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Sleep duration and excess heart age among US adults☆,☆☆,★,★★

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ABSTRACT

Objectives: Insufficient sleep negatively impacts the cardiovascular system. No study has examined the association between sleep duration and heart age (person's predicted vascular age based on cardiovascular disease [CVD] risk profile). This study examines association between sleep duration and excess heart age (EHA; difference between heart age and chronological age) among US adults.
Design and participants: Cross-sectional 2007-2014 National Health and Nutrition Examination Survey data for respondents aged 30-74 years without CVD or stroke (n = 12,775).
Measurements: Self-reported sleep duration was classified into 5 categories (≤5, 6, 7, 8, and ≥9 hours). We used sex-specific Framingham heart age algorithm to calculate heart age and multivariable linear regression to examine association between sleep duration and EHA.
Results: A total of 13.4% (95% confidence interval 12.5-14.3), 24.2% (23.1-25.2), 31.0% (29.8-32.3), 25.9% (25.0-26.9), and 5.5% (5.0-6.1) reported sleeping ≤5, 6, 7, 8, and ≥9 hours, respectively. We observed a nonlinear relationship between sleep duration and EHA using 7 hours as reference: EHA (adjusted for sociodemographics, body mass index, physical activity, Healthy Eating Index-2010, sleep disorder, and depression status) was 5.1 (4.8-5.8), 4.5 (3.9-5.1), 3.7 (3.3-4.0), 4.5 (4.1-5.0), and 4.1 (3.3-4.9) years for sleep durations of ≤5, 6, 7, 8 and ≥9 hours, respectively ($P = .015$ for quadratic trend). EHA was significantly higher among participants with lower education, lower income, and obesity.
Conclusion: Mean adjusted EHA was lowest among adults who reported sleeping 7 hours per night and increased as adults reported sleeping fewer or more hours. Discussing sleep duration in the context of EHA may be helpful for patients and clinicians.

Introduction

Sleep insufficiency is a public health problem. Approximately 34.8% of adults in the United States (US) report insufficient sleep (<7 hours per 24-hour period).[1] Insufficient sleep has been estimated to contribute up to $411 billion in economic losses each year to the US due to mortality and lost productivity.[2] Whereas insufficient sleep has fiscal consequences, its cumulative exposure has detrimental impacts on multiple body systems, notably the cardiovascular system. Studies have shown associations between sleep duration and several cardiovascular disease (CVD) risk factors, including high blood pressure, smoking, high blood cholesterol, diabetes, and being overweight or obese.[3,4] This indicates the potential role of sleep duration as a significant CVD risk factor.

Cardiovascular disease was responsible for more than 800,000 deaths in 2015 (https://www.cdc.gov/nchs/data/nvsr/nvsr66/nvsr66_06.pdf) and costs the US approximately $320 billion each year.[5] Multivariable prediction models have been developed to help with CVD prevention and management.[6–9] Most of these models use an individual's risk factor profile to estimate absolute risk of having a cardiovascular event or stroke within a certain period of time (eg, in the next 10 years). However, predicted absolute risk is a

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concept that can be difficult for patients to understand, which poses the possibility of providing false assurance for people with high lifetime, but low short-term CVD risk. Therefore, its effectiveness in promoting lifestyle changes or adherence to recommended therapeutic interventions may be limited.[9–11]

Although studies have shown an association between sleep duration and CVD risk factors, researchers have yet to combine this information in a form that simplifies the process of communicating CVD risk with the general public. In 2008, the Framingham Heart Study introduced the concept of *heart age*, defined as the predicted age of a person's vascular system based on their cardiovascular risk profile.[12] Heart age and its comparison with chronological age (defined as excess heart age [EHA]), represent an alternative, simplified way of communicating risk for developing CVD. The objective of this study is to examine the association between sleep duration and EHA using data from nationally representative samples of US adults in 2007-2014. We hope to further examine the relationship between sleep and cardiovascular health as well as to improve and simplify communication of CVD risk with the use of EHA rather than predicted absolute CVD risk score.

Participants and methods

Study population

The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional assessment of the US population's health. The survey is conducted by the Centers for Disease Control and Prevention's National Center for Health Statistics, with information gathered through interviews, medical examinations, and laboratory tests. The survey provides demographic information and laboratory data for a sample representative of civilian US residents who are not institutionalized.[13] In this study, we pooled NHANES data sets from 2007-2014 to assess the association between sleep duration and EHA. Adults aged 30 to 74 years were included consistent with the age range used in the Framingham Heart Study's heart age calculation.[12]

Exposure variable

Self-reported sleep duration was assessed based on response to the question, "How much sleep do you usually get at night on weekdays or workdays (hours)?" Responses were classified into 5 categories, ≤5, 6, 7, 8, and ≥9 hours of sleep, consistent with 2 previous studies, both of which examined sleep duration's impact on cardiovascular health outcomes.[14,15]

Outcome variable

To calculate heart age, the sex-specific laboratory-based Framingham Risk Score (FRS) was used to estimate 10-year risk for developing CVD for each participant.[12] Parameters from the FRS models were used to calculate predicted heart age and EHA (calculated as the difference between predicted heart age and chronological age).[12] The laboratory-based FRS models included 8 variables: age, sex, systolic blood pressure (SBP), hypertension treatment status (yes/no), smoking status (current/no), diabetes (yes/no), high-density lipoprotein cholesterol (HDL-C), and total cholesterol (continuous). SBP was calculated using the average of the last 2 measurements of blood pressure for participants who had 3 readings, the last measurement for participants who had 2 readings, and the only measurement for participants who had 1 blood pressure reading. Hypertension treatment status was determined from affirmative responses to the following questions: "Were you told on 2 or more different visits that you had hypertension, also called high blood pressure?", "Because of your (high blood pressure/hypertension), have you ever been told to take prescribed medicine?", "Are you now taking prescribed medicine?" Smoking status was determined from responses to 2 questions: (1) "Have you smoked at least 100 cigarettes in your entire life?" (yes/no) and (2) "Do you now smoke cigarettes?" (every day/some days/not at all). Current smokers were classified as those participants who answered "yes" to question 1 and either "every day" or "some days" to question 2. All other answer combinations represented nonsmokers. Participants were considered to have diabetes if they met at least 1 of 4 conditions: (1) if they responded affirmatively to the question "has a doctor told you that you have diabetes?", (2) if they had a level of fasting plasma glucose ≥126 mg/dL, (3) if they had a concentration of glycated hemoglobin ≥6.5%, or (4) if they responded affirmatively to the question "are you now taking diabetic pills to lower your blood sugar?" Those people who did not meet any of those 4 criteria were classified as not having diabetes. Total cholesterol concentrations and HDL-C were measured with an enzymatic method on Roche Modular P chemistry analyzers from 2007 to 2012, and on Roche Modular P and Roche Cobas 6000 chemistry analyzers during the 2013-2014 cycle.[16]

Covariates

Other demographic data included race/ethnicity (non-Hispanic White, non-Hispanic Black, Mexican American, other), educational level (<high school graduate, high school graduate, and >high school graduate), and poverty income ratio (PIR)—the ratio of household income to the poverty threshold after accounting for inflation and family size (<1.3, 1.3-3.49, ≥3.5, missing).[17] Participants with missing PIR (n = 725) were recoded as a separate category. Body mass index (BMI, kg/m^2) values were calculated using measured height and weight values. Leisure-time physical activity (PA) was categorized into 3 groups: (1) *meeting the recommended amount of PA*, defined as ≥150 minutes of moderate or ≥ 75 minutes of vigorous intensity/wk; (2) *not meeting the recommended amount of PA*, defined as 1-149 minutes of moderate or 1-74 minutes of vigorous intensity/wk; and (3) *inactive*, defined as 0 min/wk.[18] The 2010 Healthy Eating Index (HEI-2010) is a measure of diet quality derived from the first-day 24-hour dietary recall. The HEI-2010 scores range from 0 to 100, with a higher score indicating a healthier diet.[19] Sleep disorder status was determined by the question, "Have you ever been told by a doctor or other health professional that you have a sleep disorder?" Depression symptoms were assessed using the Patient Health Questionnaire (PHQ-9), a validated 9-item screening instrument that asks about the frequency of symptoms of depression over the past 2 weeks.[20] Those who responded "not at all," "several days," "more than half the day," and "nearly every day" received a score of 0-3, respectively. PHQ-9 scores range from 0 to 27, with higher scores indicating more severe depression. The PHQ-9 scores ≥10 had a sensitivity of 88% and a specificity of 88% for major depression.[20] We classified participants as having depression (PHQ-9 score ≥10) and nondepression (PHQ-9 score <10). Participants who did not complete the PHQ-9 (n = 1118) were included as a separate depression category.

Statistical analysis

Among 16,478 NHANES 2007-2014 participants aged 30-74 years, 3703 (22.5%) were excluded, including 99 pregnant women; 1302 participants with self-reported coronary heart disease, myocardial infarction, or stroke at baseline; and 2302 participants with missing data (sleep duration, n = 19; CVD risk factors, n = 1473; covariates, n = 810). This left 12,775 participants for analysis. Descriptive statistics for participant characteristics by sleep duration category are reported in Table 1.

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