HHS Public Access
Author manuscript
Sleep Health. Author manuscript; available in PMC 2021 December 01.

Published in final edited form as:
Sleep Health. 2020 December ; 6(6): 797–803. doi:10.1016/j.sleh.2020.05.005.

Association between sleep duration and differences between weekday and weekend sleep with body mass index & waist circumference among Black women in SisterTalk II

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Abstract

Objectives: Examine associations between sleep duration and differences between weekday and weekend sleep with body mass index and waist circumference in a sample of high-risk Black women from the SisterTalk II study.

Design: Cross-sectional analysis of baseline data from an intervention study targeting dietary and physical activity behaviors.

Setting: Women were recruited from the Providence, RI area.

Participants: The sample includes 569 middle-aged Black women who were hypertensive or at risk for hypertension.

Measurements: Participants self-reported their weekday and weekend sleep duration. Body mass index (BMI) and waist circumference (WC) were objectively measured. Associations between the sleep and anthropometric measures were examined using analysis of variance and multivariable regression models controlling for birthplace, educational attainment, employment status, and annual household income.

Results: 25.5% of the sample were very short sleepers (≤6 hrs), 28.8% short sleepers (≥6 to <7 hrs), 40.4% recommended sleepers (≥7 to ≤9 hrs), and 5.3% long sleepers (>9 hrs); 70.7% had a

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Competing Interests: None

consistent sleep duration (≤2-hour difference between weekday and weekend sleep duration), 21.6% were classified as "weekend snoozers" (>2-hours *more* sleep on weekends), and 7.7% were classified as "weekend warriors" (>2-hours *less* sleep on weekends). Compared to recommended sleepers, very short sleepers and long sleepers had significantly greater BMIs, while long sleepers had significantly larger WCs. Being a weekend snoozer was also associated with increased BMI and WC.

Conclusions: In this sample of high-risk Black women, sleep duration and differences between weekday and weekend sleep were independently associated with excess weight and abdominal obesity.

Keywords

sleep duration; consistency; body mass index; waist circumference; Black

INTRODUCTION

Obesity prevalence has steadily increased in the United States, with larger increases being observed across certain subgroups, including both women and individuals who identify as Black (1). The complex etiology of obesity includes genetic, physiological, environmental, psychological, economic, political, and behavioral factors that interact with one another. Among behavioral factors influencing obesity (e.g. diet, physical activity, and sedentary behavior), a growing literature has examined the influence of sleep on obesity risk. Results from reviews consisting of both cross-sectional and longitudinal studies conducted in more than a dozen countries have demonstrated an inverse association between sleep duration and obesity risk, with some studies finding a U-shaped relationship (2,3). Sleep duration has also been increasingly recognized as an essential aspect of health promotion and chronic disease prevention more broadly.

Like risk for obesity, differences in sleep duration have also been observed across subgroups, with non-white and low-income individuals having less optimal sleep than their white and high-income counterparts (4). In the U.S., Black adults sleep approximately 30 minutes less than non-Hispanic whites (5). They are also almost twice as likely to report short sleep, and 60% more likely to report long sleep, both of which have been shown to be associated with adverse health outcomes (6,7). Further, findings from a study by Stamatakis et al. (2007) illustrated that while the prevalence of short sleep duration has increased for all groups, changes over time were significantly greater for Black and Hispanic individuals compared to others, suggesting widening disparities over time (8). A widening difference in the prevalence of short sleep duration between Black and white adults is especially concerning because consequences of insufficient sleep may be more severe among adults who are Black compared to adults who are white (9,10). Black families disproportionately experience social stressors and live in environments with adverse exposures associated with both disrupted sleep and increased obesity risk (10). Not unique to this line of research, studies examining associations between sleep and obesity have largely been conducted among predominantly white samples. Thus, the strength of association between sleep duration and obesity risk specifically among Black adults, remains unclear, limiting our understanding of the extent to which differences in sleep across race may be contributing to obesity and other health related disparities. The literature on high-risk Black samples is limited even further. To our knowledge, no studies have been published examining the association between sleep and weight status among Black women who have hypertension or are at risk for hypertension.

Additional gaps in the sleep-obesity literature have also been identified. First, most studies have also included a single measure of obesity risk: body mass index (BMI). Waist circumference (WC), another simple and non-invasive anthropometric measure, provides valuable information regarding body fat distribution, namely abdominal obesity, which BMI alone does not capture. Abdominal obesity has been shown to independently predict obesity-related health risks and may be an even stronger predictor than BMI (11). Compared to 63% of non-Hispanic white women, over 76% of Black women have abdominal obesity (12). Second, most studies have focused solely on sleep duration, neglecting other characteristics of sleep that may be important. For example, the timing and consistency of sleep behaviors may also influence health risks such as obesity. Many people shift their sleep patterns and activity times several hours between weekdays and weekends to accommodate school and/or work schedules and social activities, creating a shift in circadian rhythms which results in feelings comparable to jetlag (13). Oftentimes there is an accumulation of sleep debt during the week, which people attempt to compensate for on the weekend. Findings from two studies suggest that “social jetlag” is independently associated with increased BMI (13,14). Aside from the timing of one’s sleep varying considerably on the weekend, so too may duration of sleep, particularly when sleep debt is accumulated. Results from a few studies suggest that sleeping in on the weekend may help ameliorate some of the effects of insufficient sleep during the week (15,16). However, these studies were not conducted in the United States and the extent to which Black participants were included, if at all, was not reported. Further, studies examining the effects of differences in sleep duration between weekdays and weekends have focused on sleeping in on the weekend. Thus, the effects of sleeping less on the weekend, which is also a possibility, have largely been ignored.

The present study aims to address the aforementioned gaps in the literature by examining the association between sleep duration and differences between weekday and weekend sleep with BMI and WC in a sample of high-risk Black women from the SisterTalk II study. Given the complexity and health consequences associated with obesity, which disproportionately affect Black women, understanding factors contributing to its prevalence among this high-risk group is paramount.

METHODS

Study Design & Participants

This study is a cross-sectional examination of baseline data from SisterTalk II, a randomized controlled trial designed to improve dietary and physical activity behaviors among 571 Black women who were hypertensive or at risk for hypertension (17). Participants were self-identified Black women, over the age of 18, fluent in English, with a BMI of at least 22 kg/m2. Exclusion criteria included being pregnant or recently delivered a baby (<4 months), being hospitalized, and/or being diabetic. Participants were recruited from the Providence, Rhode Island and Boston, Massachusetts metropolitan areas, between 2004 and 2006. The baseline assessment was conducted through a telephone-administered survey and followed by an in-person measurement session for physical measures. The analytic sample for sleep duration included participants with reported number of weekday hours of sleep at baseline and for whom BMI and WC information were available (N=569). The analytic sample for differences between weekday and weekend sleep duration included those who additionally reported information on their weekend sleep duration at baseline (N=539). The study protocol and informed consent were approved by the Brown University Institutional Review Board.

Measurements

Sleep exposure was assessed by self-report to the following survey questions: "In the last month, on an average day during the week/weekend about how many hours did you sleep? Please include overnight sleep and naps." Based on recommendations by the National Sleep Foundation, we created a four-category sleep duration variable: very short sleepers (<6 hours), short sleepers (≥6 – <7 hours), recommended sleepers (≥7 – ≤9 hours), and long sleepers (>9 hours).[6] To assess differences between weekday and weekend sleep, weekday sleep duration was compared to weekend sleep duration and a new three-category variable was created: consistent sleeper (≤ 2-hour difference between weekday and weekend sleep duration), "weekend snoozer" (> 2-hours *more* sleep on weekends), and "weekend warrior" (> 2-hours *less* sleep on weekends). The 2-hour threshold was informed by the weekend sleep deviation literature, particularly that assessing social jetlag (13, 14).

Anthropometric outcomes, which included height and weight to calculate BMI (kg/m2) and WC, were made in-person using the Centers for Disease Control and Prevention guidelines. All anthropometry measurements were completed twice, or a third time, if the two values differed by more than 1.0 cm, and the average of the two closest measures became the final measure. Demographics were queried by telephone survey and included the following: age, ethnicity, birthplace, educational attainment, employment status, annual household income, household composition, and number of people in the household.

Data Analysis

Demographics were analyzed by sleep exposures (weekday sleep duration and differences between weekday and weekend sleep duration) using chi-square tests, and by outcomes (BMI and WC) using one-way analysis of variance (ANOVA). Variables with significant univariate associations were included in the multivariable regression models.

Multivariable regression models were constructed to assess associations between sleep duration and differences between weekday and weekend sleep with the outcomes of BMI and WC. Adjusting for significant demographics, Model 1 examined the association between sleep duration and anthropometrics, while Model 2 examined differences between weekday and weekend sleep duration. The final model, Model 3, included both sleep duration and differences between weekday and weekend sleep duration. A complete-case analysis was conducted, with a statistical significance level set at .05 for all procedures. Analyses were performed using the Statistical Package for Social Sciences (SPSS) version 24.0.

RESULTS

Demographic characteristics of the sample (N=569) overall and by weekday sleep duration are presented in Table 1. The average age of participants was 47.6 years. While all women self-identified as Black, 64% of the sample identified as African American specifically; approximately 17% and 12% identified as West Indian/Caribbean and Cape Verdean, respectively. Less than 6% of the Black women in this study identified as Native American, while less than 2% identified as Hispanic/Latina. Most participants (79%) were born in the United States, with 27% having a college or a post-graduate degree, 48% employed full-time, and 71% reporting a household income of $40,000 or less. One third of the sample lived with both children and adults; conversely, approximately one fifth lived alone.

Based on reported weekday sleep duration, 26% of women were classified as very short sleepers (<6 hrs), 29% as short sleepers (≥6 – <7 hrs), 40% as recommended sleepers (≥7 – ≤9 hrs), and 5% as long sleepers (>9 hrs) (Table 1). The difference between participants‶ weekday and weekend sleep duration also varied with 71% of participants classified as consistent sleepers (≤ 2-hour difference between weekday and weekend sleep duration), 22% classified as weekend snoozers (> 2-hours *more* sleep on weekends), and 8% classified as weekend warriors (> 2-hours *less* sleep on weekends). Table 2 shows participant demographics by both differences between weekday and weekend sleep duration and anthropometrics. BMI averaged 36.4 kg/m2 (SD: 7.6), while the average WC was 106.8 cm (SD: 15.5). Consistent sleepers had an average weekday sleep duration of 6.59 (SD: 1.72) hours and an average weekend sleep duration of 6.70 (SD: 1.77) hours. In comparison, weekend snoozers had average weekday and weekend sleep durations of 5.89 (SD: 1.71) hours and 8.89 (SD: 2.21) hours, respectively. Weekend warriors had average weekday and weekend sleep durations of 7.61 (SD: 2.43) hours and 4.97 (SD: 1.99) hours, respectively.

Sleep duration was significantly associated with ethnicity, birthplace, employment status, income, and household composition. The difference between weekday and weekend sleep duration was associated with age, educational attainment, employment status, income, and household composition. Anthropometrics also differed by sociodemographic characteristics, such that BMI was associated with income and WC associated with birthplace, educational attainment, employment status, and income. (See Tables 1 and 2 for proportions.)

In both the unadjusted and adjusted models, sleep duration was associated with BMI (p<.001). Both very short sleepers (37.5±7.1) and long sleepers (40.8±9.7) had greater average BMIs compared to recommended sleepers (35.6±7.5). Sleep duration was also associated with WC in both the unadjusted (p=.006) and adjusted (p=.004) models, with long sleepers (114.5±21.1) having larger WC compared to recommended sleepers (106.1±16.1). (See Table 3.) Likewise, the difference between weekday and weekend sleep duration was associated with BMI and WC in both unadjusted (p=.01 and p=.02, respectively) and adjusted (p=.01 and p<.01, respectively) models. Weekend snoozers had higher average BMIs (38.1±8.8 versus 35.8±7.1) and WCs (110.4±17.3 versus 105.6±14.9) compared to consistent sleepers. (See Table 4.)

Results from the multivariable regression analyses for BMI are displayed in Table 5. Adjusting for employment status and income, being a long sleeper was associated with higher BMI of 4.90 kg/m2 compared to recommended sleepers (p=.003), while short and very short sleep duration were not significantly associated with BMI (Model 1). For differences between weekday and weekend sleep duration (Model 2), adjusting for employment and income, being a weekend snoozer was associated with an increase in BMI of 2.83 kg/m2 compared to consistent sleepers (p=.001), while no significant difference in BMI was found between consistent sleepers and weekend warriors. Long sleep duration remained significantly associated with elevated BMI even after adjusting for differences between weekday and weekend sleep duration (B=4.98, p=.003). Likewise, being a weekend snoozer remained significantly associated with elevated BMI even after adjusting for sleep duration (B=2.58, p=.001).

Results from the multivariable regression analyses for WC are displayed in Table 6. Adjusting for birthplace, employment status, and income, being a long sleeper was associated with an increase in WC of 7.15 cm compared to recommended sleepers (p=.032). Short and very short sleep duration were not significantly associated with WC (Model 1). For differences between weekday and weekend sleep duration (Model 2), adjusting for birthplace, employment, and income, being a weekend snoozer was associated with an increase in WC of 5.35 cm compared to consistent sleepers (p=.002). No significant difference in WC was found between consistent sleepers and weekend warriors. Both having long sleep (B=8.23, p=.016) and being a weekend snoozer (B=5.51, p=.002) remained significantly associated with larger WC, even after adjusting for differences between weekday and weekend sleep duration, respectively.

DISCUSSION

Sleep duration and differences between weekday and weekend sleep duration were significantly associated with body mass index (BMI) among Black women in the SisterTalk II study. Compared to recommended and consistent sleepers, very short sleepers, long sleepers, and those who were weekend snoozers had higher BMIs. Therefore, women who slept too little, those who slept too much, and those who likely accumulated sleep dept throughout the week had a higher risk for excess BMI. Both sleep duration and differences between weekday and weekend sleep duration were independently associated with BMI. These findings are consistent with other cross-sectional studies finding a U-shaped association between sleep duration and BMI and adds to the small pool of literature showing that sleep duration consistency may also impact health risks (13–16,18,19). Temporality cannot be established from this cross-sectional analysis; however, prior research suggests a bidirectional association between sleep and obesity (3), and similar results have also been reported in longitudinal studies. For example, a study by Patel et al. (2006) found that relative to women sleeping seven hours, women sleeping five hours or less gained an excess 1.14kg and women sleeping six hours gained an excess 0.71kg, suggesting the association may be causal (20). While effect estimates have varied considerably across studies, with some reporting null results, differences can likely be attributed to the lack of standardized definitions of optimal or recommended sleep duration and reliance on self-reported sleep instead of objective sleep duration measurements. Differences in findings across studies have also been attributed to variability in characteristics of participants, exclusion criteria, location of studies, and assessment of sleep duration (21). The present study provides evidence that the association between categories of sleep duration and obesity risk is also present among Black women who are hypertensive or at risk for hypertension.

Sleep duration and differences between weekday and weekend sleep duration were also significantly associated with WC in this sample of Black women. Compared to recommended and consistent sleepers, long sleepers and weekend snoozers had larger WCs. Similar to BMI, sleep duration and differences between weekday and weekend sleep duration were independently associated with WC. While some studies have demonstrated a U-shaped association between sleep duration and WC, a meta-analysis of 22 studies with data on more than 50,000 participants found the association between short sleep duration and WC to be much more consistent (22). Very short sleepers (108.7±14.5) in our sample had a larger average WC than recommended sleepers (106.1±16.1), but the difference was not significant. Interestingly, very short sleepers did have significantly larger WCs than short sleepers in this sample. While we did not find any differences in BMI or WC for short sleepers compared to recommended sleepers, a prospective study of ethnically diverse adults found that participants who slept five or fewer hours per night experienced larger increases in BMI compared to those who slept six to seven hours (23). Taken with our findings, it is plausible that six hours of sleep per day may be sufficient in terms of obesity risk, but further examinations are needed, including those among Black women not at risk for hypertension.

There are several potential mechanisms through which short sleep duration may lead to excess energy intake and increase obesity risk. Having less than the sufficient amount of sleep means having more awake hours and therefore, more opportunities for food consumption (3,24). Eating behaviors, including timing of meals, number of meals, and preference for energy-dense food items, may differ between short and recommended sleepers (25,26). Additional mechanisms include greater sensitivity to food reward when tired, greater energy needed to sustain extended wakefulness, potential decreases in energy expenditure, and changes in appetite hormones (3,18). One such hormone is cortisol. Cortisol levels and stress have been shown to be associated with both poor sleep outcomes and anthropometric obesity risk factors, thus stress may confound the association between sleep and obesity risk (27–29). This is particularly relevant to this study population. Black women are known to experience greater amounts of stress, discrimination, and financial hardship, all of which have the potential to adversely impact sleep (10). Such factors may at least partially explain the significant associations we found between sleep duration with ethnicity, birthplace, employment status, income, and household composition. These associations demonstrate heterogeneity in sleep outcomes across Black women, and future studies should investigate which subgroups of Black women are at the greatest risk for suboptimal sleep and related health consequences. While we did not find an association between age and sleep duration in this sample, age was associated with differences between weekday and weekend sleep duration. Future studies should consider how age-related health conditions and menopause status impact associations between sleep, excess weight, and abdominal obesity.

Mechanisms through which long sleep duration increases obesity risk are not well understood. The mechanism linking sleep duration and time/opportunities to eat previously described, does not hold (3,24). Instead, comorbid health conditions, such as sleep apnea, depression, and socioeconomic status have been proposed as confounders contributing to the association, but results are inconclusive (30). In this study, the associations between long sleep and BMI and WC were only modestly attenuated after adjustment for employment status, income, and birthplace. Thus, these factors alone do not explain the larger BMI and WC of long sleepers relative to recommended sleepers. Given these results and the average BMI of the sample (36.4±7.6), our findings are consistent with those from a 10+ year prospective study by Nagai et al. (2013) that found that long sleep increased risk for weight gain among adults with obesity (31).

To our knowledge, this study is the first to examine the association between differences between weekday and weekend sleep and markers of obesity in a sample of Black women. We found that an inconsistent sleep duration, with more sleep on the weekends compared to weekdays, was associated with higher BMI and WC. Contrary to findings from studies focused on mortality and hypertension as outcomes, our results suggest that sleeping in on the weekend does not adequately compensate for the effects of sleep debt accumulated during the week (27). The fact that overall estimated sleep (based on the average weekday and weekend sleep durations reported for each group) was actually greater for weekend snoozers than consistent sleepers, provides further support that consistency is an important and independent characteristic of sleep. It must be noted however, that this was a high-risk sample, with all women already having hypertension, or being at risk for hypertension. Nonetheless, results from experimental studies on the ameliorating effects of sleep compensation and recovery are mixed, and further studies, including large epidemiological studies with diverse samples, are needed (32–35). With regard to potential effects of sleeping less on the weekend, the relatively small sample size of women who we categorized as weekend warriors, (N=42), may not have provided adequate statistical power to measure the expected effects. Further, it is unclear how aware individuals are of variability in their sleep duration and raises questions regarding the accuracy of reporting. Future assessments of differences between weekdays and weekend sleep duration, including objective measurements, are needed to determine the impact of sleep duration consistency, and sleep pattern more broadly, on obesity risk. Studies should consider using the terminology workdays and free days in addition to or instead of weekdays and weekends to account for the fact that work schedules often influence activity times and some women work on weekends.

The proposed mechanism through which an inconsistent weekday-weekend sleep duration may increase obesity risk is a potential shift in circadian rhythm. Circadian rhythm helps maintain energy homeostasis and sleep schedule variability may predispose individuals to visceral obesity (36). Further, disruptions in circadian rhythm may lead to changes in dietary intake (quantity, quality, and timing) and physical activity (36,37). However, more investigations are needed, including those centered on how best to measure and categorize sleep consistency and other aspects of sleep pattern. Investigations around determinants of differences in weekday and weekend sleep are also needed. Our findings suggest that women with relatively shorter weekday sleep durations are more likely to be weekend snoozers, while women with relatively longer weekday sleep durations are more likely to be weekend warriors. Weekend sleep deviation was associated with age, educational attainment, employment status, income, and household composition. Thus, differences in weekday and weekend sleep are likely the consequence of a combination of work schedules, school schedules, social activities, and sociodemographic factors.

The present study is not without limitations. Because sleep was not the focus of the SisterTalk II study, sleep problems such as sleep apnea and other sleep quality indicators were not measured. We also did not assess timing or other aspects of sleep hygiene. Further, the sample consisted of women who were hypertensive or at-risk for hypertension, thus results may not be generalizable to all Black women. However, given the existing literature, we would expect greater heterogeneity in the sample to result in stronger associations. Next, as previously mentioned, because this study used a cross-sectional design, causality cannot be determined, but findings from longitudinal studies, demonstrate a bidirectional association between sleep and obesity (3). While poor sleep increases risk for obesity via the mechanisms previously described, obesity increases risk for poor sleep because individuals with obesity have a higher risk of excess adipose tissue located around the neck and obstructive sleep apnea (38). Other comorbid physical and mental health conditions may also contribute to the association. A final limitation is that this study used self-reported sleep estimates. Self-reported sleep duration is subjective because it is an assessment of an individual's perceived amount of sleep. Nonetheless, previous studies have demonstrated associations between sleep duration and obesity using both self-reported and objective measures, and self-reported measures may actually underestimate the strength of associations (39,40).

CONCLUSION

The results of this study support the growing literature linking sleep duration and consistency with obesity risk and provide evidence that the association is also present among Black women who are hypertensive or at risk for hypertension. In this sample, very short sleep, long sleep, and sleeping more on the weekend were associated with body mass index, while long sleep and sleeping more on the weekend were associated with WC. Having recommended amounts of sleep (i.e. seven to nine hours) and a consistent sleep duration may be protective against obesity. However, further research using objective measures, is needed to ascertain the appropriate lower boundary for recommended amounts of and consistent sleep with regard to obesity risk. Given the disproportionate risk for both poor sleep and obesity among individuals identifying as Black, studies examining associations between sleep and obesity risk, as well as potential mechanisms and contributing factors among this population to determine which aspects of sleep are modifiable, are both warranted and necessary.

ACKNOWLEDGEMENTS

Our team would like to thank all of our study participants. We would also like to thank Tamara Clegg for her contributions in editing the manuscript. Individual participant data and the study protocol will be made available upon request after the intervention is completed and the main effects have been published. Proposals should be directed to patricia_risica@brown.edu.

We would also like to thank the National Heart, Lung, and Blood Institute for funding this work (7R01HL069379).

Abbreviations:

BMI	body mass index
WC	waist circumference

REFERENCES

1. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. Jama 2016;315(21):2284–2291. [PubMed: 27272580]
2. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep 2008;31(5):619–626. [PubMed: 18517032]
3. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity 2008;16(3):643–653. [PubMed: 18239586]
4. 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]
5. Ruiter ME, DeCoster J, Jacobs L, Lichstein KL. Normal sleep in African-Americans and Caucasian-Americans: a meta-analysis. Sleep Med (2011) 12(3):209–14. doi:10.1016/j.sleep.2010.12.010 [PubMed: 21317037]
6. Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. American journal of epidemiology 2009;169(9):1052–1063. [PubMed: 19299406]
7. Williams N, Jean-Louis G, Blanc J, & Wallace DM (2019). Race, socioeconomic position and sleep. In Sleep and Health (pp. 57–76). Academic Press.
8. Stamatakis KA, Kaplan GA, Roberts RE. Short sleep duration across income, education, and race/ethnic groups: population prevalence and growing disparities during 34 years of follow-up. Annals of epidemiology 2007;17(12):948–955. [PubMed: 17855122]
9. Brimah P, Oulds F, Olafiranye O, et al. Sleep duration and reported functional capacity among black and white US adults. Journal of Clinical Sleep Medicine 2013;9(06):605–609. [PubMed: 23772195]
10. Jackson CL. Determinants of racial/ethnic disparities in disordered sleep and obesity. Sleep health 2017;3(5):401–415. [PubMed: 28923201]
11. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. The American journal of clinical nutrition 2004;79(3):379–384. [PubMed: 14985210]
12. Ford ES, Maynard LM, Li C. Trends in mean waist circumference and abdominal obesity among US adults, 1999– 2012. Jama 2014;312(11):1151–1153. [PubMed: 25226482]
13. Mota MC, Silva CM, Balieiro LCT, Fahmy WM, Crispim CA. Social jetlag and metabolic control in non-communicable chronic diseases: a study addressing different obesity statuses. Scientific Reports 2017;7(1):6358. [PubMed: 28743872]
14. Roenneberg T, Allebrandt KV, Merrow M, Vetter C. Social jetlag and obesity. Current Biology 2012;22(10):939–943. [PubMed: 22578422]
15. Åkerstedt T, Ghilotti F, Grotta A, Zhao H, Adami HO, Trolle‐ Lagerros Y, & Bellocco R. (2019). Sleep duration and mortality–Does weekend sleep matter?. Journal of sleep research, 28(1), e12712.
16. Hwangbo Y, Kim WJ, Chu MK, Yun CH, & Yang KI (2013). Association between weekend catch-up sleep duration and hypertension in Korean adults. Sleep medicine, 14(6), 549–554. [PubMed: 23643647]
17. Risica PM, Gans KM, Kumanyika S, Kirtania U, Lasater TM. SisterTalk: final results of a culturally tailored cable television delivered weight control program for Black women. International Journal of Behavioral Nutrition and Physical Activity 2013;10(1):141.
18. Chaput JP, Després JP, Bouchard C, Tremblay A. Short sleep duration is associated with reduced leptin levels and increased adiposity: results from the Quebec family study. Obesity 2007;15(1):253–261. [PubMed: 17228054]

19. Gottlieb DJ, Redline S, Nieto FJ, et al. Association of usual sleep duration with hypertension: the Sleep Heart Health Study. Sleep 2006;29(8):1009–1014. [PubMed: 16944668]
20. Patel SR, Malhotra A, White DP, Gottlieb DJ, Hu FB. Association between reduced sleep and weight gain in women. American journal of epidemiology 2006;164(10):947–954. [PubMed: 16914506]
21. Ford ES, Cunningham TJ, Croft JB. Trends in self-reported sleep duration among US adults from 1985 to 2012. Sleep 2015;38(5):829–832. [PubMed: 25669182]
22. Sperry SD, Scully ID, Gramzow RH, Jorgensen RS. Sleep duration and waist circumference in adults: a meta-analysis. Sleep 2015;38(8):1269–1276. [PubMed: 25581918]
23. Hairston KG, Bryer-Ash M, Norris JM, Haffner S, Bowden DW, Wagenknecht LE. Sleep duration and five-year abdominal fat accumulation in a minority cohort: the IRAS family study. Sleep 2010;33(3):289–295. [PubMed: 20337186]
24. St-Onge MP, Roberts AL, Chen J, et al. Short sleep duration increases energy intakes but does not change energy expenditure in normal-weight individuals–. The American journal of clinical nutrition 2011;94(2):410–416. [PubMed: 21715510]
25. Kant AK, Graubard BI. Association of self-reported sleep duration with eating behaviors of American adults: NHANES 2005–2010–. The American journal of clinical nutrition 2014;100(3):938–947. [PubMed: 25057157]
26. Spaeth AM, Dinges DF, Goel N. Effects of experimental sleep restriction on weight gain, caloric intake, and meal timing in healthy adults. Sleep 2013;36(7):981–990. [PubMed: 23814334]
27. Åkerstedt T, Orsini N, Petersen H, Axelsson J, Lekander M, Kecklund G. Predicting sleep quality from stress and prior sleep–a study of day-to-day covariation across six weeks. Sleep Medicine 2012;13(6):674–679. [PubMed: 22621983]
28. Kumari M, Badrick E, Chandola T, et al. Cortisol secretion and fatigue: associations in a community based cohort. Psychoneuroendocrinology 2009;34(10):1476–1485. [PubMed: 19497676]
29. Moore CJ, Cunningham SA. Social position, psychological stress, and obesity: a systematic review. Journal of the Academy of Nutrition and Dietetics 2012;112(4):518–526. [PubMed: 22709702]
30. Knutson KL, Turek FW. The U-shaped association between sleep and health: the 2 peaks do not mean the same thing. Sleep 2006;29(7):878–879. [PubMed: 16895253]
31. Nagai M, Tomata Y, Watanabe T, Kakizaki M, Tsuji I. Association between sleep duration, weight gain, and obesity for long period. Sleep Medicine 2013;14(2):206–210. [PubMed: 23218534]
32. Simpson NS, Diolombi M, Scott-Sutherland J, Yang H, Bhatt V, Gautam S, … & Haack M. (2016). Repeating patterns of sleep restriction and recovery: Do we get used to it?. Brain, behavior, and immunity, 58, 142–151.
33. Broussard JL, Wroblewski K, Kilkus JM, & Tasali E. (2016). Two nights of recovery sleep reverses the effects of short-term sleep restriction on diabetes risk. Diabetes Care, 39(3), e40–e41. [PubMed: 26786578]
34. Killick R, Hoyos CM, Melehan KL, Dungan GC, Poh J, & Liu PY (2015). Metabolic and hormonal effects of „catch‐ up'sleep in men with chronic, repetitive, lifestyle‐ driven sleep restriction. Clinical endocrinology, 83(4), 498–507. [PubMed: 25683266]
35. Depner CM, Melanson EL, Eckel RH, Snell-Bergeon JK, Perreault L, Bergman BC, … & Wright KP Jr (2019). Ad libitum weekend recovery sleep fails to prevent metabolic dysregulation during a repeating pattern of insufficient sleep and weekend recovery sleep. Current Biology, 29(6), 957–967. [PubMed: 30827911]
36. Rutters F, Lemmens SG, Adam TC, et al. Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile?. Journal of biological rhythms 2014;29(5):377–383. [PubMed: 25252710]
37. Depner CM, Stothard ER, Wright KP. Metabolic consequences of sleep and circadian disorders. Current diabetes reports 2014;14(7):507. [PubMed: 24816752]
38. Krishnan V, Patel SR. Sleep apnea and obesity In Sleep Loss and Obesity. Springer, New York, NY; 20122012. pp. 119–131.
39. Lauderdale DS, Knutson KL, Yan LL, Liu K, & Rathouz PJ (2008). Self-reported and measured sleep duration: how similar are they?. Epidemiology (Cambridge, Mass.), 19(6), 838–845.

40. Jackson CL, Patel SR, Jackson WB, Lutsey PL, & Redline S. (2018). Agreement between self-reported and objectively measured sleep duration among white, black, Hispanic, and Chinese adults in the United States: Multi-Ethnic Study of Atherosclerosis. Sleep, 41(6), zsy057.

Table 1.

Participant Demographics Overall and by Weekday Sleep Duration

		Weekday Sleep Duration (N=569)				
	Total	**Very Short Sleepers <6 hrs**	**Short Sleepers ≥ 6-<7 hrs**	**Recommended Sleepers ≥ 7-≤9 hrs**	**Long Sleepers >9 hrs**	***p***
Count (%)		145 (25.5)	164 (28.8)	230 (40.4)	30 (5.3)	
Age (N=569)	47.6 ± 11.7	48.2 ± 12.4	46.8 ± 11.1	48.0 ±11.6	45.7 ± 12.8	.52
Ethnicity (N=558)						<.001*
African American	356 (63.8)	74 (20.8)	103 (28.9)	156 (43.8)	23 (6.5)	
West Indian/Caribbean	93 (16.7)	30 (32.4)	34 (36.6)	27 (29.0)	2 (2.2)	
Cape Verdean/African	66 (11.8)	13 (19.7)	17 (25.8)	33 (50.0)	3 (4.5)	
Hispanic/Latina	10 (1.8)	4 (40.0)	2 (20.0)	4 (40.0)	0 (0)	
Native American	33 (5.9)	20 (60.6)	4 (12.1)	7 (21.2)	2 (6.1)	
Birthplace (N=566)	449 (79.3)	110 (24.5)	120 (26.7)	191 (42.5)	28 (6.2)	.04*
United States	449 (79.3)	110 (24.5)	120 (26.7)	191 (42.5)	28 (6.2)	
Africa/Cape Verde	15 (2.7)	1 (6.7)	6 (40.0)	8 (53.3)	0 (0)	
Caribbean Country	89 (15.5)	28 (31.8)	32 (36.4)	27 (30.7)	1 (1.1)	
Central/South America	14 (2.5)	6 (42.9)	4 (28.6)	3 (21.4)	1 (7.1)	
Educational Attainment (N=563)						.17
< High School	74 (13.1)	25 (33.8)	20 (27.0)	23 (31.1)	6 (8.1)	
High School Grad/GED	188 (33.4)	46 (24.5)	51 (27.1)	76 (40.4)	15 (8.0)	
Some College	152 (27.0)	41 (27.0)	44 (28.9)	61 (40.1)	6 (3.9)	
College /Postgraduate	149 (26.5)	33 (22.1)	47 (31.5)	66 (44.3)	3 (2.0)	
Employment Status (N=531)						.01*
Full-time	257 (48.4)	55 (21.4)	90 (35.0)	109 (42.4)	3 (1.2)	
Part-time	82 (15.4)	26 (31.7)	15 (18.3)	35 (42.7)	6 (7.3)	
Unemployed	126 (23.7)	34 (27.0)	37 (29.4)	43 (34.1)	12 (9.5)	
Homemaker/Student/ Retired	66 (12.4)	20 (30.3)	16 (24.2)	27 (40.9)	3 (4.5)	
Annual HH Income (N=528)						<.001*
20K or less	184 (34.8)	64 (34.8)	43 (23.4)	59 (32.1)	18 (9.8)	
21K to 40K	189 (35.8)	39 (20.6)	63 (33.3)	79 (41.8)	8 (4.2)	
41K to 60K	80 (15.2)	18 (22.5)	22 (27.5)	37 (46.3)	3 (3.8)	
61K or more	75 (14.2)	8 (10.7)	25 (33.3)	42 (56.0)	0 (0)	
HH Composition (N=569)						.04*
Live w Children only	127 (22.3)	40 (31.5)	42 (33.1)	39 (30.7)	6 (4.7)	
Live w Adults only	128 (22.5)	30 (23.4)	28 (21.9)	60 (46.9)	10 (7.8)	

		Weekday Sleep Duration (N=569)				
	Total	**Very Short Sleepers <6 hrs**	**Short Sleepers ≥ 6-<7 hrs**	**Recommended Sleepers ≥ 7-≤9 hrs**	**Long Sleepers >9 hrs**	***p***
Live w children/adults	190 (33.4)	43 (22.6)	65 (34.2)	76 (40.0)	6 (3.2)	
Live alone	124 (21.8)	32 (25.8)	29 (23.4)	55 (44.4)	8 (6.5)	
People in HH (N=568)	3.2 ± 2.5	3.3 ± 2.9	3.3 ± 2.7	2.9 ± 1.8	3.8 ± 3.0	.20

Note. Data expressed Mean ± SD or N (%). % in each sleep duration category expressed in rows. HH: household. Complete case analysis conducted for variables with missing data: N=11 for ethnicity, N=3 for birthplace, N=6 for education, N=38 for employment, N=41 for income, N=1 for number of people in HH.

Table 2.

Participant Demographics & Anthropometrics by Difference Between Weekday and Weekend Sleep Duration

		Sleep Duration Consistency: Weekdays to Weekends (N=566)				Anthropometrics			
	Total	**Wkd Warriors < wkd sleep**	**Consistent Sleepers (w/n 2 hrs)**	**Wkd Snoozers > wkd sleep**	***p***	**BMI**	***p***	**WC**	***p***
Count (%)		44 (7.7)	400 (70.7)	122 (21.6)		36.4 ± 7.6		106.8 ± 15.5	
Age (N=566)	47.7 ± 11.7	44.10 ± 10.96[2]	48.82 ± 11.81[1,3]	44.83 ± 11.01[2]	<.001*				
Ethnicity (N=555)					.12		.13		.11
African American	357 (63.8)	28 (7.3)	257 (72.6)	69 (20.1)		36.7 ± 7.4		107.5 ± 16.1	
West Indian/ Caribbean	103 (18.6)	9 (8.7)	62 (60.2)	32 (31.1)		36.3 ± 8.1		105.6 ± 15.9	
Cape Verdean	44 (7.9)	5 (11.4)	34 (77.3)	5 (11.4)		34.2 ± 6.3		102.4 ± 13.3	
Hispanic/Latina	21 3.8)	2 (9.5)	15 (71.4)	4 (19.0)		34.1 ± 7.1		101.9 ± 14.5	
Native American	33 (5.9)	0 (0)	25 (75.8)	8 (24.2)		35.9 ± 7.0		108.6 ± 14.8	
Birthplace (N=563)					.85		.06		.02*
United States	446 (79.2)	36 (7.6)	320 (71.7)	90 (20.7)		36.7 ± 7.7		107.7 ± 16.3	
Africa/Cape Verde	15 (2.6)	1 (6.7)	11 (73.3)	3 (20.0)		32.3 ± 6.0		96.5 ± 11.4	
Caribbean Country	88 (15.6)	7 (8.5)	56 (68.2)	25 (23.3)		35.4 ± 6.9		104.7 ± 14.4	
Central/South America	14 (2.6)	0 (0)	10 (71.4)	4 (28.6)		35.4 ± 7.0		103.3 ± 14.8	
Educational Attainment (N=560)					.01*		.07		.01*
< High School	73 (13.0)	10 (11.0)	52 (71.2)	11 (17.8)		35.9 ± 7.9		108.3 ± 17.7	
High School Grad/GED	158 (28.2)	18 (11.4)	108 (68.4)	32 (20.3)		36.9 ± 7.8		107.5 ± 15.8	
Some College	180 (32.1)	13 (7.2)	117 (65.0)	50 (27.8)		37.1 ± 8.0		108.8 ± 16.2	
College /Post Graduate	149 (26.6)	3 (2.2)	118 (79.1)	28 (18.7)		35.1 ± 6.5		102.8 ± 14.3	
Employment Status (N=542)					.03*		.05		.01*
Full-time	251 (46.3)	15 (5.6)	177 (70.5)	59 (23.9)		35.7 ± 6.8		105.6 ± 14.3	
Part-time	72 (13.2)	6 (6.9)	49 (68.1)	17 (25.0)		35.6 ± 8.0		103.4 ± 16.7	

	Total	Sleep Duration Consistency: Weekdays to Weekends (N=566)				Anthropometrics			
		Wkd Warriors < wkd sleep	Consistent Sleepers (w/n 2 hrs)	Wkd Snoozers > wkd sleep	*p*	BMI	*p*	WC	*p*
Unemployed	112 (20.6)	10 (8.9)	79 (70.5)	23 (20.5)		37.9 ± 8.8		110.6 ± 18.9	
Homemaker/ Student/Retired	107 (19.9)	8 (7.4)	85 (79.4)	14 (13.0)		36.0 ± 6.8		106.8 ± 14.8	
Annual HH Income (N=525)					.04*		.01*		.02*
20K or less	181 (34.5)	24 (12.7)	115 (63.5)	42 (23.8)		37.8 ± 8.4		109.3 ± 17.7	
21K to 40K	189 (36.0)	10 (4.8)	141 (74.6)	38 (20.6)		35.3 ± 6.7		105.9 ± 14.6	
41K to 60K	80 (15.2)	3 (3.8)	62 (77.5)	15 (18.8)		36.8 ± 8.3		107.6 ± 17.4	
61K or more	75 (14.3)	5 (6.7)	54 (72.0)	16 (21.3)		35.4 ± 6.1		102.8 ± 13.0	
HH Composition (N=566)					.01*		.25		.40
Live w Children only	127 (22.4)	8 (6.3)	85 (66.9)	34 (26.8)		37.5 ± 8.2		108.8 ± 17.4	
Live w Adults only	126 (22.3)	7 (4.8)	104 (82.5)	15 (12.7)		35.9 ± 7.6		105.6 ± 14.9	
Live w children/ adults	190 (33.6)	15 (7.4)	125 (65.8)	50 (26.8)		35.8 ± 7.2		106.2 ± 16.2	
Live alone	123 (21.7)	14 (11.4)	86 (69.9)	23 (18.7)		36.5 ± 7.3		106.8 ± 15.0	
People in HH (N=566)	3.2 ± 2.5	2.9 ± 2.0	3.1 ± 2.6	3.4 ± 1.9	.46				

Note. Data expressed Mean ± SD or N (%). % in each sleep duration consistency category expressed in rows. HH: Household, BMI: body mass index, WC: waist circumference; wkd: weekend; w/n: within. Complete case analysis conducted for variables with missing data: N=11 for ethnicity, N=3 for birthplace, N=6 for education, N=24 for employment, N=41 for income, N=1 for number of people in HH.

Table 3.

Body Mass Index & Waist Circumference by Sleep Duration in both crude and adjusted ANOVA models

	Overall	**Sleep Duration**					
		Very Short Sleepers <6 hrs[a]	**Short Sleepers ≥6-<7 hrs**[b]	**Recommended Sleepers ≥7 – ≤9 hrs**[c]	**Long Sleepers >9 hrs**[d]	***F-statistic/p (Unadjusted)***	***F-statistic/p (Adjusted)*** [e]
BMI	36.4±7.6	37.5±7.1[b,c,d]	35.7±7.4[a,d]	35.6±7.5[a,d]	40.8±9.7[a,b,c]	5.90/ <.001*	4.12/ <.001*
WC	106.8±15.5	108.7±14.5[b]	104.7±15.4[a,d]	106.1±16.1[d]	114.5±21.1[b,c]	4.15/ .006*	2.99/ .004*

Note. Data expressed Mean±SD. BMI: body mass index; WC: waist circumference.

[a,b,c,d]Represents significant pairwise difference from corresponding group via Fisher's least significant difference test.

[e]BMI adjusted for income and employment; WC adjusted for birthplace, education, employment, and income.

Table 4.

Body Mass Index & Waist Circumference by Difference Between Weekday and Weekend Sleep Duration in both crude and adjusted ANOVA models

	Overall	Sleep Duration Consistency: Weekdays to Weekends				
		Wkd Warriors < wkd sleep[a]	**Consistent (w/n 2 hrs)**[b]	**Weekend Snoozers > wkd sleep**[c]	***F-statistic/p (Unadjusted)***	***F-statistic/p (Adjusted)***[d]
BMI	36.3±7.5	35.9±7.4	35.8±7.1[c]	38.1±8.8[b]	4.64/ .01*	3.91/ .01*
WC	106.8±15.9	107.0±18.8	105.6±14.9[c]	110.4±17.3[b]	4.18/ .02*	4.62/ <.01*

Note. Data expressed Mean ± SD. BMI: body mass index; WC: waist circumference; wkd: weekend; w/n: within.

[a,b,c]Represents significant pairwise difference from corresponding group via Fisher's least significant difference test.

[d]BMI adjusted for income and employment status; WC adjusted for birthplace, education, employment, and income.

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Table 5.

Multivariable Adjusted Regression Examining Sleep Duration & Difference Between Weekday and Weekend Sleep Duration on Body Mass Index

Variable	B	SE(B)	β	*F*	*P*	R^2	$R^2\Delta$
Model 1: Sleep Duration				4.456	.001*	.034	.006
Very short	1.619	.844	.091		.056		
Short	−.531	.923	−.027		.565		
Long	4.899	1.625	.139		.003*		
Model 2: Consistency				3.916	.004*	.023	−.011
Weekend warrior	−.287	1.336	−.010		.830		
Weekend snoozer	2.832	.844	.152		.001*		
Model 3: Sleep Duration + Consistency				4.273	<.001*	.044	.010
Very short	1.443	.877	.082	1.645	.101		
Short	−.662	.816	−.040	−.811	.418		
Long	4.982	1.670	.138	2.983	.003*		
Weekend warrior	−.670	1.344	−.023	−.499	.618		
Weekend snoozer	2.582	.839	.153	3.397	.001*		

Note. All models were adjusted for employment and income. Categorical variables were represented as dummy variables; recommended sleep duration, consistent sleep duration.

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Table 6.

Multivariable Adjusted Regression Examining Sleep Duration & Difference Between Weekday and Weekend Sleep Duration on Waist Circumference

Variable	B	SE(B)	β	*F*	*P*	R^2	$R^2\Delta$
Model 1: Sleep Duration				4.224	<.001*	.038	.020
Very short	2.664	1.745	.073		.128		
Short	−1.546	1.911	−.038		.419		
Long	7.148	3.331	.099		.032*		
Model 2: Consistency				4.621	<.001*	.043	.005
Weekend warrior	−.689	2.734	−.011		.804		
Weekend snoozer	5.345	1.740	.139		.002*		
Model 3: Sleep Duration + Consistency				4.011	.008*	.018	.018
Very short	1.588	1.818	.044	.873	.383		
Short	−2.232	1.686	−.065	−1.324	.186		
Long	8.232	3.414	.112	2.411	.016*		
Weekend warrior	−1.472	2.762	−.024	−.533	.594		
Weekend snoozer	5.512	1.736	8.143	3.175	.002*		

Note. All models were adjusted for birthplace, employment, and income. Categorical variables were represented as dummy variables; recommended sleep duration, consistent sleep duration, birthplace outside the United States, unemployed, and income $20,000 or less were the reference groups.