless legs syndrome; REI = respiratory event index; Dx = diagnosis; WASO = wake after sleep onset; WHIIRS = Women’s Health Initiative Insomnia Rating Scale. Adjusted model includes age, sex, education, income, employment. Exposures are modeled in separate models. Higher scores indicate worse sleep quality.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .10$.

[a] Modified WHIIRS.

[b] Below the statistically significant threshold: $p \leq .0310$ and $p \leq .0276$ for unadjusted and adjusted estimates, respectively, based on the Benjamini-Hochberg adjustment for multiple comparisons.