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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: Two nights of in-home 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 about 20–30 minutes longer by questionnaire and their prospective sleep diaries compared with both PSG- and actigraphy-assessed sleep duration. Persons reporting higher hostility had smaller associations between PSG-assessed sleep duration and other methods compared with those with lower hostility; those reporting more depressive symptoms and poorer overall health had smaller associations between actigraphy-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.

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Abbreviations: PSG, polysomnography; SES, socioeconomic status; HeartSCORE, Heart Strategies Concentrating on Risk Evaluation; SleepSCORE, Sleep Strategies Concentrating on Risk Evaluation; PSQI, Pittsburgh Sleep Quality Index; AHI, apnea-hypopnea index; BMI, body mass index; CES-D, Center for Epidemiologic Studies Depression Scale.

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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 7 to 8 hours of sleep per night and the highest risk related to shorter and longer sleep durations. Most findings linking sleep duration to cardiovascular morbidity or mortality are based upon single, self-reported retrospective assessments of habitual sleep length (eg, “Indicate total hours of actual sleep in a 24-hour period.”³).

Lauderdale and colleagues⁸ 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 with 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 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 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 with 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 4 estimates of sleep duration, that is, by PSG, actigraphy, prospective daily diary, and retrospective questionnaire, and identified the participant characteristics that may impact the magnitude of associations among the 4 estimates. Thus, the primary aims of the current investigation are 2-fold. First, because PSG is considered to 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 2000 Black, White, and Asian men and women in western Pennsylvania. Exclusion criteria for the current study, Sleep Strategies Concentrating on Risk Evaluation (SleepSCORE), included the following: 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 antihypertensive 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 3 months of a HeartSCORE visit. Beginning early in the week, the 10-day protocol for SleepSCORE included 2 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 4 and 5; 2 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, sex, 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 5 categories of < \$10,000 to \$80,000 or more. A composite 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.

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