HHS Public Access

Author manuscript

Sleep Med. Author manuscript; available in PMC 2021 November 01.

Published in final edited form as:

Sleep Med. 2020 November ; 75: 459–467. doi:10.1016/j.sleep.2020.09.004.

Patterns and correlates of sleep duration in the Southern Cohort Community Study

Tao Liang[1], **Heather M. Munro**[2,3], **Margaret K. Hargreaves**[4], **Mark D. Steinwandel**[2,3], **William J. Blot**[2,3,5], **Maciej S. Buchowski**[1]

[1]Division of Gastroenterology, Department of Medicine, Vanderbilt University Medical Center, Nashville, TN, USA

[2]International Epidemiology Field Station, Rockville, Maryland, MD, USA

[3]Vanderbilt Institute for Clinical and Translational Research, Vanderbilt University Medical Center, Nashville, TN, USA

[4]Department of Internal Medicine, Meharry Medical College, Nashville, TN, USA

[5]Division of Epidemiology, Department of Medicine, Vanderbilt University Medical Center, Nashville, TN, USA

Abstract

Objective—To investigate whether race (African American (AA) and white) is associated with sleep duration among adults from low socioeconomic (SES) strata and whether SES status, lifestyle behaviors, or health conditions are associated with sleep duration within race-sex groups.

Methods—This cross-sectional study includes 78,549 participants from the Southern Community Cohort Study (SCCS). Averaged daily sleep duration was assessed by weighted averages of self-reported sleep duration on weekdays and weekends. Adjusted odds ratios (ORs) of very short (<5 h/day), short (5 – 6 h/day), and long sleep (≥9 h/day) associated with pre-selected risk factors in each race-sex group were determined by multinomial logistic models.

Results—The prevalence of very short and short sleep was similar among AAs (6.2% and 29.1%) and whites (6.5% and 29.1%). Long sleep was considerably more prevalent among AAs (19.3%) than whites (13.0%). Very short sleep was associated with lower education and family income, with stronger associations among whites. Higher physical activity levels significantly decreased odds for both very short (OR=0.80) and long sleep (OR=0.78). Smoking, alcohol use,

Correspondence: Maciej S. Buchowski, Department of Medicine, Vanderbilt University Medical Center, 1161 21st Avenue South Nashville, TN 37232, USA, Telephone: 615-343-4192, maciej.buchowski@vumc.org.

Credit Author Statement

Tao Liang: Methodology, Writing-Original draft preparation; **Heather M. Munro:** Formal analysis, Data Curation; **Margaret K. Hargraves**: Resources; **Mark D. Steinwandel:** Project administration; **William J. Blot:** Writing-Reviewing and Editing; **Maciej S. Buchowski:** Writing-Reviewing and Editing, Funding acquisition

No potential conflicts of interest for any authors

Data described in the manuscript and analytic code will be made available upon request pending application and approval

and dietary intake were not associated with sleep duration. Regardless of race or sex, very short, short, and long sleep were significantly associated with self-reported health conditions, especially depression (ORs were 2.06, 1.33, and 1.38, respectively).

Conclusions—Sleep duration patterns differed between AAs and whites from the underrepresented SCCS population with low SES. Sleep duration was associated with several socioeconomic, health behaviors, and health conditions depending on race and sex.

Keywords

Southern Community Cohort Study; sleep; demographics; risk behaviors; socio-economic status; health conditions

1. Introduction

Sleep disorders have affected millions of Americans across all demographic groups. Shorter or longer sleep durations have been associated with poorer health conditions such as obesity (1, 2), cardiovascular disease (3, 4), diabetes (5–8), liver disease, and cancer (9–11), mental health issues such as mood disorders (12, 13) and substance abuse (14, 15), and increased all-cause mortality (16). One of the goals of Healthy People 2020 is to increase the proportion of U.S. adults who experience sufficient sleep, defined as 7–8 hours for adults aged 22 and older (17). However, the Healthy People mid-year progress review indicated "little or no change" in reaching this target (17)

Racial and ethnic minorities, particularly African Americans (AAs), have a higher prevalence of sleep deficiency and lower prevalence of healthy sleep than other groups (18, 19). Previous studies suggested that sleep deficiencies and disorders in racial/ethnic minority populations are often affected by socio-cultural and environmental factors, such as occupational shift work, economic adversity, financial insecurity, neighborhood deprivation, increased exposure to allergens, noisy and crowded sleeping environment, urban residence, and residential segregation (12, 17, 20–28). However, there is a limited literature discussing sleep disparities (27, 29–31), which might have left some racial disparities in sleep deficiencies unobserved. Although racial and/or ethnic minorities are more likely to live in low SES strata than the general population, current literature provides limited knowledge of whether SES plays a role in racial/ethnic disparities in sleep duration and sleep disorders.

The goal of this study was to evaluate the prevalence of self-reported very short, short, and long sleep as well as the relationship between sleep duration and demographics, SES, body mass index (BMI, kg/m^2), health behavior, and health condition variables in the Southern Community Cohort Study (SCCS), a population-based ongoing prospective study of predominantly low-income adults in the southeastern U.S.

We hypothesized that the prevalence estimates of very short (< 5 h/day), short (5 – 6 h/day) and long (≥ 9 h/day) sleep are higher in AA than white SCCS participants. Our secondary hypothesis was that the risk factors for sleep duration, including SES, lifestyle characteristics and health conditions, varied between AA and white SCCS participants.

2. Methods

2.1. Participants

Initiated in 2002, the SCCS is an ongoing prospective cohort study focusing on racial and socioeconomic disparities in the risk of cancer and other chronic diseases among underserved populations aged 40 – 79 years old. Between 2002 and 2009, over 85,000 males and females were recruited from 12 southeastern US states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia). Approximately about 65.4% of the cohort are self-reported AA participants, 29.7% are white, and less than 4.5% are other racial groups (Hispanic, Asian, Native Americans, and mixed races). About 85% of the study participants were enrolled from 71 Community Health Centers (CHC), institutions providing essential health and preventive services mainly to low-income, underinsured, and uninsured individuals. The rest of the participants were enrolled in 2004–2006 by responding to a telephone interview or mailed questionnaire sent to randomly selected residents of the same 12 states. Informed consent was obtained from each participant upon enrollment into the SCCS. Institutional Review Boards at Vanderbilt University (Nashville, TN, USA) and Meharry Medical College (Nashville, TN, USA) approved the study. An analytical sample was obtained by excluding participants other than AAs or whites, those with missing sleep duration or the average sleep duration of less than 2 or more than 20 hours per day. The final analytic sample included 78,549 participants.

2.2. Assessment of sleep duration and covariates

In the questionnaire, participants were asked for the number of hours they usually slept in 24 hours using full-hour increments, on weekdays, and weekends. Sleep duration per 24 hours was calculated as the weighted average [(weekday sleep duration × 5) + (weekend sleep duration × 2)/7] amount of sleep for weekdays and weekends. If a participant provided only one valid response to the two sleep questions, sleep duration was calculated based on that response alone (weekday or weekend). Sleep duration was rounded to one decimal place and indexed to the closest hour to be consistent and comparable with studies using the NHIS data (29, 30). For example, an indexed 5 hours per day sleep includes rounded sleep from 4.5 to 5.4 hours. The indexed sleep was grouped into four categories: very short sleep (<5 h/day), short sleep (5–6 h/day), normal sleep (7–8 h/day), and long sleep (≥ 9 h/day), based on previous studies (29, 32).

The baseline questionnaire collected comprehensive information on SES, demographic (including self-reported race), lifestyle, and anthropometric characteristics, as well as personal medical history, at cohort enrollment via standardized computer-assisted personal interviews for community health center participants, and self-administered mailed questionnaire for the general population participants. For self-reported race or ethnic background, a multiple-choice question was offered with available options of White, Black/African American, Hispanic/Latino, Asian or Pacific Islander, American Indian or Alaska Native, and Other racial or ethnic groups. Those with more than one race reported were classified as mixed race (excluding Hispanic/Latino). In this study, only participants who reported their race as AA or white were included in the analyses. Dietary intake was

assessed using an 89 item food frequency questionnaire (FFQ) and physical activity with a physical activity questionnaire (PAQ), both included in the baseline questionnaire (33, 34).

Medical history included questions related to the presence of diseases by asking a participant "Has a doctor ever told you that you have had, or have you been treated for…" a specific disease including diabetes, hypertension, cardiovascular disease (CVD) or stroke, depression, asthma, or chronic obstructive pulmonary disease (COPD) and cancer. Those responding yes to the question were classified as having a self-reported condition.

2.3. Statistical analyses

The prevalence of very short, short, and long sleep among SCCS participants was computed for all participants with at least one self-reported sleep duration, and the difference in prevalence was compared by the chi-square test. Descriptive cross-sectional data at enrollment (baseline) were stratified by race (AA and white) and sex (male and female). Continuous variables were presented as means and standard deviations and categorical variables as frequencies and percentages. Multinomial logistic regression models were used to determine risk factors for participants with very short, short, and long sleep, with those normal (7 – 8 h) sleep as the reference group. A total of 10,365 participants were excluded from multinomial logistic analysis due to missing values for the explanatory variables, including 3,907 (12.5%) AA females, 3,044 (13.6%) AA males, 1,943 (12.8%) white females and 1,471(15.1%) white males (for missing counts and fraction of each variable, see Supplemental Table 1). For each race-sex group, a multinomial logistic regression model containing all risk factors as explanatory variables was used to estimate ORs and 95% CIs for very short, short, and long sleep. The explanatory variables adjusted in multinomial models were age at enrollment (restricted cubic splines), education (less than 9 years, 9 – 11 years, high school or General Education Development (GED), vocational training or some college, college graduate or higher), marital status (married or living with a partner, separated or divorced, widowed, single), household income (<$15,000, $15,000 – $24,999, $25,000 – $49,999, ≥$50,000), body mass index (BMI <18.5, 18.5 – <25, 25 – <30, 30 – <35, ≥35 kg/m^2), smoking status (current, former, never), alcohol use (0 – <1, 1 – <3, 3 or more drinks/day). Physical activity variables included total time spent in sedentary behavior (race-sex-specific tertiles, h/day), and the total amount of light, moderate, and strenuous occupational or household activities (racesex-specific tertiles, daily metabolic equivalent hours expressed as MET-h/day). Dietary intake variables included daily intake of fruits and vegetables (servings/day), bread (servings/day), and meats (servings/day), total amount of energy (race-sex-specific tertiles, kcal/day), regular coffee consumption (0 – <1, 1 – <3, 3 or more times/day), beverages (soda) consumption (0 – 1, 1 – <2, 2 or more times/day), and Healthy Eating Index (HEI, in race-sex-specific tertiles) (35). Self-reported health conditions included hypertension (yes, no), cardiovascular disease (CVD) or stroke (yes, no), diabetes (yes, no), COPD (yes, no), asthma (yes, no), depression (yes, no), and cancer (yes, no). The use of hormone replacement therapy (yes, no) was evaluated only in females.

All statistical tests were two-tailed with p-values <0.05 considered significant. Analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

3. Results

Baseline characteristics of 78,549 participants, including 68% AAs (N=53,630) and 32% whites (N=24,919) individuals with an average age of 52 ± 8.8 years, are presented in Table 1 stratified by race-sex groups. Baseline characteristics stratified by sleep duration and race-sex group are in Supplemental Tables 2a and 2b. Participants' education, income, and employment status tended to be low, and obesity prevalence to be high (45% and 41%) for AAs and whites, respectively. Among health conditions, hypertension was reported by 55%, and diabetes by 21% of participants.

Approximately half (47.4%) of the cohort reported normal (7 – 8 hours) sleep duration. The prevalence of long sleep was 19.3% and 13.0% for AAs and whites, respectively. There was a significant difference in the prevalence of long sleep between AAs and whites (P<0.001). Between AAs and whites, the prevalence of very short (6.2% for AAs and 6.5% for whites, P=0.142) and short sleep (29.1% for AAs and 29.1% for whites, P=0.937) did not differ significantly. The prevalence of very short, short, and long sleep was 6.7%, 29.7%, and 16.6% for females, and 5.7%, 28.2%, and 18.3% for males, respectively. The differences in the prevalence of very short, short, and long sleep between males and females were significant (all P<0.001).

SES characteristics were associated with very short, short, and long sleep in some race-sex groups (Table 2). Household income and education were strongly related to very short and short sleep, especially among whites, with the percentages with sleep falling as income and education rose. The associations between long sleep and household income and education were weak, although the odd of long sleep decreased as income or education increased.

Health and lifestyle characteristics were associated with very short, short, and long sleep (Table 3). Participants with healthier eating habits (2^{nd} or 3^{rd} tertiles of HEI) had a lower odd of both very short and short sleep than participants with the least healthy eating habits (1^{st} tertiles of HEI). Individuals with higher meat or meat products consumption tend to have lower odds of very short and short sleep compared to participants with lower meat consumption (Supplementary Table 3). There was a tenuous association between very short or short sleep and smoking status as well as alcohol usage, but current smoking was significantly associated with long sleep. The participants with a higher level of physical activity (MET-h/day) had lower odds of very short or long sleep. The longer time spent in sitting behaviors (h/day) was associated with long, but not very short, or short sleep. BMI was associated with very short and short sleep prevalence, with higher odds among the underweight (BMI <18.5 kg/m^2) and morbidly obese (BMI >35 kg/m^2) in all race-sex groups.

The associations between self-reported health conditions and sleep duration are in Table 4. Depression and CVD/stroke were associated with very short, short, and long sleep, regardless of race and sex. Hypertension, COPD, asthma, and depression were associated with very short and short sleep. Diabetes was associated with very short sleep in AA males and long sleep in females of both races. There was no association between sleep duration and cancer in any race-sex group.

4. Discussion

4.1. Sleep duration and race

In this study, AAs had a higher prevalence of long sleep (≥ 9 h/day) compared to whites (19.3 % and 13.0%, respectively). Similar observations have been reported (29, 30, 36) from the NHIS cohort consisting of a cross-sectional sample of non-institutionalized US adults. However, some of these studies used sleep duration categories that were different from those used in this study. One study based on the NHIS data showed that from 1977 to 2009, 8.3% – 16.1% AAs and 6.6% – 11.2% of whites reported sleeping longer than 8 hours per day (33). Another NHIS-based study using the 2004 – 2007 data, reported that compared to whites, the ORs for AAs to have more than 9-hour sleep was 1.72 (95% CI, 1.59 – 1.87) (30). Compared to shorter sleep, the effect of longer sleep on health in adults is less recognized and needs further studies. However, according to the American Academy of Sleep Medicine (AASM), longer sleep is rather the result of poor health than its cause (37).

The average prevalence of very short sleep in this study was 6.3%. This value is much higher than the NHIS cohort, in which the prevalence of very short sleep ranged from 2.4% to 4.4% in AAs and from 1.1% to 2.3% in whites (29). The prevalence of short sleep in this study was 29.1%. Similarly, in the NHIS cohort, the prevalence of short sleep ranged from 24.6% to 33.7% in AAs and from 19.3% to 26.2% in whites (29). This study did not find a difference in the prevalence of very short and short sleep between AAs and whites. In contrast, previous studies frequently reported noticeable differences in very short and short sleep prevalence between AAs and whites (29, 30, 32, 38). The differences might be caused by the discrepancy between the populations studied. Participants included in the NHIS cohort had higher SES than those in the SCCS. In our study, 63.7% white and 80.7% AA participants had household income less than $25,000. In contrast, in the NHIS study, 66.6% – 72.5% of whites and 45.9% – 53.0% of AAs had household income equal or higher than $35,000 in a similar period (2002 – 2008 and 2004 – 2009, respectively) (29). Another contributor to the difference might be the age distribution. In the NHIS cohort participants were 18 years old and older, and the SCCS participants were 39 years old or older. Nevertheless, the high prevalence of very short sleep in the low-income underserved SCCS population, warrants further investigations.

Compared to studies using the NHIS data, our results in a higher income group were similar. For example, significantly longer sleep duration was observed in AAs both in the NHIS and SCCS cohort. However, we did not observe a difference in the proportion of shorter sleep between AAs and whites. These findings add to previous findings that racial/ethnic minorities are more likely to have shorter sleep duration than other populations but also suggests that a contribution of disadvantaged SES contributes to short sleep, independent of race/ethnicity.

4.2. Sleep duration and SES characteristics

SES characteristics were associated with sleep duration but with racial heterogeneity. In this study, a higher income did not protect AAs from very short and long sleep duration as much as whites. As annual family income increased, the odds of very short and long sleep

decreased in both AAs and whites, but the decrease was steeper in whites. A very recent report from The Reasons for Geographic And Racial Differences in Stroke (REGARDS) cohort, showed that higher income decreased the odds of <6 hours sleep overall, but the odds decrease was less in AAs than whites (39). In another study, Jean-Lois and colleagues reported that in the mentioned earlier NHIS cohort, compared to adults with income above $35,000, the odds ratio of very short sleep in adults with income below $35,000 in whites (OR, 2.08; 95% CI, 1.89 – 2.30) was higher than in AAs (OR, 1.52; 95% CI, 1.25 – 1.85) (29). Overall, these results suggest that the magnitude of racial differences in short sleep duration increases with higher income such that AAs still have higher odds of short sleep duration than whites.

We observed a similar racial disparity regarding the educational level. For whites, the odds of very short and long sleep decreased as the educational level increased. For AAs, neither very short nor long sleep was associated with the increased educational level. Jackson and colleagues in their report from the NHIS cohort showed that whites but not AAs with less educational attainment had a higher prevalence of short sleep (40). To summarize, these results suggest that the association between SES factors and sleep durations among AAs and whites should be interpreted with caution and requires further studies.

4.3. Sleep duration and health/lifestyle characteristics

In this study, the associations between sleep duration and lifestyle behaviors such as smoking status, alcohol use were weak. Several other studies have reported the association between smoking and sleep duration, but the strength of associations varied (29–31, 41–43). The discrepancies among these studies could be attributed to the inconsistent measurement of smoking status. Our analysis and many other studies use qualitative terms like “Former,” “Current, “and “Never” to categorize the study population (29, 30, 43). Other studies reported the cigarettes use per day and categorized the whole population into multiple groups (30, 41), and some considered different types of nicotine use or second-hand smoking (42).

This study confirmed the association between sleep duration and high BMI (≥35 kg/m^2) suggested by previous studies (44, 45), but did not found a strong association between sleep duration and HEI, or consumption of specific food groups.

Physical activity duration and intensity is another factor that potentially affects sleep duration. In this study, participants with longer time spent in sedentary behaviors had increased odds of long sleep. Similarly, Stranges and colleagues reported that US adults from the Western New York Health Study with less than 1.5 MET-h of vigorous weekly activity were more likely to report both short (< 6 h) and long (>8 h) sleep duration (46). The SCCS participants in this study with higher total light, moderate, and strenuous work (MET-h/day) had a lower prevalence of very short and long sleep. These results are in agreement with the results of a study reported by Tsunoda and colleagues (47). They found that one or more bouts of moderate or vigorous-intensity of physical activity in middle-aged (< 60 years old) adults or moderate or low-intensity physical activity in older adults (> 60 years old) per week can promote sufficient sleep duration. Nevertheless, more systematic studies of the relationship between sleep and physical activity are needed.

4.4. Sleep duration and health conditions

In this study, health conditions were associated with very short, short, and long sleep independently of race and sex. We found a significant association of CVD or stroke, diabetes, COPD, and depression with very short sleep and depression with long sleep. The association of shorter sleep durations and health conditions, such as CVD or stroke, diabetes, COPD, and depression with very short sleep and depression with long sleep has been reported previously (3, 6, 7, 18), and some underlying biological mechanisms have been suggested (3). Depression has been associated with poor sleep in cross-sectional studies (48, 49), and this association has been confirmed by prospective studies (50, 51). In this and other studies, depression and CVD or stroke were strongly associated with both short and long sleep durations (52, 53). We did not observe qualitative racial differences in these associations. One possible explanation is that biological factors might have an essential role in regulating the association between sleep duration and health conditions. For example, a chronic inflammatory state is a wellknown risk factor and biomarker for CVD occurrence and progression (54). Also, it has been reported that in both sleep deficient (55, 56) and depressed individuals (57), levels of pro-inflammatory biomarkers were elevated, indicating that both sleep deficiency and depressive state correlate with inflammatory responses. These associations suggest potential physiological interrelation among sleep duration, depression, and CVD and deserves further studies (58). In this study, we also observed some quantitative racial differences in associations between sleep duration and health conditions that require further analyses. For example, for participants with depression, the odds of having very short sleep was higher in AAs than in whites, whereas the odds of having long sleep was higher in whites than in AAs.

This study provides useful data for the development of evidence-based behavioral, sleep hygiene, or other clinical intervention for older adults. For example, the results may be useful in adapting existing behavioral sleep interventions to a version culturally tailored for both underserved AA and white populations with low SES. Results from this study may also serve as a useful reference for health policymakers assessing the effect of racial/ethnic and SES disparities on health promotion and guidance.

Future studies related to racial/ethnic disparities in every short, short, and long sleep should be designed to explore differences within AA, white, and other (e.g., Hispanic, Native American, and Asian) populations and identify their causes. These studies should also examine a contribution of suboptimal sleep to disparities in the prevalence of chronic diseases like CVD, hypertension, stroke, and depression that disproportionally affect racial/ethnic minorities and populations from the low SES strata.

4.5. Strengths and Limitations

The SCCS is among the largest prospective cohorts ever assembled to investigate risk and preventive factors for cancer and other chronic diseases with a high number of individuals from low SES strata and over-representation of AA in proportions higher than present in general US population. The large sample size enabled controlling for many potential confounders, including SES and lifestyle factors, activity level and health conditions, and yielding narrow 95% confidence intervals. Another unique strength of our study was that by

design, most of our participants were from similar SES backgrounds enhancing comparability of results between AAs and whites, with adjustment for residual SES differences in statistical modeling.

Our study also has limitations to be considered. First, sleep duration and other variables, including health conditions, were self-reported rather than objectively measured. For example, a validation study comparing self-reported and actigraphy-assessed sleep duration among adults found that reported sleep duration tended to be longer than objectively assessed, particularly among people with short sleep duration and among AAs (59). Such measurement error in assessing sleep duration might have led to a misclassification of those reporting very short or short sleep as having normal or long sleep, which could have attenuated the study results. Also, if some participants had an undiagnosed health condition or conditions when the data were collected, our analysis might have underestimated their associations with sleep duration.

On the other hand, in participants who reported having a health condition but have managed it successfully, the analysis might have overestimated the association between this condition and sleep duration. Second, we lacked information on other important aspects of sleep and circadian rhythm such as sleep quality, snoring, current sleep disorder, and chronotype, which may influence the associations of demographic, and SES factors (24, 60, 61). Moreover, we also did not have information about shift work, another potentially important confounder of the association between sleep and chronic disease risk. Fourth, because the study was cross-sectional and a single report of sleep duration was obtained, inferences regarding causal and temporal relationships cannot be made, and long-term sleep patterns among the study population cannot be captured.

In this study, our primary focus was on percentages in pre-specified short or long sleep hours categories. We used multinomial logistic models, which enabled us to evaluate the association between various covariates and these sleep percentages. Although the large sample size promotes the robustness of results, the logistic regression model generates the odds ratio, which mathematically always overestimates the prevalence ratio, especially when the outcome is not rare (62). An alternative approach could be Poisson regression (40, 63), which directly estimate the prevalence ratio. However, we thought that it might be challenging to measure associations between multiple covariates and the sleep duration with Poisson regression.

Nevertheless, researchers should choose a regression method appropriate to their study goals. Another statistical limitation is multiple testing. In the respective models, we included 43 variables for men and 44 variables for women. As a result, the significance of intercept and coefficients of the model were tested 44 and 45 times for men and women, respectively. The probability of finding significant association by chance could be reduced by using Bonferroni corrected p-values, which in our sample were 0.00111 for men and 0.00109 for women. However, we decided not to use the Bonferroni corrected values because the method is considered highly conservative, and that would increase false negative rates in our analysis.

5. Conclusions

Sleep duration patterns differed between AAs and whites from the SCCS underrepresented population with low SES. Sleep duration was associated with marital status, educational level, and family income, but the effect varied depending on the race-sex population. Lifestyle behaviors such as smoking status, except for current smoking, alcohol use, and dietary intake except for meat, were not significantly associated with either short or long sleep in either race or sex. BMI was associated with very short and long sleep. Higher physical activity levels significantly decrease odds for both very short and long sleep duration. The association between sleep duration and health conditions such as depression, asthma, COPD, and CVD and stroke were uniformly distributed across AAs and whites and male and female SCCS participants and should be further examined.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding sources

Research reported in this publication was supported by the National Cancer Institute of the National Institutes of Health under Award Number U01CA202979, DK058404, and DK20593.

Research reported in this publication was supported by the National Cancer Institute of the National Institutes of Health under Award Number U01CA202979. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

List of Abbreviations

AA	African American
BMI	body mass index
CHC	community health center
CI	confidence interval
COPD	chronic obstructive pulmonary disease
CVD	cardiovascular disease
FFQ	food frequency questionnaire
GED	general education development
HEI	healthy eating index
MET	metabolic equivalent
OR	odds ratio
PAQ	physical activity questionnaire

SES	socio-economic status

References

1. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity (Silver Spring, Md). 2008;16(3):643–53. doi: 10.1038/oby.2007.118.
2. Mezick EJ, Wing RR, McCaffery JM. Associations of self-reported and actigraphy-assessed sleep characteristics with body mass index and waist circumference in adults: moderation by gender. Sleep Medicine. 2014;15(1):64–70. doi: 10.1016/j.sleep.2013.08.784. [PubMed: 24239499]
3. Rangaraj VR, Knutson KL. Association between sleep deficiency and cardiometabolic disease: implications for health disparities. Sleep Medicine. 2016;18:19–35. doi: 10.1016/j.sleep.2015.02.535. [PubMed: 26431758]
4. Cooper AJM, Westgate K, Brage S, Prevost AT, Griffin SJ, Simmons RK. Sleep duration and cardiometabolic risk factors among individuals with type 2 diabetes. Sleep Medicine. 2015;16(1):119–25. doi: 10.1016/j.sleep.2014.10.006. [PubMed: 25439076]
5. Beihl DA, Liese AD, Haffner SM. Sleep Duration as a Risk Factor for Incident Type 2 Diabetes in a Multiethnic Cohort. Annals of Epidemiology. 2009;19(5):351–7. doi: 10.1016/j.annepidem.2008.12.001. [PubMed: 19362278]
6. Chaput J-P, Després J-P, Bouchard C, Astrup A, Tremblay A. Sleep duration as a risk factor for the development of type 2 diabetes or impaired glucose tolerance: analyses of the Quebec Family Study. Sleep medicine. 2009;10(8):919–24. [PubMed: 19332380]
7. Chao C-Y, Wu J-S, Yang Y-C, Shih C-C, Wang R-H, Lu F-H, et al. Sleep duration is a potential risk factor for newly diagnosed type 2 diabetes mellitus. Metabolism. 2011;60(6):799–804. [PubMed: 20846701]
8. Larcher S, Benhamou PY, Pépin JL, Borel AL. Sleep habits and diabetes. Diabetes & Metabolism. 2015;41(4):263–71. doi: 10.1016/j.diabet.2014.12.004. [PubMed: 25623152]
9. Vogtmann E, Levitan EB, Hale L, Shikany JM, Shah NA, Endeshaw Y, et al. Association between Sleep and Breast Cancer Incidence among Postmenopausal Women in the Women's Health Initiative. Sleep. 2013;36(10):1437–44. doi: 10.5665/sleep.3032. [PubMed: 24082303]
10. Bower JE, Ganz PA, Desmond KA, Rowland JH, Meyerowitz BE, Belin TR. Fatigue in Breast Cancer Survivors: Occurrence, Correlates, and Impact on Quality of Life. Journal of Clinical Oncology. 2000;18(4):743. [PubMed: 10673515]
11. Gu F, Xiao Q, Chu LW, Yu K, Matthews CE, Hsing AW, et al. Sleep Duration and Cancer in the NIH-AARP Diet and Health Study Cohort. PLOS ONE. 2016;11(9):e0161561. doi: 10.1371/journal.pone.0161561. [PubMed: 27611440]
12. Johnson DA, Lisabeth L, Lewis TT, Sims M, Hickson DA, Samdarshi T, et al. The Contribution of Psychosocial Stressors to Sleep among African Americans in the Jackson Heart Study. Sleep. 2016;39(7):1411–9. doi: 10.5665/sleep.5974. [PubMed: 27166234]
13. El-Sheikh M, Keiley M, Bagley EJ, Chen E. Socioeconomic Adversity and Women's Sleep: Stress and Chaos as Mediators. Behavioral Sleep Medicine. 2015;13(6):506–23. doi: 10.1080/15402002.2014.940110. [PubMed: 25115947]
14. Schierenbeck T, Riemann D, Berger M, Hornyak M. Effect of illicit recreational drugs upon sleep: Cocaine, ecstasy and marijuana. Sleep Medicine Reviews. 2008;12(5):381–9. doi: 10.1016/j.smrv.2007.12.004. [PubMed: 18313952]
15. Thakkar MM, Sharma R, Sahota P. Alcohol disrupts sleep homeostasis. Alcohol (Fayetteville, NY). 2015;49(4):299–310. doi: 10.1016/j.alcohol.2014.07.019.
16. Gallicchio L, Kalesan B. Sleep duration and mortality: a systematic review and meta-analysis. Journal of Sleep Research. 2009;18(2):148–58. doi: 10.1111/j.1365-2869.2008.00732.x. [PubMed: 19645960]
17. Williams NJ, Grandner MA, Wallace DM, Cuffee Y, Airhihenbuwa C, Okuyemi K, et al. Social and behavioral predictors of insufficient sleep among African Americans and Caucasians. Sleep Medicine. 2016;18:103–7. doi: 10.1016/j.sleep.2015.02.533. [PubMed: 26514614]

18. Egan KJ, Knutson KL, Pereira AC, von Schantz M. The role of race and ethnicity in sleep, circadian rhythms and cardiovascular health. Sleep medicine reviews. 2017;33:70–8. [PubMed: 27908540]
19. Johnson DA, Jackson CL, Williams NJ, Alcántara C. Are sleep patterns influenced by race/ethnicity–a marker of relative advantage or disadvantage? Evidence to date. Nature and science of sleep. 2019;11:79.
20. Van Dyke ME, Vaccarino V, Quyyumi AA, Lewis TT. Socioeconomic status discrimination is associated with poor sleep in African-Americans, but not Whites. Social Science & Medicine. 2016;153:141–7. doi: 10.1016/j.socscimed.2016.02.012. [PubMed: 26896878]
21. Slopen N, Lewis TT, Williams DR. Discrimination and sleep: a systematic review. Sleep Medicine. 2016;18:88–95. doi: 10.1016/j.sleep.2015.01.012. [PubMed: 25770043]
22. Sims M, Diez-Roux AV, Gebreab SY, Brenner A, Dubbert P, Wyatt S, et al. Perceived discrimination is associated with health behaviours among African-Americans in the Jackson Heart Study. Journal of epidemiology and community health. 2016;70(2):187–94. doi: 10.1136/jech-2015-206390. [PubMed: 26417003]
23. Petrov ME, Lichstein KL. Differences in sleep between black and white adults: an update and future directions. Sleep Medicine. 2016;18:74–81. doi: 10.1016/j.sleep.2015.01.011. [PubMed: 25754383]
24. Grandner MA, Williams NJ, Knutson KL, Roberts D, Jean-Louis G. Sleep disparity, race/ethnicity, and socioeconomic position. Sleep medicine. 2016;18:7–18. [PubMed: 26431755]
25. Fuller-Rowell TE, Curtis DS, El-Sheikh M, Chae DH, Boylan JM, Ryff CD. Racial disparities in sleep: the role of neighborhood disadvantage. Sleep Medicine. 2016;27–28:1–8. doi: 10.1016/j.sleep.2016.10.008.
26. Carnethon MR, De Chavez PJ, Zee PC, Kim K-YA, Liu K, Goldberger JJ, et al. Disparities in sleep characteristics by race/ethnicity in a population-based sample: Chicago Area Sleep Study. Sleep Medicine. 2016;18:50–5. doi: 10.1016/j.sleep.2015.07.005. [PubMed: 26459680]
27. Johnson DA, Thorpe RJ, McGrath JA, Jackson WB, Jackson CL. Black–white differences in housing type and sleep duration as well as sleep difficulties in the United States. International journal of environmental research and public health. 2018;15(4):564.
28. Jehan S, Myers AK, Zizi F, Pandi-Perumal SR, Jean-Louis G, Singh N, et al. Sleep health disparity: the putative role of race, ethnicity and socioeconomic status. Sleep medicine and disorders: international journal. 2018;2(5):127. [PubMed: 31179440]
29. Jean-Louis G, Grandner MA, Youngstedt SD, Williams NJ, Zizi F, Sarpong DF, et al. Differential increase in prevalence estimates of inadequate sleep among black and white Americans. BMC public health. 2015;15(1):1185. [PubMed: 26611643]
30. Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. American journal of epidemiology. 2009;169(9):1052–63. [PubMed: 19299406]
31. Patel NP, Grandner MA, Xie D, Branas CC, Gooneratne N. “ Sleep disparity” in the population: poor sleep quality is strongly associated with poverty and ethnicity. BMC Public Health. 2010;10(1):475. [PubMed: 20701789]
32. Whinnery J, Jackson N, Rattanaumpawan P, Grandner MA. Short and long sleep duration associated with race/ethnicity, sociodemographics, and socioeconomic position. Sleep. 2014;37(3):601–11. [PubMed: 24587584]
33. Buchowski MS, Matthews CE, Cohen SS, Signorello LB, Fowke JH, Hargreaves MK, et al. Evaluation of a questionnaire to assess sedentary and active behaviors in the Southern Community Cohort Study. Journal of physical activity & health. 2012;9(6):765–75. [PubMed: 21952413]
34. Signorello LB, Buchowski MS, Cai Q, Munro HM, Hargreaves MK, Blot WJ. Biochemical validation of food frequency questionnaire-estimated carotenoid, alpha-tocopherol, and folate intakes among African Americans and non-Hispanic Whites in the Southern Community Cohort Study. Am J Epidemiol. 2010;171(4):488–97. doi: 10.1093/aje/kwp402. [PubMed: 20061366]
35. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, et al. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: considerations and caveats. Journal of the Academy of Nutrition and Dietetics. 2018;118(9):1603–21. [PubMed: 30146072]

36. Zizi F, Pandey A, Murrray-Bachmann R, Vincent M, McFarlane S, Ogedegbe G, et al. Race/ethnicity, sleep duration, and diabetes mellitus: analysis of the National Health Interview Survey. The American journal of medicine. 2012;125(2):162–7. [PubMed: 22269619]
37. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. Sleep. 2015;38(6):843–4. [PubMed: 26039963]
38. Eastman CI, Molina TA, Dziepak ME, Smith MR. Blacks (African Americans) have shorter free-running circadian periods than whites (Caucasian Americans). Chronobiology international. 2012;29(8):1072–7. [PubMed: 22894720]
39. Petrov ME, Long DL, Grandner MA, MacDonald LA, Cribbet MR, Robbins R, et al. Racial differences in sleep duration intersect with sex, socioeconomic status, and US geographic region: The REGARDS study. Sleep Health. 2020.
40. Jackson CL, Redline S, Kawachi I, Williams MA, Hu FB. Racial disparities in short sleep duration by occupation and industry. American journal of epidemiology. 2013;178(9):1442–51. [PubMed: 24018914]
41. Riedel BW, Durrence HH, Lichstein KL, Taylor DJ, Bush AJ. The relation between smoking and sleep: the influence of smoking level, health, and psychological variables. Behavioral sleep medicine. 2004;2(1):63–78. [PubMed: 15600225]
42. Sabanayagam C, Shankar A. The association between active smoking, smokeless tobacco, second-hand smoke exposure and insufficient sleep. Sleep medicine. 2011;12(1):7–11. [PubMed: 21144798]
43. Zhang L, Samet J, Caffo B, Punjabi NM. Cigarette smoking and nocturnal sleep architecture. American Journal of Epidemiology. 2006;164(6):529–37. [PubMed: 16829553]
44. Anic GM, Titus-Ernstoff L, Newcomb PA, Trentham-Dietz A, Egan KM. Sleep duration and obesity in a population-based study. Sleep medicine. 2010;11(5):447–51. [PubMed: 20363668]
45. Hasler G, Buysse DJ, Klaghofer R, Gamma A, Ajdacic V, Eich D, et al. The association between short sleep duration and obesity in young adults: a 13-year prospective study. Sleep. 2004;27(4):661–6. [PubMed: 15283000]
46. Stranges S, Dorn JM, Shipley MJ, Kandala N-B, Trevisan M, Miller MA, et al. Correlates of short and long sleep duration: a cross-cultural comparison between the United Kingdom and the United States: the Whitehall II Study and the Western New York Health Study. American journal of epidemiology. 2008;168(12):1353–64. [PubMed: 18945686]
47. Tsunoda K, Kitano N, Kai Y, Uchida K, Kuchiki T, Okura T, et al. Prospective study of physical activity and sleep in middle-aged and older adults. American journal of preventive medicine. 2015;48(6):662–73. [PubMed: 25891000]
48. Dørheim SK, Bondevik GT, Eberhard-Gran M, Bjorvatn B. Sleep and depression in postpartum women: a population-based study. Sleep. 2009;32(7):847–55. [PubMed: 19639747]
49. Hayashino Y, Yamazaki S, Takegami M, Nakayama T, Sokejima S, Fukuhara S. Association between number of comorbid conditions, depression, and sleep quality using the Pittsburgh Sleep Quality Index: results from a population-based survey. Sleep medicine. 2010;11(4):366–71. [PubMed: 20219425]
50. Chang PP, Ford DE, Mead LA, Cooper-Patrick L, Klag MJ. Insomnia in young men and subsequent depression: The Johns Hopkins Precursors Study. American journal of epidemiology. 1997;146(2):105–14. [PubMed: 9230772]
51. Roberts RE, Duong HT. The prospective association between sleep deprivation and depression among adolescents. Sleep. 2014;37(2):239–44. [PubMed: 24497652]
52. Dauvilliers Y, Lopez R, Ohayon M, Bayard S. Hypersomnia and depressive symptoms: methodological and clinical aspects. BMC medicine. 2013;11(1):78. [PubMed: 23514569]
53. Patel SR, Malhotra A, Gottlieb DJ, White DP, Hu FB. Correlates of long sleep duration. Sleep. 2006;29(7):881–9. [PubMed: 16895254]
54. Haffner SM. The metabolic syndrome: inflammation, diabetes mellitus, and cardiovascular disease. The American journal of cardiology. 2006;97(2):3–11. [PubMed: 16675316]

55. Mullington JM, Haack M, Toth M, Serrador JM, Meier-Ewert HK. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. Progress in cardiovascular diseases. 2009;51(4):294–302. [PubMed: 19110131]

56. Wright KP Jr, Drake AL, Frey DJ, Fleshner M, Desouza CA, Gronfier C, et al. Influence of sleep deprivation and circadian misalignment on cortisol, inflammatory markers, and cytokine balance. Brain, behavior, and immunity. 2015;47:24–34.

57. Miller AH, Raison CL. The role of inflammation in depression: from evolutionary imperative to modern treatment target. Nature reviews immunology. 2016;16(1):22.

58. Mezick EJ, Hall M, Matthews KA. Are sleep and depression independent or overlapping risk factors for cardiometabolic disease? Sleep medicine reviews. 2011;15(1):51–63. [PubMed: 20494595]

59. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-Reported and Measured Sleep Duration: How Similar Are They? Epidemiology. 2008;19(6):838–45. doi: 10.1097/EDE.0b013e318187a7b0. [PubMed: 18854708]

60. Anders MP, Breckenkamp J, Blettner M, Schlehofer B, Berg-Beckhoff G. Association between socioeconomic factors and sleep quality in an urban population-based sample in Germany. The European Journal of Public Health. 2013;24(6):968–73. [PubMed: 24280873]

61. Grandner MA, Petrov MER, Rattanaumpawan P, Jackson N, Platt A, Patel NP. Sleep symptoms, race/ethnicity, and socioeconomic position. Journal of clinical sleep medicine. 2013;9(09):897–905. [PubMed: 23997702]

62. Reed P, Wu Y. Logistic regression for risk factor modelling in stuttering research. Journal of fluency disorders. 2013;38(2):88–101. [PubMed: 23773663]

63. Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC medical research methodology. 2003;3(1):21. [PubMed: 14567763]

Highlights

- Association of sleep duration and socioeconomic status, health and lifestyle characteristics, and prevalence of chronic diseases were evaluated in a large cohort (n=78,549) of underrepresented African American (AA) and white adults from the Southern Community Cohort Study (SCCS).
- The prevalence of very short and short sleep durations was similar between AAs and whites, while AAs (19.3%) were more likely to experience long sleep duration than whites (13.0%), from the SCCS population with low socioeconomic status.
- Lower household income was associated with very short and short sleep durations in whites but not AAs.
- Very short, short, and long sleep durations were associated with physical activity and comorbid conditions such as depression and cardiovascular disease (CVD) and stroke, independently of race and sex.

Table 1.

Socio-demographic, health risk behaviors and contextual characteristics of study participants

Variable[1]	African American		White	
	Females (N=31,296)	Males (N=22,334)	Females (N=15,200)	Males (N=9,719)
Age at enrollment, years	52 ± 9	51 ± 8	54 ± 9	54 ± 9
Source of enrollment, n (%)				
Community Health Center	28,545 (91.2)	20,353 (91.1)	12,276 (80.8)	6,519 (67.1)
General Population mailing	2,751 (8.8)	1,981 (8.9)	2,924 (19.2)	3,200 (32.9)
County of residence, n (%)				
Rural	8,099 (25.9)	4,540 (20.3)	3,735 (24.6)	2,272 (23.4)
Urban	2,3195 (74.1)	1,7788 (79.7)	1,1464(75.4)	7,444 (76.6)
Sleep duration, n (%)				
< 5	2,061 (6.6)	1,258 (5.6)	1,046 (6.9)	565 (5.8)
5 – 6	9,296 (29.7)	6,300 (28.2)	4,495(29.6)	2,744 (28.2)
7 – 8	14,244 (45.5)	10,123(45.3)	7,649 (50.3)	5,194 (53.4)
≥ 9	5,695 (18.2)	4,653 (20.8)	2,010 (13.2)	1,216 (12.5)
Education completed, n (%)				
< 9 years	2,273 (7.3)	1,958 (8.8)	1,140 (7.5)	816 (8.4)
9 – 11 years	7,033 (22.5)	5,498 (24.6)	2,537 (16.7)	1,319 (13.6)
High school or equivalent	10,241 (32.7)	7,959 (35.7)	4,964 (32.7)	2,863 (29.5)
Junior college	8,277 (26.5)	4,972 (22.3)	4,055 (26.7)	2,395 (24.7)
College graduate	3,447 (11.0)	1,933 (8.7)	2,500 (16.5)	2,317 (23.9)
Annual household income, n (%)				
<$15,000	18,267 (59.1)	13,190 (59.7)	7,356 (49.2)	3,971 (41.5)
$15,000 – $24,999	7,124 (23.1)	4,710 (21.3)	2,915 (19.5)	1,620 (16.9)
$25,000 – $49,999	3,949 (12.8)	2,810 (12.7)	2,466 (16.5)	1,665 (17.4)
≥$50,000	1,547 (5.0)	1,386 (6.3)	2,204 (14.8)	2,320 (24.2)
Marital status, n (%)				
Married/living with partner	8,412 (27.0)	7,121 (32.0)	6,806 (45.2)	5,119 (53.9)
Divorced/separated	10,818 (34.7)	7,482 (33.6)	5,100 (33.9)	2,714 (28.6)
Widowed	4,399 (14.1)	819 (3.7)	2,000 (13.3)	342 (3.6)
Never been married	7,554 (24.2)	6,816 (30.7)	1,146 (7.6)	1,323 (13.9)
Body Mass Index (kg/m^2), n (%)				
<18.5	327 (1.1)	287 (1.3)	266 (1.8)	86 (0.9)
18.5–24.9	4,813 (15.6)	7,727 (34.9)	3,775 (25.2)	2,668 (27.6)
25–29.9	7,838 (25.5)	7,777 (35.1)	3,979 (26.5)	3,599 (37.3)
30–34.9	7,673 (24.9)	3,971 (17.9)	3,246 (21.6)	1,997 (20.7)
≥35	10,145 (32.9)	2,405 (10.8)	3,739 (24.9)	1,304 (13.5)
Currently working, n (%)				
Yes	12,507 (40.2)	8,543 (38.4)	5,834 (38.6)	4,016 (41.5)
No	18,624 (59.8)	13,705 (61.6)	9,289 (61.4)	5,665 (58.5)
Cigarette smoking, n (%)				

Variable[1]	African American		White	
	Females (N=31,296)	Males (N=22,334)	Females (N=15,200)	Males (N=9,719)
Current	10,126 (32.5)	12,598 (56.7)	5,392 (35.7)	3,898 (40.7)
Former	6,141 (19.7)	4,657 (21.0)	3,870 (25.6)	3,229 (33.7)
Never	14,857 (47.7)	4,947 (22.3)	5,859 (38.7)	2,462 (25.7)
Total sedentary time, h/day	9.57 ± 5.18	9.37 ± 5.33	8.84 ± 4.49	9.09 ± 4.80
Total light, moderate and vigorous work, MET-h/day	20.13 ± 15.41	24.54 ± 22.32	19.82 ± 15.45	21.65 ± 20.29
Total energy intakes, kcal/day	2,346 ± 1,341	3,177 ± 1,633	1,932 ± 974	2,803 ± 1,355
Healthy Eating Index, score	60 ± 12	55 ± 11	59 ± 13	55 ± 12
Dietary intakes (FFQ), servings/day				
Fruits/vegetables	4 ± 2	3 ± 2	3 ± 2	3 ± 2
Bread	2 ± 1	2 ± 1	2 ± 1	2 ± 1
Meat	2 ± 1	2 ± 1	1 ± 1	2 ± 1
Coffee consumption, times/day	0.41 ± 0.75	0.46 ± 0.77	1.00 ± 1.16	1.17 ± 1.20
Soda consumption, times/day	0.83 ± 1.12	0.77 ± 1.06	1.12 ± 1.36	1.05 ± 1.28
Alcohol use, n (%)				
Yes	13,754 (44.5)	15,280 (69.3)	6,495 (43.4)	5,734 (60.2)
No	17,123 (55.5)	6,769 (30.7)	8,481 (56.6)	3,787 (39.8)
Alcohol use among drinkers, drinks/day	1.71 ± 4.14	4.06 ± 6.32	1.00 ± 2.98	3.13 ± 5.87

[1] data are presented as n (%) or mean ± sd as denoted for each variable.

Table 2.

Associations of sleep duration and SES characteristics, stratified by race and sex

Variable[1]	African American		White	
	Males	Females	Males	Females
Very short sleep (< 5 h) – OR (95% CI)				
Education (reference: High school or equivalent)				
< 9 years	1.34 (1.06, 1.71) *	1.47 (1.21, 1.79) ***	0.93 (0.67, 1.31)	1.54 (1.20, 1.97) ***
9–11 years	1.11 (0.94, 1.32)	1.36 (1.19, 1.55) ***	1.01 (0.77, 1.31)	1.18 (0.97, 1.43)
Some college	1.02 (0.85, 1.23)	1.04 (0.90, 1.19)	0.70 (0.53, 0.91) **	0.88 (0.72, 1.06)
College graduate	1.20 (0.91, 1.59)	0.84 (0.67, 1.04)	0.52 (0.34, 0.78) **	0.47 (0.34, 0.66) ***
Total family income (reference: $25,000 – $49,999)				
<$15,000	1.26 (1.00, 1.58)	1.33 (1.09, 1.62) **	2.54 (1.76, 3.67) ***	2.04 (1.57, 2.64) ***
$15,000 – $24,999	0.98 (0.76, 1.26)	1.17 (0.95, 1.45)	1.75 (1.16, 2.62) **	1.19 (0.89, 1.60)
≥$50,000	0.63 (0.41, 0.96) *	0.95 (0.66, 1.35)	0.44 (0.24, 0.81) **	0.47 (0.30, 0.74) **
Short sleep (5 – 6 h) – OR (95% CI)				
Education (reference: High school or equivalent)				
< 9 years	1.02 (0.89, 1.17)	0.85 (0.75, 0.96) **	1.02 (0.83, 1.25)	1.04 (0.88, 1.22)
9–11 years	0.97 (0.89, 1.07)	1.02 (0.95, 1.11)	1.04 (0.88, 1.23)	1.05 (0.93, 1.18)
some college	1.18 (1.07, 1.29) ***	1.08 (1.00, 1.16)	0.95 (0.83, 1.10)	0.92 (0.83, 1.02)
College graduate	1.22 (1.06, 1.40) **	1.04 (0.93, 1.15)	0.80 (0.68, 0.96) *	0.66 (0.57, 0.77) ***
Total family income (reference: $25,000 – $49,999)				
<$15,000	0.88 (0.79, 0.99) *	0.96 (0.87, 1.05)	1.17 (0.99, 1.38)	1.30 (1.15, 1.48) ***
$15,000 – $24,999	0.88 (0.79, 1.00) *	0.98 (0.89, 1.08)	1.25 (1.05, 1.49) *	1.18 (1.03, 1.36) *
≥$50,000	1.02 (0.86, 1.20)	0.95 (0.82, 1.10)	0.71 (0.59, 0.86) ***	0.75 (0.64, 0.89) ***
Long sleep (≥ 9 h) – OR (95% CI)				
Education (reference: High school or equivalent)				
< 9 years	1.16 (1.00, 1.34) *	1.12 (0.98, 1.29)	1.27 (0.99, 1.65)	1.03 (0.82, 1.29)
9–11 years	1.14 (1.03, 1.26) **	1.09 (1.00, 1.19)	1.23 (0.99, 1.54)	1.07 (0.91, 1.26)
some college	0.93 (0.83, 1.03)	0.98 (0.89, 1.07)	1.07 (0.88, 1.30)	0.99 (0.86, 1.14)
College graduate	0.86 (0.72, 1.03)	0.79 (0.69, 0.90) ***	0.93 (0.73, 1.19)	0.95 (0.79, 1.15)
Total family income (reference: $25,000 – $49,999)				
<$15,000	1.32 (1.15, 1.51) ***	1.14 (1.02, 1.29) *	1.24 (0.99, 1.55)	1.54 (1.29, 1.83) ***
$15,000 – $24,999	1.04 (0.90, 1.20)	1.06 (0.94, 1.20)	1.03 (0.80, 1.31)	1.25 (1.03, 1.51) *
≥$50,000	0.74 (0.59, 0.94) *	0.84 (0.69, 1.03)	0.62 (0.48, 0.81) ***	0.81 (0.65, 1.00)

1. adjusted for age at enrollment (restricted cubic spline), body mass index, marital status, smoking status, alcohol usage, total time spent in sedentary behavior, total occupational or household activities, intake of fruits and vegetables, bread, and meats, total amount of energy intakes, coffee consumption, beverages consumption, healthy eating index, hypertension, CVD or stroke, diabetes, COPD, asthma, depression, and cancer, hormone replacement therapy (only in females).

2. * P<0.05; ** P<0.01; ***P<0.001.

Table 3.

Associations of sleep duration and health/lifestyle characteristics, stratified by race and sex

Variable[1.]	African American		White	
	Male	Female	Male	Female
Very short sleep (< 5 h/day) – OR (95% CI)				
Smoking status (reference: Never)				
Past	0.92 (0.75, 1.13)	0.89 (0.78, 1.03)	0.82 (0.60, 1.12)	0.77 (0.62, 0.95) *[3]
Current	1.00 (0.84, 1.20)	1.02 (0.90, 1.16)	1.05 (0.79, 1.41)	1.37 (1.14, 1.66) ***
Alcohol use (reference: 0–<1/day)				
1–2/day	1.10 (0.92, 1.33)	0.91 (0.74, 1.12)	0.85 (0.61, 1.19)	1.18 (0.84, 1.67)
3 or >/day	1.18 (0.99, 1.41)	1.19 (0.97, 1.47)	1.17 (0.89, 1.54)	0.99 (0.67, 1.46)
Body Mass Index (reference: 18.5 – 24.9 kg/m^2)				
<18.5	1.32 (0.80, 2.18)	1.18 (0.74, 1.90)	1.96 (0.84, 4.57)	1.38 (0.83, 2.30)
25–29.9	0.98 (0.84, 1.16)	1.03 (0.87, 1.21)	1.04 (0.81, 1.34)	1.27 (1.03, 1.57) *
30–34.9	1.13 (0.93, 1.38)	0.88 (0.74, 1.04)	1.04 (0.77, 1.40)	1.12 (0.90, 1.41)
≥35	1.35 (1.07, 1.70) *	1.10 (0.94, 1.30)	1.27 (0.91, 1.77)	1.23 (0.98, 1.54)
HEI (reference: Least healthy)				
Medium healthy	0.79 (0.68, 0.93) **	0.93 (0.82, 1.05)	0.85 (0.68, 1.07)	0.92 (0.77, 1.10)
Healthiest	0.78 (0.66, 0.92) **	0.76 (0.66, 0.88) ***	0.82 (0.61, 1.08)	0.87 (0.71, 1.07)
Time spent in sitting behaviors (reference: Least sitting)				
Medium sitting	1.05 (0.89, 1.23)	0.82 (0.72, 0.93) **	1.04 (0.82, 1.32)	0.76 (0.63, 0.92) **
Most sitting	1.17 (0.99, 1.38)	0.93 (0.82, 1.05)	1.13 (0.89, 1.44)	1.09 (0.92, 1.29)
Total light, moderate, and strenuous work (reference: Least active)				
Medium active	0.77 (0.66, 0.90) **	0.79 (0.69, 0.89) ***	0.71 (0.56, 0.90) **	0.89 (0.75, 1.06)
Most active	0.74 (0.62, 0.88) ***	0.88 (0.78, 1.00) *	0.61 (0.47, 0.79) ***	0.84 (0.70, 1.01)
Short sleep (5 – 6 h/day) – OR (95% CI)				
Smoking status (reference: Never)				
Past	0.97 (0.87, 1.08)	1.01 (0.93, 1.08)	1.01 (0.88, 1.17)	1.01 (0.91, 1.13)
Current	0.98 (0.89, 1.07)	0.96 (0.89, 1.03)	1.16 (1.00, 1.35)	1.19 (1.07, 1.33) **
Alcohol use (reference: 0–<1/day)				
1–2/day	1.02 (0.92, 1.12)	0.99 (0.88, 1.11)	0.90 (0.77, 1.06)	0.93 (0.77, 1.13)
3 or >/day	1.13 (1.03, 1.24) **	1.14 (1.00, 1.30)	1.08 (0.92, 1.26)	0.99 (0.78, 1.25)
Body Mass Index (reference: 18.5 – 24.9 kg/m^2)				
<18.5	1.11 (0.81, 1.50)	1.05 (0.78, 1.41)	1.81 (1.03, 3.17) *	1.43 (1.06, 1.93) *
25–29.9	0.95 (0.87, 1.03)	0.97 (0.88, 1.06)	1.04 (0.91, 1.19)	1.13 (1.01, 1.27) *
30–34.9	1.03 (0.93, 1.14)	0.96 (0.87, 1.06)	1.09 (0.93, 1.28)	1.10 (0.97, 1.24)
≥35	1.11 (0.98, 1.26)	1.12 (1.02, 1.23) *	1.23 (1.02, 1.48) *	1.12 (0.99, 1.28)
HEI (reference: Least healthy)				
Medium healthy	0.97 (0.89, 1.05)	0.90 (0.84, 0.97) **	0.99 (0.87, 1.13)	0.95 (0.86, 1.05)

Variable[1.]	African American		White	
	Male	Female	Male	Female
Healthiest	0.92 (0.84, 1.01)	0.88 (0.81, 0.95) **	0.96 (0.83, 1.12)	0.84 (0.75, 0.94) **
Time spent in sitting behaviors (reference: Least sitting)				
Medium sitting	0.94 (0.87, 1.03)	0.98 (0.91, 1.05)	1.18 (1.04, 1.34) **	0.99 (0.89, 1.09)
Most sitting	1.01 (0.93, 1.11)	1.01 (0.94, 1.08)	1.13 (0.99, 1.29)	1.05 (0.95, 1.16)
Total light, moderate, and strenuous work (reference: Least active)				
Medium active	1.00 (0.92, 1.09)	0.98 (0.91, 1.05)	0.90 (0.79, 1.02)	0.97 (0.87, 1.07)
Most active	0.98 (0.90, 1.07)	1.04 (0.97, 1.12)	1.02 (0.89, 1.17)	1.16 (1.05, 1.29) **
Long sleep (≥ 9 h/day) – OR (95% CI)				
Smoking status (reference: Never)				
Past	1.01 (0.89, 1.14)	1.01 (0.92, 1.11)	0.97 (0.80, 1.18)	1.06 (0.92, 1.22)
Current	1.18 (1.06, 1.31) **	1.20 (1.10, 1.30) ***	1.03 (0.84, 1.27)	1.20 (1.04, 1.39) *
Alcohol use (reference: 0–<1/day)				
1–2/day	0.95 (0.85, 1.06)	1.15 (1.01, 1.31) *	0.90 (0.71, 1.13)	1.21 (0.96, 1.54)
3 or >/day	0.93 (0.83, 1.03)	1.12 (0.97, 1.30)	1.07 (0.87, 1.33)	1.29 (0.97, 1.73)
Body Mass Index (reference: 18.5 – 24.9 kg/m^2)				
<18.5	0.87 (0.62, 1.23)	1.00 (0.73, 1.37)	2.67 (1.40, 5.09) **	0.94 (0.59, 1.48)
25–29.9	0.92 (0.83, 1.00)	0.89 (0.80, 0.99) *	0.97 (0.80, 1.17)	1.12 (0.96, 1.31)
30–34.9	0.96 (0.86, 1.08)	0.85 (0.77, 0.95) **	1.17 (0.95, 1.45)	1.13 (0.96, 1.34)
≥35	1.00 (0.86, 1.16)	0.92 (0.83, 1.03)	1.39 (1.09, 1.78) **	1.22 (1.03, 1.45) *
HEI (reference: Least healthy)				
Medium healthy	1.11 (1.01, 1.22) *	1.03 (0.95, 1.12)	1.01 (0.85, 1.20)	0.96 (0.84, 1.10)
Healthiest	1.02 (0.92, 1.13)	0.87 (0.79, 0.95) **	0.85 (0.69, 1.04)	0.81 (0.69, 0.94) **
Time spent in sitting behaviors (reference: Least sitting)				
Medium sitting	1.05 (0.95, 1.15)	1.07 (0.99, 1.17)	1.15 (0.96, 1.37)	1.23 (1.07, 1.42) **
Most sitting	1.37 (1.24, 1.50) ***	1.31 (1.21, 1.43) ***	1.28 (1.07, 1.53) **	1.44 (1.26, 1.65) ***
Total light, moderate, and strenuous work (reference: Least active)				
Medium active	0.79 (0.72, 0.87) ***	0.91 (0.84, 0.99) *	0.82 (0.70, 0.97) *	0.80 (0.71, 0.92) **
Most active	0.79 (0.72, 0.87) ***	0.83 (0.77, 0.91) ***	0.72 (0.60, 0.87) ***	0.73 (0.63, 0.83) ***

[1.] Adjusted for age at enrollment (restricted cubic spline), education, marital status, household income, coffee consumption, beverages consumption, total energy intake, hypertension, CVD or stroke, diabetes, COPD, asthma, depression, and cancer, hormone replacement therapy (only in females).

[2.] * P<0.05; ** P<0.01; ***P<0.001.

Table 4.

Association of sleep duration and self-reported health conditions, stratified by race and sex

Variable[1]	African American		White	
	Male	Female	Male	Female
Very short sleep (< 5 h/day) – OR (95% CI)				
Hypertension	1.14 (0.99, 1.32)	1.07 (0.96, 1.20)	1.14 (0.92, 1.42)	1.13 (0.97, 1.33)
CVD or stroke	1.55 (1.28, 1.87) *** [2]	1.39 (1.19, 1.62) ***	1.67 (1.30, 2.13) ***	1.90 (1.57, 2.29) ***
Diabetes	1.44 (1.22, 1.70) ***	1.01 (0.89, 1.14)	0.98 (0.74, 1.29)	1.33 (1.11, 1.59) **
COPD	1.66 (1.30, 2.13) ***	1.30 (1.10, 1.53) **	1.51 (1.15, 1.99) **	1.32 (1.09, 1.59) **
Asthma	1.18 (0.96, 1.44)	1.57 (1.39, 1.78) ***	1.59 (1.23, 2.06) ***	1.21 (1.01, 1.43) *
Cancer	1.01 (0.67, 1.51)	1.20 (0.97, 1.48)	1.00 (0.69, 1.45)	1.12 (0.92, 1.37)
Depression	2.83 (2.41, 3.31) ***	2.12 (1.89, 2.37) ***	1.99 (1.62, 2.45) ***	1.51 (1.30, 1.75) ***
Short sleep (5 – 6 h/day) – OR (95% CI)				
Hypertension	1.15 (1.07, 1.24) ***	1.03 (0.96, 1.09)	1.17 (1.04, 1.31) **	1.10 (1.00, 1.20) *
CVD or stroke	1.14 (1.01, 1.28) *	1.24 (1.13, 1.36) ***	1.07 (0.93, 1.24)	1.25 (1.10, 1.42) ***
Diabetes	1.06 (0.96, 1.16)	0.96 (0.90, 1.03)	1.12 (0.97, 1.30)	1.04 (0.94, 1.17)
COPD	1.17 (1.00, 1.38)	1.16 (1.04, 1.29) **	1.29 (1.08, 1.54) **	1.18 (1.04, 1.33) **
Asthma	1.14 (1.01, 1.27) *	1.11 (1.03, 1.20) **	1.10 (0.93, 1.30)	1.22 (1.10, 1.36) ***
Cancer	0.96 (0.78, 1.19)	1.06 (0.94, 1.20)	0.87 (0.73, 1.04)	0.99 (0.89, 1.11)
Depression	1.51 (1.36, 1.68) ***	1.34 (1.25, 1.43) ***	1.19 (1.06, 1.35) **	1.26 (1.16, 1.38) ***
Long sleep (≥ 9 h/day) – OR (95% CI)				
Hypertension	1.01 (0.92, 1.10)	0.96 (0.90, 1.04)	1.02 (0.87, 1.19)	0.96 (0.85, 1.08)
CVD or stroke	1.23 (1.08, 1.39) **	1.18 (1.06, 1.32) **	1.34 (1.12, 1.60) **	1.01 (0.85, 1.20)
Diabetes	1.06 (0.95, 1.18)	1.09 (1.00, 1.18) *	1.13 (0.93, 1.36)	1.22 (1.06, 1.41) **
COPD	1.01 (0.84, 1.22)	1.02 (0.89, 1.16)	1.28 (1.02, 1.60) *	1.18 (1.01, 1.38) *
Asthma	1.04 (0.91, 1.18)	1.09 (0.99, 1.20)	1.25 (1.01, 1.54) *	0.94 (0.81, 1.08)
Cancer	1.09 (0.87, 1.38)	1.03 (0.88, 1.20)	1.12 (0.91, 1.39)	0.99 (0.85, 1.15)
Depression	1.20 (1.07, 1.36) **	1.21 (1.11, 1.31) ***	1.61 (1.37, 1.88) ***	1.91 (1.70, 2.14) ***

[1] Adjusted for age at enrollment (restricted cubic spline), education, marital status, household income, BMI, smoking status, alcohol usage, total time spent in sedentary behavior, total occupational or household activities, intakes of fruits and vegetables, bread, and meats, total amount of energy intakes, coffee consumption, beverages consumption, healthy eating index, hormone replacement therapy (only in females). The reference group for all variables in this table was 'no condition'.

[2] * P<0.05; ** P<0.01; ***P<0.001.