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Sleep duration and the associated cardiometabolic risk scores in adults

Thirumagal Kanagasabai, PhD [a,*], Jean-Philippe Chaput, PhD [b]

[a] School of Kinesiology and Health Science, York University, Toronto, Ontario, Canada
[b] Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada

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ABSTRACT

Objectives: To identify the sleep duration associated with the lowest cardiometabolic risk score in adults and to determine if the association varies by subgroups (eg, sex, age groups, ethnicity, and smoking status).
Design: Cross-sectional data from the 2005–2012 National Health and Nutrition Examination Survey.
Setting: Non-institutionalized civil sample from the United States.
Participants: Age ≥20 y (N = 8827) with sleep and cardiometabolic health data.
Interventions: N/A.
Measurements: Sleep duration from the Sleep Disorders Questionnaire was categorized as ≤3, 4, 5, 6, 7, 8, 9, and ≥10 h per night. HDL cholesterol (HDL) and waist circumference (WC) were stratified by sex first, while fasting insulin, fasting plasma glucose (Glu), triglycerides (TG), body max index (BMI), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were standardized without stratifications. The standardized scores were summed for each participant using the following formula: −zHDL + zInsulin + zGlu + zTG + (zBMI + zWC)/2 + (zSBP + zDBP)/2.
Results: Seven hours of sleep was associated with the lowest cardiometabolic risk score (−0.30 (95% CI: −0.43, −0.18)), which remained similar after adjusting for age, sex, ethnicity, education, family income, alcohol intake and smoking status. However, 8 hours of sleep was associated with the lowest score in non-Hispanic Blacks.
Conclusions: This study supports recent sleep duration recommendations in adults, and provides evidence that in general 7 hours of sleep per night is associated with optimal cardiometabolic health of adults. Longitudinal studies using objective measures of sleep would help further clarify this association.

Introduction

Sleep is important for health, but many adults do not get the recommended 7 to 9 h of sleep per night.[1] Increased work hours, sedentary working conditions, technology use, lack of physical activity, family responsibilities, and social jetlag continue to compromise adults' sleep on a regular basis.[2,3] Despite the well-known beneficial effects of adequate sleep on cardiovascular and metabolic health, insufficient sleep is a common problem in our society.[4–8] In the United States, for instance, the frequency of adults sleeping ≤6 h daily has doubled since the 1980s, and nearly a third of the adults sleep ≤6 h per night.[9]

The US Center for Disease Control and Prevention acknowledges insufficient sleep as a public health epidemic.[10] However, until recently, even among sleep experts, there was a lack of consensus on what constitutes sufficient sleep for adults' overall health.[11] To address this, the American Academy of Sleep Medicine and the Sleep Research Society developed a consensus statement for adults in 2015 highlighting the sleep duration needed for optimal health.[12] This statement was developed by a team of 15 sleep experts, and it concluded that at least 7 hours of sleep per night is needed on a regular basis for overall health in adults.[12]

The consensus statement's recommendation is consistent with studies that found 7 to 8 h of sleep is associated with the lowest metabolic syndrome prevalence in adults.[13–15] Metabolic syndrome is a cluster of cardiometabolic risk factors that increase the risk of developing diabetes and cardiovascular disease.[16] Previous studies have also found that several individual cardiometabolic risk factors are optimal among 7 to 8 h sleepers,[17,18] but poor sleep patterns and the prevalence of cardiometabolic risks are also higher in subgroups such as men, older adults, non-Hispanic Blacks, and smokers.[19–25] Further, the relationship between sleep duration and cardiometabolic risk may be U-shaped.[14,18] The relationship between sleep duration

* Corresponding author at: Department of Epidemiology, Biostatistics and Occupational Health, McGill University, 1130 Avenue des Pins, Montréal, QC, Canada, H3G 1A1.
E-mail address: thirumagal.kanagasabai@mcgill.ca (T. Kanagasabai).

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and a continuous measure of cardiometabolic risk may also be moderated by sex, age, ethnicity, and smoking status, which have been considered as confounding variables in previous studies,[4,13] but they may be significant moderators of the relationship. Therefore, the objectives of this study are to identify the sleep duration associated with the lowest cardiometabolic risk, and to determine if this relationship varies in subgroups of the population. We hypothesize that the lowest cardiometabolic risk would be found among 7 h sleepers in both the general adult population and across subgroups.

Participants and methods

Participants

Data for this analysis were obtained from the US National Health and Nutrition Examination Survey (NHANES), a nationally-representative cross-sectional study designed to assess the health and nutritional status of its non-institutionalized civilian population.[26] Approximately 10,000 people are sampled bi-annually by NHANES. Data are collected from personal interviews, standardized physical examinations, and laboratory samples.[26] NHANES 2005–2012 cycles had an initial sample of 40,790 participants. Exclusions were made for age (<20 y, n = 18,098), pregnancy (n = 516), missing sleep (n = 43) and cardiometabolic health data ($n_{\text{HDL cholesterol}} = 2218$, $n_{\text{fasting plasma glucose}} = 10{,}217$, $n_{\text{systolic/diastolic blood pressure}} = 423$, $n_{\text{triglycerides}} = 35$, $n_{\text{body mass index}} = 101$, $n_{\text{waist circumference}} = 198$, and $n_{\text{fasting insulin}} = 114$) in sequence, which resulted in a final analytic sample of 8,827 participants. Excluding participants without fasting blood sample for glucose and lipids, which were collected in the morning examination session participants only, resulted in the greatest loss of adult sample.[26]

Sleep duration

The Sleep Disorders Questionnaire was administered to participants aged ≥16 y, who reported their typical sleep duration for the past month.[26] Although this questionnaire has not been validated in its entirety, it contains items from two previously validated sleep questionnaires.[27] Our study used the question that collected data on participants' sleep duration: "How much sleep do you usually get on weekdays or workdays?" Response to this question was collected in whole numbers between 1 and 11 h and curtailed at ≥12 h.[26] Sleep duration was categorized further in this study as ≤3, 4, 5, 6, 7, 8, 9, and ≥10 h per night to ensure sample size was sufficient for the analyses.

Cardiometabolic risk score

The continuous cardiometabolic risk score was calculated using the sums of standardized scores for HDL cholesterol (HDL), fasting insulin (Insulin), fasting plasma glucose (Glu), triglycerides (TG), body mass index (BMI), waist circumference (WC), systolic blood pressure (SBP) and diastolic blood pressure (DBP) using the formula below.[13]

$$\begin{aligned}\text{Cardiometabolic Risk Score} = &-\text{zHDL} + \text{zInsulin} + \text{zGlu} + \text{zTG} \\ &+ (\text{zBMI} + \text{zWC})/2 \\ &+ (\text{zSBP} + \text{zDBP})/2\end{aligned}$$

However, since HDL and waist circumference vary by sex, this study stratified them by sex before standardizing them.[16,28] Participants' blood was used to obtain the levels of HDL, Insulin, Glu, and TG using standardized laboratory procedures.[26] Height, weight, WC, SBP and DBP were measured by trained medical professionals at the mobile examination sites. Height and weight were then used by NHANES to calculate the BMI (kg/m^2).[26] The continuous cardiometabolic risk score method was recently validated in Australian adults.[28]

Covariates

Demographic variables used to describe the sample included age, sex, ethnicity, family poverty income ratio (PIR), education, alcohol intake, and smoking history. Age was categorized as 20 to <40 y, 40 to <65 y, and ≥65 y. Ethnicity groups were Non-Hispanic Whites, Non-Hispanic Blacks, Hispanics, and Others.[26] The family PIR in the demographics file of NHANES was used as a continuous variable of socioeconomic status. Education was categorized as <high school, high school, and college, which includes some college education as well as above college graduation. Self-reported alcohol intake was categorized into three categories (none, moderate, and high) based on sex-specific cut-offs (men: ≤2 drinks per day = moderate and >2 drinks per day = high; women: ≤1 drinks per day = moderate and >1 drinks per day = high).[29] Smoking history was also grouped into three categories: current (if smoking now), past (if smoked ≥100 cigarettes in one's life but not a current smoker) or never (if smoked <100 cigarettes in one's life). These covariates have been chosen based on their known association with sleep and cardiometabolic health.

Statistics

Mean and 95% confidence interval (CI) for continuous variables and frequency and percentage for categorical variables were determined by sleep duration. ANOVA and χ^2 tests were used, as appropriate, to test for any differences in demographic and behavioral characteristics. The mean and standard deviation (SD) of individual cardiometabolic risk factors, and the mean (95% CI) cardiometabolic risk score were estimated by sleep durations. The moderating effect of sex, age, ethnicity and smoking was also tested for the relationship between sleep duration and cardiometabolic risk score using interaction terms. In subsequent analyses, adjusted mean (95% CI) cardiometabolic risk score was estimated using analysis of covariance (ANCOVA) using the PROC GLM procedure, and between-group comparisons were made with the Tukey post hoc test. Covariates included in the final adjusted model were age, sex, ethnicity, education, family PIR, alcohol intake and smoking history. Additionally, we conducted weighted analyses using the cluster, strata and sample exam weights within the demographics files provided by the NHANES. Analyses were conducted in SAS version 9.3 (Cary, NC, USA), and statistical significance was set at an α of .05.

Results

The mean age of the study sample was significantly higher among the extreme sleep durations, ie, 7 h sleepers were younger (Table 1). A higher proportion of adults aged 40 to <65 y reported shorter sleep durations, while adults aged ≥65 y reported longer sleep durations. Higher family income was also more common among 8 h sleepers. However, shorter sleep durations were more common among less educated individuals and current smokers. Further, high alcohol intake was more prevalent among extremely short sleep durations, while more non-Hispanic Blacks reported sleeping ≤3 h per night. Overall, 7 h sleepers had the lowest mean WC, SBP, TG, and Glu levels (Table 2). DBP and BMI, on the other hand, were lower for those with more sleep, while fasting insulin level was lowest among 7–9 h sleepers.

Sleeping 7 h per night was associated with significantly lower cardiometabolic risk scores in both the crude (black, $P < .01$) and multivariable adjustment (gray, $P = .02$) models (Fig. 1). Women with 6–8 h of sleep per night had lower cardiometabolic risk scores compared to men, but this disparity diminished in extreme sleep durations