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Similarities and Differences in Estimates of Sleep Duration by Polysomnography, Actigraphy, Diary, and Self-reported Habitual Sleep in a Community Sample

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Abstract

Objectives—To compare estimates of sleep duration defined by polysomnography (PSG), actigraphy, daily diary, and retrospective questionnaire and to identify characteristics associated with differences between measures.

Design—Cross-sectional

Setting—Community sample

Participants—The sample consisted of 223 Black, White and Asian middle-to-older-aged men and women residing in the Pittsburgh PA area.

Interventions—Not applicable

Measurements—2 nights of in-home polysomnography (PSG), 9 nights of wrist actigraphy and sleep diaries, retrospective sleep questionnaires, and measures of sociodemographic, psychosocial, and adiposity characteristics.

Results—All measures of sleep duration differed significantly, with modest associations between PSG-assessed and retrospective questionnaire-assessed sleep duration. Individuals estimated their habitual sleep duration as 20–30 minutes longer by questionnaire and their prospective sleep diaries, compared to both PSG- and actigraphy-assessed sleep duration. Persons reporting higher

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hostility had smaller associations between PSG-assessed sleep duration and other methods, compared to those with lower hostility; those reporting more depressive symptoms and poorer overall health had smaller associations between actigraphic-assessed sleep duration and questionnaire and diary measures. Apnea-hypopnea index was not related to differences among estimates of sleep duration.

Conclusions—PSG, actigraphy, diary, and retrospective questionnaire assessments yield different estimates of sleep duration. Hostility, depressive symptoms and perceptions of poor health were associated with the magnitude of differences among some estimates. These findings may be useful in understanding the health consequences of short or long self-reported sleep duration and for guiding investigator decisions about choices of measures in specific populations.

Keywords

polysomnography; actigraphy; sleep diary; sleep duration

INTRODUCTION

Duration of sleep predicts the development of obesity, diabetes and cardiovascular disorders, and mortality (1–4). Sleep duration is also related to risk factors implicated in the development of cardiovascular disease, such as lipid levels, inflammatory biomarkers, and metabolic syndrome (5–7). Associations between sleep duration and adverse cardiovascular outcomes are typically u-shaped, with the lowest health risks observed in those individuals reporting an average of seven to eight hours of sleep per night, and the highest risk related to shorter and longer sleep durations. The majority of findings linking sleep duration to cardiovascular morbidity or mortality are based upon single, self-reported retrospective assessments of habitual sleep length (e.g., ‘Indicate total hours of actual sleep in a 24-hour period.’ (3)).

Lauderdale and colleagues (8) suggest that differences between self-reported retrospective assessments of sleep duration and more objective assessments of sleep duration may influence the interpretation of epidemiological study findings. In a large community study, unattended in-home polysomnography- (PSG) measured sleep duration was shorter by about an hour compared to a diary-based estimate of sleep duration (9). Similarly, actigraphic-estimates of sleep are also about an hour less than questionnaire (10). Perhaps more importantly, large epidemiological studies found that differences among various measures of habitual sleep duration vary by sociodemographic characteristics and sleep characteristics themselves. For example, in the Coronary Artery Risk Development in Young Adults (CARDIA) study, associations between self-reported and actigraphic measures of sleep were smaller in blacks, younger participants, those from lower socioeconomic status (SES), those who reported poorer overall health, and those with less efficient sleep; depressive symptoms did not impact the extent of associations in this study (8). In the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) study, associations were smaller among younger participants, men, more educated individuals, and those with more variability in sleep time across the sleep measurement period (10). In a study of older adults without sleep disorders, those with poor global sleep quality and those using sleep medication reported shorter total sleep time in diaries, relative to actigraphy compared to participants with better

quality sleep (11). Reporting less sleep time relative to PSG- or actigraphy-measures of sleep duration is also observed in clinical sleep samples, most notably among individuals with insomnia, as well as those with sleep apnea (12,13).

No study has compared simultaneously four estimates of sleep duration, i.e., by PSG, actigraphy, prospective daily diary, and retrospective questionnaire, and identified the participant characteristics that may impact the magnitude of associations among the four estimates. Thus, the primary aims of the current investigation are twofold. First, because PSG is considered to be the “gold standard” in clinical studies, we compare PSG estimates of sleep duration to estimates based on other methods. Because PSG measures are impractical for some epidemiological studies and are based on relatively few days, we also compare actigraph- to prospective diary- and retrospective questionnaire-assessed sleep duration. Second, we analyze the sociodemographic, sleep, and psychological characteristics that may moderate associations with measures, expecting participant characteristics indicative of disadvantage and poor health to be related to smaller associations among the estimates of sleep duration. Such differences would support using multiple methods of assessing sleep duration, especially in disadvantaged groups.

METHODS

Participants

Participants in the current study were recruited from a larger study called Heart Strategies Concentrating on Risk Evaluation (HeartSCORE), a prospective/nested intervention study at the University of Pittsburgh, Pittsburgh, PA. HeartSCORE is designed to identify the impact of nontraditional cardiovascular risk factors in 2,000 African-American, White and Asian men and women in western Pennsylvania. Exclusion criteria for the current study, SleepSCORE (Sleep Strategies Concentrating on Risk Evaluation), included: known preexisting heart disease or stroke; active treatment for diabetes; active treatment for sleep apnea including regular positive pressure therapy; regular use of pharmacologic treatment for sleep problems; oxygen therapy; shift work; pregnancy; and any other medical condition that would make data collection unreasonable or unsafe. Individuals on anti-hypertensive medication were not excluded. Eligible persons enrolled in HeartSCORE were approached to determine their interest in participating in SleepSCORE. Data were collected over 46 months from 2004 to 2008. The sample consisted of 223 middle-aged men and women, 123 Whites, 4 Asians and 96 Blacks.

Overview of Protocol

The SleepSCORE protocol began within approximately three months of a HeartSCORE visit. Beginning early in the week, the 10-day protocol for SleepSCORE included two nights of in-home PSG, with sleep disordered breathing measured on the first night; daily wrist actigraphy and daily sleep diary entries in the morning and evening of all days, 48 hours of ambulatory blood pressure monitoring typically on days four and five; two overnight urine collections for catecholamines; and completion of psychosocial questionnaires, including the measure of habitual sleep on the second day. The Institutional Review Board of the University of Pittsburgh reviewed and approved the protocol and all participants signed

informed consent prior to beginning the protocol. Participants received financial remuneration for their participation as well as detailed reports of their PSG sleep. A complete description of the protocol can be found elsewhere (14).

Measurement of Sociodemographic Characteristics

Age, race, gender, marital status, employment, and income were determined by self-report. Participants were asked about the highest level of education completed from grade school to doctoral degree (11 categories) and annual income by five categories of < \$10,000 to \$80,000 or more. A composite socioeconomic status (SES) score was created by standardizing education and income categories and creating an average for each person, as previously described (14). Marital status was based on participants' reports of being currently married or in a committed relationship.

Measurement of Sleep Characteristics

Sleep diary measures—Participants completed a sleep diary in the evening before going to bed and upon awakening in the morning. The diary, a modification of the Pittsburgh Sleep Diary (15), is a daily record of sleep-wake timing, sleep quality, mood and physical symptoms, napping, exercise, substance and medication use, and factors that interrupted nighttime sleep. Participants recorded their total sleep time in the diary by noting the time they “tried to go to sleep” (bed time) and the time they “finally awoke for the day” (wake time), as well as the number of minutes that it took them to fall asleep (sleep latency) and the total number of minutes they spent awake after they fell asleep (wake time after sleep onset). Total sleep time for each night was then calculated as: bed time to wake time, minus sleep latency and wake time after sleep onset. Thus, daily diary-based sleep duration was calculated from other questions rather than being ascertained directly by self-report.

Sleep Questionnaires—Pittsburgh Sleep Quality Index (PSQI) is an 18-item self-report questionnaire designed to measure sleep quality and quantity over the preceding month (16). Retrospective estimates of habitual sleep duration were obtained using the PSQI item: “During the past month, how many hours of actual sleep did you get at night?” Thus, PSQI habitual sleep duration was ascertained by direct self-report, rather than being calculated from other questions. The Epworth Sleepiness Scale (ESS) is an eight-item questionnaire designed to assess daytime sleepiness by determining the propensity of dozing or falling asleep during daytime activities (17). Each question is rated from “never” to “highly likely” regarding the likelihood that one would fall asleep during a given activity. Items are totaled to compute a final score ranging between 0 and 24, with scores above 10 indicative of clinically significant daytime sleepiness (18). Insomnia was determined by use of Insomnia Symptom Questionnaire (19). A participant considered to have symptoms of insomnia had to respond that he/she had trouble falling asleep or difficulty staying asleep three or more times a week, feeling that sleep was unrefreshing three or more times a week, *and* reporting that sleep problems were affecting at least one area of her/his life or daytime functioning, quite a bit or extremely so (3 or 4 on a scale of 0–4).

Polysomnography—Polysomnography (Siesta, Compumedics, Inc – Charlotte, NC) was conducted in the participant's home on the first two nights of the 10 day protocol using

portable equipment. Certified technologists applied electrodes and sensors to measure bilateral central and occipital electroencephalograms (EEG), bilateral electro-oculograms (EOG), bipolar submental is electromyograms (EMG) and a lead II electrocardiogram (ECG). Certified technologists scored sleep records in 20-second epochs using Rechtschaffen and Kales' stage scoring criteria (20). PSG outcomes included total sleep time, sleep latency, and wakefulness after sleep onset. Sleep disordered breathing was measured on the first night of PSG. Measures included: nasal pressure and flow, respiratory effort using thoracic and abdominal bands, and oxygen saturation using fingertip oximetry. The apnea-hypopnea index (AHI) was calculated during nighttime sleep time using American Academy of Sleep Medicine Task Force definitions (21). All sleep records were coded prior to the updated guidelines for sleep scoring published in 2007 (22). Total sleep time across the two nights were averaged for a PSG measure of sleep duration. Two individuals did not have PSG data and six participants reported in their diary being ill on both nights of data collection and were excluded.

Actigraphy—Participants wore the Actiwatch 16 (Respironics, Bend, OR), a light weight battery-operated wrist activity monitor for all 10 days of the protocol. Data were collected in one-minute epochs using the default (medium) threshold for detection of wake and sleep periods. The Actiware software program (version 5.0) calculated sleep variables; stored data were downloaded into the program for statistical analysis of sleep measures, including total sleep time: total minutes scored as sleep from sleep start to sleep end by the program. Bed time and wake time from the sleep diary were compared to the data from the Actiware program; nights which involved discrepancies of more than two hours from the sleep time recorded in diary occurred were eliminated from the averages. This occurred for 2 participants, resulting in 4 and 5 nights of accepted data. The Actiwatch has been widely used in research studies and the resulting sleep outcome measures have been validated against PSG measures in the laboratory (23–25). Correlations between PSG- and actigraphy-measured total sleep time range from .72 to .98 in laboratory validation studies (24).

Measurement of Psychosocial Characteristics and Self-rated Health

Depressive symptoms were measured using the 20-item Center for Epidemiologic Studies Depression Scale, with the item regarding restless sleep removed (CES-D; (26)). The top quartile of the distribution was 8 and above. Alpha coefficient was .88 in the present sample. Hostility was measured using the 27-item Cook-Medley scale (27); the top quartile of the distribution was 11.4 and above. Alpha coefficient was .77. Using one item from the SF-36, participants rated their overall health on a 5 point scale: excellent, very good, good, fair, and poor. Only 18 reported their health as fair or poor.

Data Analyses

Actigraphy- and diary-assessed total sleep time was measured over nine nights, with the first two nights typically coinciding with the PSG measures and nights three and four typically coinciding with hourly assessment of BP throughout 48 hours. Therefore, for estimates of sleep duration, we considered averaging total sleep time over different time periods for assessing the associations with PSG: for nights of concurrent actigraphy and diary (two nights); all nine nights of actigraphy and diary, which should be the most reliable estimates;

and nights that did not coincide with other measurements that could potentially disturb sleep, i.e., nights five through nine. Findings for nights five through nine did not differ from results for all nine nights. Prior to the analysis with nine nights, we averaged the nights that were the same day of the week, e.g., participants may have had two Monday nights or two Tuesday nights. Thus, we averaged those nights and then averaged the entire week of nights. We conducted Pearson correlations among the sleep variables and compared sleep duration estimates by paired t-tests. We then conducted a series of linear regression analyses predicting PSG-assessed sleep duration from habitual sleep duration estimates obtained through the retrospective self-report, and sleep diaries and actigraphy; and predicting actigraphy-assessed sleep duration from sleep duration estimates obtained through retrospective questionnaire and sleep diaries. Following these analyses, we tested whether the associations varied by sociodemographic characteristics (age, sex, race, marital status, SES), sleep characteristics (insomnia, Epworth score, AHI, variability in sleep duration for actigraphy and diary measures as appropriate), depressive symptoms, Cook-Medley hostility, and self-rated health. For ease of interpretation, these moderation hypotheses are presented with categories based on clinical cutoffs, e.g., AHI ≥ 15 , or by classifying individuals into the highest risk quartile, e.g., lowest quartile of SES, or for overall health with excellent and very good combined and good, fair, and poor combined. We also conducted the analyses testing for interactions with the continuous moderator variables, e.g., full distribution of SES, and statistically significant results were virtually the same. Interactions, i.e., moderation analyses, at $p < .10$ are presented in tabular form to reduce size of tables but also to allow readers who may value knowing trends that approach conventional levels of significance. Because so few participants reported greater than eight hours of habitual sleep, we did not test for curvilinear relationships. Post-hoc power calculations showed we could detect a partial correlation of .187 at 80% power. P values of $<.05$ were considered statistically significant.

RESULTS

Sociodemographic, sleep, psychosocial characteristics of the sample are shown in Table 1. The sample included approximately equal numbers of men and women, and a sizeable proportion of African-Americans. The sample was about 60 years of age on average (range 45–78). Median income was \$40,000, and approximately half of the sample had completed college or had an advanced degree post-college. Most were married or in a committed relationship and most rated their health as excellent or very good.

On average persons reported habitual sleep duration of about 6 ½ hours (Table 2). Habitual sleep duration of 5 hours or less was reported by 17.0% of participants; $>5 - 6$ hours by 22.9%; $>6 - 7$ hours by 35.3 %; $>7 - 8$ hours by 20.7%; and >8 hours by 4.0% of participants. About 10% reported significant insomnia symptoms and a quarter reported elevated daytime sleepiness scores and elevated AHI scores.

Correlations among the estimates of sleep duration were all statistically significant (Table 2). As might be expected based on study procedures, sleep duration estimates based on actigraphy and diary were highly correlated. PSG-assessed sleep duration correlated most strongly with actigraphy assessments on concurrent nights. Retrospective reports of habitual

sleep duration were only modestly associated with PSG-assessed sleep duration. Despite the observed correlations, mean values for sleep duration differed across all of the measurement methods.

Predicting PSG-assessed habitual sleep duration

Compared to PSG-assessed sleep duration, participants reported longer sleep duration by retrospective questionnaire and sleep diary on concurrent nights, and had shorter sleep duration by actigraphy on concurrent nights (Table 3). The correlations of PSG with retrospectively self-reported habitual sleep duration were modest and with actigraphy- and diary-assessed sleep duration substantial on the same two nights. The same pattern of results was obtained for actigraphy- and diary-assessed sleep duration averaged across the nine nights, although the associations were smaller.

We evaluated whether participants' characteristics moderated the associations between PSG-assessed sleep duration and other sleep duration estimates (Table 4; significance level of $p < .10$). For the association of PSG- and retrospectively self-reported sleep duration, one interaction term was significant: less hostile participants had a stronger association between the two estimates of sleep duration relative to the more hostile individuals. For the associations of PSG- and actigraphy-assessed sleep duration across 9 nights, those with insomnia had a stronger association. For the association of PSG- and diary-assessed sleep duration across nine nights, four interaction terms were significant. Participants who were white, reported better overall health, were less hostile, and had less variability in diary-reported sleep duration had stronger associations between PSG- and diary-reported sleep duration, compared to their counterparts. AHI did not moderate the relationships between PSG-assessed sleep duration and any of the other methods of assessment.

Predicting actigraphy-assessed sleep duration

Compared to actigraphy-assessed sleep duration, retrospective report of habitual sleep duration was longer, showing a moderate association (Table 5). Diary-reported sleep duration was also longer, although the associations with diary- and actigraphy-assessed sleep duration were substantial.

The association between actigraphy-assessed and PSQI-assessed habitual sleep duration was modified by age, insomnia symptoms, depressive symptoms, and perceptions of overall health (Table 6). Older participants, those without insomnia symptoms, fewer depressive symptoms, and those with better self-rated health had larger associations between actigraphy- and retrospectively self-reported habitual sleep duration. Five significant interactions were observed for associations between actigraphy- and diary-reported sleep duration: participants without insomnia symptoms, and those with less depressive symptoms, less hostility, better self-rated health, and less variability in diary-assessed sleep duration had stronger associations.

DISCUSSION

One objective of this study was to compare estimates of sleep duration by four commonly used methods: electrophysiological recordings by in-home PSG studies; behavioral sleep-

wake patterns by actigraphy; prospective daily diaries; and retrospective self-reports. Sleep duration estimated by in-home PSG studies differed from other methods of estimating sleep duration. On average PSG-assessed sleep duration was shorter by about 20 - 30 minutes than retrospective self-reports or prospective diary-based sleep duration estimates. On the other hand, PSG-assessed sleep estimates were somewhat longer compared to actigraphy-assessed sleep duration by 7 to 20 minutes, depending on the number of nights assessed. PSG-assessed sleep duration was modestly associated with retrospective self-reported habitual sleep duration, with less than 2% of overlapping variance, whereas its association with actigraphy- and diary-assessed sleep duration across the same two nights was substantial, with 44% and 31% overlapping variance, respectively. However, those associations were substantially reduced when duration (to 11.6% and 5.3% respectively) was estimated by averaging across nine nights of data collection, which statistically should provide a more reliable estimate of sleep duration. Taken together, these findings suggest that in studies of habitual sleep duration, actigraphy measures of sleep duration would be useful.

Second, considering that the estimate of habitual sleep duration in epidemiological studies often consists of a simple retrospective questionnaire, it is noteworthy that not only is the retrospective self-reported habitual sleep duration modestly related to PSG sleep duration, but it is also moderately associated with actigraphy- and diary-assessed values averaged across nine nights, with overlapping variance of 16% and 25%, respectively. These findings are similar to those reported for a sample of participants 55 years and older, with retrospective self-reported habitual sleep duration correlating .29 with actigraphy-measured sleep duration across 14 nights (28). Nonetheless, it is clear that factors other than measured sleep duration by PSG, actigraphy, and diary determine retrospective self-reported habitual sleep duration.

That brings us to the second objective of the study -- to identify characteristics associated with the magnitude of associations between different estimates of sleep duration. The extent of hostility, depressive symptoms, and perceptions of overall health impacted the results.

Participants who had higher hostility scores had weaker associations between PSG-assessed and both retrospective self-reports of habitual sleep and diary-reported sleep duration; and between actigraphic-assessed and diary reports of sleep duration. Similarly, participants who had higher depressive symptom scores had weaker associations between actigraphic-assessed and retrospective self-reports, and between actigraphic-assessed and diary reports of sleep duration. Those who rated their health as poorer had weaker associations between actigraphy-assessed and both retrospective self-reports of habitual sleep duration and diary-assessed sleep duration. In fact, stratified analyses showed that PSG-assessed sleep duration was unrelated to retrospectively reported habitual sleep in participants in the highest quartile of hostility or depressive symptoms scores.

Previous work in clinical samples has shown that depression is associated with smaller associations between PSG- and self-reported habitual sleep duration, although not all studies have produced consistent results (29,30). As sub-clinical depressive symptoms and hostility are each associated with decreased sleep continuity and quality (31,32), these aspects of sleep may have contributed to null associations between PSG-assessed and retrospective

self-reports of habitual sleep duration among individuals with greater hostility and depressive symptoms in our sample. It is also possible that endorsement of negative affect and short sleep are both influenced by a negative reporting style or heightened somatic sensitivity (33). In any case, investigators should be aware that self-reported retrospective assessments of sleep duration may be quite different from other measures of sleep in persons high in negative affect or experiencing poorer general health.

Insomnia symptoms also moderated the associations but the direction varied across sleep measures. We observed a larger PSG-actigraphy association among those with more insomnia symptoms but smaller associations between actigraphy and retrospective questionnaire and actigraphy and diary measures. This may be due to decreased accuracy of actigraphy in measuring sleep in the setting of insomnia. Perhaps the PSG measurements resulted in greater than usual levels of arousal, akin to “performance anxiety”, whereas the actigraphy protocol did not. More variable sleep estimates in the diary were also associated with a lower correspondence between diary and actigraphy estimates of sleep duration.

Sociodemographic characteristics impacted few associations between sleep duration measures. Whites had somewhat stronger associations between PSG and diary-based estimates across nine nights, respectively. This result was similar to Lauderdale et al. with regard to actigraphic and self-reported retrospective sleep duration association being larger in Whites (8). We observed no effects for gender or SES but marital status did impact a number of associations. Those who were married or in a committed relationship had stronger PSG-actigraphy associations than those not in a committed relationship, perhaps because their sleep patterns were co-entrained with their partners. In this context it is noteworthy that in two cohort studies, retrospective reports of short sleep duration were more apparent among unmarried, lower SES, depressed, and those in poorer overall health (34). Our data raise the possibility that these findings may be more likely to have differences in associations among habitual sleep duration measures.

Limitations and Strengths of Study

Limitations of this study include the possibility that self-monitoring of sleep may disrupt typical behavior, and, thus, partially account for differences in self-reported, behavioral, or electrophysiological data. It is also possible that the more intensive the monitoring, the less typical the sleep duration. As we only included participants who were free from previously diagnosed sleep disorders, generalization to samples with known sleep pathologies may be limited. The data were collected as part of a larger community study of cardiovascular risk in Blacks and Whites in one urban area, and findings may not generalize to other settings. However, this investigation extends previous work by studying a large sample of Black and White adults, collecting data over a nine-night period, and comparing various methods of assessing sleep duration. Finally, the paper focused on only one dimension of sleep health and did not compare estimates of sleep continuity, timing, or regularity by the different methods.

Implications and Summary

The vast majority of epidemiological studies supporting an association between sleep duration and cardiovascular health are based on retrospective self-reported habitual sleep duration, often derived from a single item. The present analyses suggest that the magnitudes of the relationship between retrospective reports of habitual sleep duration and PSG measures of sleep duration as well as between diary reports with both PSG and actigraphy measures of sleep duration are attenuated among individuals with high levels of hostility. Furthermore, the magnitude of the associations between retrospective reports of habitual sleep and actigraphic-assessed sleep duration as well as between diary reports and actigraphic measures of sleep duration are attenuated among individuals with high levels of depressive symptoms and poorer self-rated health. It may be important to consider the extent to which hostility, depressive symptoms, and perceptions of overall health contributes to the cardiovascular health risk associated with habitual sleep duration. On the other hand, it is reassuring that the relationships between estimates of habitual sleep duration by retrospective reports, daily diaries, behavioral sleep-wake patterns, and electrophysiology are similar among individuals who differ in the amount of sleep-disordered breathing. These findings suggest that investigators consider the distributions of insomnia, depressed mood, and night to night variability in sleep duration in the cohort to be studied as these factors may impact the performance of simpler measures of sleep duration. Furthermore, findings also suggest that it is important to use multiple methods of measuring sleep duration in order to have confidence in the findings. A better understanding of how various methods of sleep assessment are related may have important implications for interpreting studies of habitual sleep duration and health, which typically rely on retrospective, self-report assessments of sleep.

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Abbreviations

PSG	Polysomnography
CARDIA	Coronary Artery Risk Development in Young Adults
SES	socioeconomic status
HeartSCORE	Heart Strategies Concentrating on Risk Evaluation
SleepSCORE	Sleep Strategies Concentrating on Risk Evaluation
HCHS/SOL	Hispanic Community Health Study/Study of Latinos
PSQI	Pittsburgh Sleep Quality Index
ESS	Epworth Sleepiness Scale

EEG	electroencephalogram
EOG	bilateral electro-oculogram
EMG	bipolar submental is electromyogram
ECG	electrocardiogram
AHI	apnea-hypopnea index
BMI	Body mass index
CES-D	Center for Epidemiologic Studies Depression Scale
SBP	systolic blood pressure
DBP	diastolic blood pressure

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Table 1

Sociodemographic, Psychosocial and Adiposity Factors in Men and Women in SleepSCORE

Mean (SD) Age (years)	59.9 (7.2)
Range	45.6–77.6
N (%) Gender	
Male	113 (50.7)
Female	110 (49.3)
N (%) Race	
African American	96 (43.0)
White/Asian	127 (57.0)
N (%) Married/committed relationship	
Yes	146 (65.4)
No	77 (34.5)
N (%) Income	
< \$20,000	32 (14.4)
\$20,000 – 40,000	64 (28.7)
\$40,000 – 80,000	75 (33.6)
> \$80,000	37 (16.6)
N (%) Educational attainment	
High school or less	35 (15.6)
Some college or non- 4 yr degree	74 (33.2)
College degree	46 (20.6)
Advanced degree	68 (30.5)
Mean (SD) CES-D depressive symptoms	5.3 (6.6)
Mean (SD) Cook Medley hostility	8.6 (4.3)
N (%) self-rated health	
Excellent/very good	122 (55.0)
Good/fair/poor	100 (45.0)
N (%) Insomnia Symptoms	
Yes	22 (9.9)
No	201 (90.1)
N (%) Epworth Daytime Sleepiness scale	
> 10	56 (25.1)
10	167 (74.9)
Mean (SD) Apnea-Hypopnea Index	13.3 (14.9)
N (%) AHI 15	60 (26.9)

Note. CES-Depressive symptom score removed the one sleep item from the total.

Table 2

Means (SD) and Correlations amongst PSQI Self-report Habitual, Polysomnography, Diary, and Actigraphy Measures of Sleep Duration

	PSG (Nights 1,2)	Actigraphy (Nights 1–2)	Diary (Nights 1–2)	Actigraphy (Nights 1–9)	Diary (Nights 1–9)	Mean (SD)
Self-report habitual sleep	0.14 *	0.29 ***	0.28 ***	0.40 ***	0.51 ***	6.46 (1.21)
PSG (Nights 1,2)	--	0.66 ***	0.56 ***	0.34 ***	0.23 **	6.10 (0.98)
Actigraphy (Nights 1–2)		--	0.69 ***	0.64 ***	0.38 ***	5.98 (1.08)
Diary (Nights 1–2)			--	0.40 ***	0.56 ***	6.36 (1.32)
Actigraphy (Nights 1–9)				--	0.68 ***	5.78 (0.89)
Diary (Nights 1–9)					--	6.64 (1.02)

Note:

*

p<0.05,

**

p<0.01,

p<0.001

Note all means differ by paired t-tests.

Table 3
 Prediction of Polysomnography Sleep Duration (M=6.10, SD = .98) by Other Measures of Sleep Duration (N=215)

	Mean (SD)	Mean Difference from PSG (SD)	Paired T-test P-value	Correlation (P-value)	β (95% C.I.)
Self-report habitual sleep	6.46 (1.21)	-0.37 (1.45)	<0.001	0.14 (0.05)	0.11 (0.00, 0.22)
Actigraphy (Nights 1–2)	5.98 (1.08)	0.12 (0.85)	0.040	0.66 (<0.001)	0.60 (0.51, 0.69)
Diary (Nights 1–2)	6.35 (1.32)	-0.26 (1.12)	0.001	0.56 (<0.001)	0.41 (0.33, 0.50)
Actigraphy (Nights 1–9)	5.78 (0.89)	0.31 (1.08)	<0.001	0.34 (<0.001)	0.37 (0.24, 0.51)
Diary (Nights 1 – 9)	6.62 (1.02)	-0.53 (1.24)	<0.001	0.23 (<0.001)	0.22 (0.10, 0.24)

Table 4

Polysomnography Sleep Duration as Predicted by other Sleep Measures according to Participant Characteristics, $p < .10$ for Interaction Terms

Other Sleep Measure/Participant Characteristic	N	PSG Mean (SD)	Other Sleep Mean (SD)	Correlation (P-value)	Interaction Term (P-value)
Self-report habitual sleep					
Depressive symptoms					
Highest quartile	56	6.14 (.98)	6.32 (1.43)	-.03 (.85)	-.20 (.08)
Others	159	6.08 (.98)	6.51 (1.12)	.21 (.01)	
Hostility					
Highest quartile	55	6.02 (.93)	6.16 (1.29)	-.12 (.37)	-.28 (.02)
Others	160	6.12 (.99)	6.57 (1.16)	.22 (<.001)	
Actigraphy (nights 1–9)					
Insomnia					
Yes	20	6.22 (1.32)	5.84 (.85)	.57 (.01)	.56 (.03)
No	195	6.09 (.94)	5.78 (.90)	.31 (<.001)	
Variability in actigraphy duration (nights 1–9)					
Highest quartile	55	6.00 (1.27)	5.73 (.74)	.39 (<.001)	.35 (.06)
Others	159	6.13 (.86)	5.82 (.94)	.34 (<.001)	
Diary (nights 1–9)					
Race					
Black	89	5.91 (1.04)	6.42 (1.11)	.03 (.76)	.34 (.01)
White	126	6.23 (.91)	6.77 (.94)	.38 (<.001)	
Married/committed relationship					
No	73	6.12 (1.17)	6.58 (1.13)	.06	.27 (.04)
Yes	142	6.09 (.87)	6.65 (.97)	.37	
Hostility					
Highest quartile	55	6.02 (.93)	6.61 (1.14)	-.05 (.71)	-.38 (.01)
Others	160	6.12 (.99)	6.63 (.99)	.34 (<.001)	
Variability in diary duration (nights 1–9)					
Highest quartile	54	5.92 (1.27)	6.50 (1.20)	-.04 (.76)	-.40 (<.001)
Others	161	6.16 (.86)	6.67 (.96)	.39 (<.001)	

Prediction of Actigraphy Sleep Duration (M=5.78, SD=.89) across Nine Nights by Self-report Habitual Sleep and Daily Diary (N=223)

Table 5

	Mean (SD)	Mean Difference from Actigraphy (SD)	Paired T-test P-value	Correlation (P-value)	β (95% C.I.)
Self-reported habitual sleep	6.46 (1.21)	-.68 (1.18)	<.001	.40 (<.001)	.29 (.21, .38)
Diary (nights 1 – 9)	6.64 (1.02)	-.85 (.77)	<.001	.68 (<.001)	.60 (.51, .68)

Actigraphic Sleep Duration across Nine Nights by Self-Report Habitual Sleep and Daily Diary According to Participant Sleep Characteristics, $p < .10$ for Interaction Terms

Other Sleep Measure/Participant Characteristic	N	Actigraphic Mean (SD)	Other Sleep Mean (SD)	Correlation (P-value)	Interaction Term (P-value)
Self-report habitual sleep					
Age					
Younger	115	5.84 (.78)	6.43 (1.29)	.31 (<.001)	.27 (<.001)
Older	108	5.73 (1.0)	6.50 (1.12)	.50 (<.001)	
Insomnia					
Yes	22	5.77 (.84)	5.75 (1.19)	-.04 (.87)	-.37 (.02)
No	201	5.79 (.90)	6.54 (1.19)	.45 (<.001)	
Depressive symptoms					
Highest Quartile	58	5.70 (.76)	6.28 (1.42)	.23 (.08)	-.27 (<.001)
Others	165	5.81 (.94)	6.53 (1.12)	.47 (<.001)	
Self-reported health					
Poor to Good	100	5.67 (.84)	6.28 (1.33)	.23 (.02)	.31 (<.001)
Very good to Excellent	122	5.87 (.93)	6.60 (1.09)	.54 (<.001)	
Diary					
Age					
Younger	115	5.84 (.78)	6.71 (.93)	.61 (<.001)	.16 (.07)
Older	108	5.73 (1.00)	6.56 (1.11)	.73 (<.001)	
Race					
Black	96	5.43 (.83)	6.45 (1.10)	.65 (<.001)	.15 (.08)
White	127	6.05 (.85)	6.77 (.94)	.70 (<.001)	
Married/committed relationship					
No	77	5.66 (.79)	6.59 (1.11)	.54 (<.001)	.36 (<.001)
Yes	146	5.85 (.94)	6.66 (.97)	.77 (<.001)	
Insomnia					
Yes	22	5.77 (.84)	6.48 (1.05)	.38 (.08)	-.32 (.02)
No	201	5.79 (.90)	6.65 (1.02)	.71 (<.001)	

Other Sleep Measure/Participant Characteristic	N	Actigraphic Mean (SD)	Other Sleep Mean (SD)	Correlation (P-value)	Interaction Term (P-value)
Depressive symptoms					
Highest Quartile	58	5.70 (.76)	6.72 (1.23)	.46 (<.001)	-.50 (<.001)
Others	165	5.81 (.94)	6.61 (.94)	.79 (<.001)	
Hostility					
Highest quartile	57	5.66 (.82)	6.60 (1.13)	.57 (<.001)	-.26 (<.001)
Others	166	5.83 (.92)	6.65 (.98)	.73 (<.001)	
Self-reported health					
Poor to Good	100	5.67 (.84)	6.63 (1.09)	.59 (<.001)	.29 (<.001)
Very good to Excellent	122	5.87 (.93)	6.64 (.96)	.77 (<.001)	
Variability in diary duration (nights 1–9)					
Highest quartile	56	5.64 (.84)	6.50 (1.19)	.54 (<.001)	-.32 (<.001)
Others	167	5.83 (.91)	6.68 (.96)	.74 (<.001)	