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# Association of sleep characteristics with cardiovascular and metabolic risk factors in a population sample: the Chicago Area Sleep Study☆,☆☆

Samantha E. Montag, MS [a], Kristen L. Knutson, PhD [b], Phyllis C. Zee, MD [b], Jeffrey J. Goldberger, MD [c], Jason Ng, PhD [c], Kwang-Youn A. Kim, PhD [a], Mercedes R. Carnethon, PhD [a,*]

[a] Department of Preventive Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL
[b] Center for Circadian and Sleep Medicine, Department of Neurology, Feinberg School of Medicine, Northwestern University, Chicago, IL
[c] Division of Cardiology, Department of Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL

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ABSTRACT

*Objectives:* To investigate the association of sleep characteristics with prevalent hypertension, diabetes, and obesity in a multiethnic cohort.
*Design:* This study used a population-based cross-sectional study design.
*Setting:* Participants were recruited between 2009 and 2011 from Chicago, Illinois, and the surrounding suburbs.
*Participants:* Participants were 492 adults aged 35 to 64 years who self-reported as white, black, Hispanic, or Asian and who had a low likelihood of sleep apnea based on the apnea screening questionnaires and 1 night of apnea screening using an in-home device (apnea hypopnea index <15 or oxygen desaturation index <10).
*Measurements:* Participants wore a wrist actigraphy monitor (Actiwatch™) for 7 days. During a clinical examination, participants completed questionnaires about sleep, other health behaviors, and medical history and had their blood pressure, anthropometric measures, and fasting blood glucose measured; metabolic risk factors were determined based on standard clinical guidelines.
*Results:* The prevalence of hypertension, obesity, and diabetes was 17.1%, 5.5%, and 35.4%, respectively. Sleep duration was not associated with any cardiovascular risk factor. There was a significantly increased odds for hypertension (odds ratio [OR], 1.05; 95% confidence interval [CI], 1.01-1.08) and obesity (OR, 1.03; 95% CI, 1.00-1.05) associated with higher sleep fragmentation (per 1%). There was also a significantly increased odds for hypertension associated with poorer self-reported sleep quality (OR, 1.14 [95% CI, 1.05-1.24] per 1-unit higher Pittsburgh Sleep Quality Index global score).
*Conclusion:* Objective and self-reported sleep quality may be more important than duration in relation to prevalent hypertension.


## Introduction

Prior population studies describe an association between sleep duration and cardiovascular and metabolic disorders, hereafter cardiometabolic disorders, including diabetes, hypertension, and obesity.[1–3] However, most of these studies have relied on self-report, which can lead to imprecise and inconsistent results, because adults may misreport their sleep.[4] Much of the prior literature has typically examined the association between sleep duration and risk for cardiometabolic disease. However, this approach is limited in that sleep duration does not reflect of sleep quality. For example, although an individual's sleep duration may be within recommended 7 or more hours, as suggested by the American Academy of Sleep Medicine and Sleep Research Society,[5] it is possible for this individual to have poor sleep quality, such as fragmented sleep. It is plausible that self-reported (eg, daytime sleepiness) or objectively determined (eg, sleep efficiency) sleep quality is also relevant to cardiometabolic

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* Corresponding author at: 680 N Lake Shore Drive, Suite 1400, Chicago, IL 60611. Tel.: +1 312 503 4479; fax: +1 312 908 9588.
*E-mail address:* carnethon@northwestern.edu (M.R. Carnethon).

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health.[6] Consequently, sleep quality may provide additional insights beyond sleep duration. To our knowledge, no prior studies have investigated a combination of objectively determined sleep characteristics and self-reported quality measures.

Prior studies by our research group[7,8] and others[4,9–13] describe differences in sleep characteristics by race/ethnicity. These differences may be particularly relevant given the higher prevalence of cardiovascular (eg, hypertension) and metabolic (eg, obesity, diabetes) risk factors in blacks, Hispanics, and some Asians (particularly for diabetes).[14–17] Recent reviews highlight the contribution of sleep to cardiovascular disease risk factors and highlight the potential for differences in sleep to contribute to disparities.[18] Consequently, more research is needed in multiracial/ethnic samples using both self-reported and objective assessment of sleep alongside measurements (vs self-report) of cardiovascular disease risk factors.

Prior literature has not screened for sleep apnea or taken into risk for sleep apnea using objective screening tools. Sleep apnea is estimated to affect 10% to 20% of the population and rates have gone up over time.[19] Sleep apnea is inversely associated with sleep duration and quality. Hypoxia is independently associated with endothelial dysfunction, which underlies cardiometabolic disorders.[20,21] Because sleep interruption occurs during the sleep period, self-reported sleep is plagued by misreporting in persons with apnea. Although the use of objective measures of sleep can overcome this limitation, characterization of breathing, chest movements, and oxygen saturation overnight is required, at a minimum, to capture apnea risk. No prior population-based studies have captured this information alongside objectively measured sleep, although apnea could confound the association of sleep with cardiometabolic disorders. Characterization of apnea risk is required to test the association of short sleep independent of apnea on cardiometabolic risk.

Our first objective was to expand beyond the current literature to determine whether objectively determined sleep duration and sleep quality are associated with cardiometabolic disorders (ie, diabetes, hypertension, and obesity) in adults who have a low likelihood of having sleep apnea. Because prior reports have suggested that there is a U-shaped association with too much or too little sleep resulting in an increased odds of negative health outcomes, we hypothesized that sleep duration would display a U-shaped association with cardiometabolic risk factors and that sleep quality would be inversely associated with prevalence. We evaluated whether any observed associations remained after adjustment for demographic characteristics, health behaviors, and other clinical characteristics. Our second objective was to use this multiracial/ethnic sample that includes white, black, Hispanic, and Asian adults in roughly equal numbers to explore whether the relationship between sleep and cardiometabolic risk factors is moderated by race (ie, effect measure modification). Furthermore, given differences in sleep by sex,[22] we also tested effect modification by sex.

## Methods

### *Participants*

The Chicago Area Sleep Study was a cross-sectional study conducted between 2009 and 2011.[23]

Approximately 650 participants aged 35 to 64 years from Chicago, Illinois, and the surrounding suburbs were recruited from neighborhoods with heavy concentrations of adults from the racial and ethnic groups of interest (ie, white, black, Hispanic, and Asian) using commercial telephone lists from Info USA. Hispanics were defined as any individual claiming Hispanic ethnicity; they were not included in the white, black, or Asian category to ensure that the groups were mutually exclusive. We attempted to restrict our recruitment of Asians to those of East Asian descent based on self-report (eg, Chinese, Korean, Japanese, and Vietnamese), given the variation in cardiometabolic risk profiles among individuals from across the Asian continent.[24] For example, rates of diabetes are lower among East Asians than Southeast Asians (eg, Filipinos).[16] Further details on the methods of recruitment are published elsewhere.[23]

### *Study design*

Individuals who met the inclusion criteria of having a body mass index (BMI) <35 kg/m$^2$ and a low likelihood of sleep apnea as determined by the Berlin questionnaire and the Snoring, Tiredness, Observed apnea, blood Pressure, Body mass index, Age, Neck circumference and Gender (STOP-BANG) questionnaire were invited to attend a clinical examination.[25,26] At the initial examination, participants were consented and given all questionnaires and sleep equipment. They were instructed to wear the sleep watch for 7 days and the apnea screening device for 1 night and to return to the clinic for a second examination within 8 to 14 days when all cardiovascular risk factors were measured. The study protocol was approved by the institutional review board at Northwestern University. Informed consent was obtained for all participants involved.

### *Sleep characteristics*

Participants wore an actigraphy device (the Actiwatch™ 2; Phillips Respironics, Bend, OR) on their wrist for 1 week. The actigraphy device contains a piezoelectric accelerometer that captures movement in orthogonal dimensions. These movements were collected in 30-second epochs and plotted as a histogram, and the device software was used an algorithm to determine sleep duration based on the absence of movement during time in bed. The device also contains a marker, which participants were asked to press any time they went to bed or woke up. In addition, participants recorded bed times, wake times, and any nap times in a Karolinska sleep dairy. A member of the research team identified sleep intervals using the sleep logs and event markers. To ensure quality control, a 10% random sample of sleep records was re-read by a second member of the research team. Sleep duration was based on the total amount of sleep obtained during their primary sleep period (which was nocturnal for most participants). The bed time and wake time for this primary sleep period were identified based on the sleep logs and event markers. We then averaged across all available days of rerecording, which was 7 days for most subjects and therefore no weighting by day of the week was required. Sleep fragmentation is a measure of restlessness during sleep that sums the percentage of sleep spent moving (more than 2 activity counts in a 1-minute period) and the percentage of consecutive phases of no movement that are less than 1 minute in duration determined using the actigraph. Higher values indicate sleep that is more fragmented. The total scores for the Pittsburgh Sleep Quality Index (PSQI; score range, 5-18) and Epworth Sleepiness Scale (ESS; score range, 6-22) were used to measure perceived global sleep quality and daytime sleepiness, respectively, and both have been validated for that purpose.[27,28] There were more final scores missing for the PSQI survey than for the other measures (n = 153) because it is required that the first 9 questions be answered—a single missing question in this section prevents the whole survey from being scored.[28]

### *Cardiometabolic factors*

The cardiometabolic risk factors of interest were hypertension, obesity, and diabetes. Participants were asked to fast for a minimum of 12 hours before their examination and to bring all of their prescription and over-the-counter medications with them to the examination. Measurements were collected between 7:30 AM and 11:00 AM.