Sleep Duration and BMI Percentile in Adolescents: An Analysis of the 2013 National Youth Risk Behavioral Survey

Article · January 2017

CITATION
1

READS
197

1 author:

Timothy Makubuya
University of Missouri–St. Louis
22 PUBLICATIONS **286** CITATIONS

SEE PROFILE

Sleep Duration and BMI Percentile in Adolescents: An Analysis of the 2013 National Youth Risk Behavioral Survey

Timothy Makubuya

Sleep is increasingly gaining attention in the research literature for its role in body weight. Sleep deprivation can impact multiple aspects of metaregulation. This study examined the relationship between sleep duration and Body Mass Index (BMI) percentiles, a common measure of weight status. Data from the 2013 National Youth Risk Behavior Survey (YRBS) from the U.S. Center for Disease Control and Prevention (CDC) were analyzed for 9th to 12th grade boys and girls. Spearman Rho correlations were calculated on sleep deprivation and BMI percentiles. Significant indirect associations between sleep duration with BMI percentiles were found in high school boys but not girls. Longer sleep duration was associated with lower BMI percentiles in boys. Future research should consider non subjective measures of sleep deficits and disorders. The inclusion of additional YRBS questions targeting more aspects of sleep, such as sleep quality, is recommended.

Key Words: sleep deprivation; adolescent overweight, Youth Risk Behavior Survey

Adolescent sleep habits are a challenge to many parents, especially with the increasing use of technology. Adolescents tend to shift sleep hours to hours texting, viewing, gaming, web surfing and the like. Concern is not only focused on the total number of sleep hours lost, but also on quality of sleep and how these aspects of sleep are related to overweight and obesity.

How would sleep deprivation be associated with overweight and obesity? At first glance, one might think that additional waking hours result in an increase in calories burned. This is not necessarily the case. Sleep deprivation leads to a breakdown of metaregulation. "Sleep deprivation is associated with altered transcription or translation of a wide range of molecules involved in a wide range of other fundamental physiological processes" (Vyazovskiy, 2015, p. 172; see also Bass & Takahashi, 2010). Lack of sleep alters the hypothalamus-pituitary-adrenal (HPA) axis, delaying recovery of HPA and altering negative glucocorticoid feedback regulation. Chronic sleep deprivation also impairs glucose tolerance, increasing the chances of developing diabetes and cardiovascular disease. When the body does not take glucose into the cells properly, one feels tired

and hungry and eats more (Leproult, Copinschi, Buxton, & Van Cauter, 1997). Leproult et al. also found that cortisol was elevated the evening following sleep loss. Chronic sleep deprivation, then, could cause higher insulin levels, with blood sugar dropping and eventually craving of sugary, fatty foods.

Sleep deprivation lowers leptin, an appetite-suppressing hormone that is produced at night. Also, ghrelin, a hormone that stimulates hunger, is increased (Leproult et al., 1997). Sleep, then, has many complex effects on body regulation and loss of sleep can contribute to overweight and obesity in a number of ways. Cauter and Knutson (2008) cited epidemiological studies that additionally point towards chronic sleep deprivation as a contributor to overweight and obesity.

There are suggested recommendations from the National Sleep Foundation as well as the National Institute of Health regarding the recommended sleep durations. Albeit these recommendations slightly differ, they all point towards 8 to 10 hours of sleep for children and adolescents. The total number of sleep hours per night can be reduced by lifestyles that encourage increased social media usage, television viewing, time on computers, and time on other internet powered games or devices.

Understanding the effect of sleep duration on adolescent weight status and BMI percentiles in adolescents is important in discussions of reducing the incedience of overweight and obesity in children and adolescents. These discussions have been shaped by numerous findings including those of Cauter and Knutson (2008) who noted that there is increasing information on chronic partial sleep from both epidemiological and clinical studies indicating its link to obesity risk and weight gain. Patel and Hu (2006) also conducted a review of literature that supports this finding.

Lowry et al. (2012) conducted an analysis of national Youth Risk Behavior Survey (YRBS) data and examined the association between self- reported obesity and self reported sleep duration and found gender differences, with girls having significant association between sleep loss and obesity compared to boys who had no significant association. They cautioned against any suggestions of abrupt sleep adjustment without further studies.

Aspects of sleep, rather than just mere sleep duration, need to be acknowledged. Jarinn, McGrath and Drake (2013) conducted a study of about 240 healthy children and adolescents with an average age of 13 years. They looked at factors beyond sleep duration, such as sleep disturbances and sleep quality and pattern, and subjectively measured them. Sleep duration was significantly associated with obesity; however, the link depreciated after adjustments of covariates. Their results suggested that these other aspects of sleep might indicate or suggest influences that drive the negative associations between sleep deprivation and obesity more precisely. The researchers recommended that more longitudinal and prospective research designs be used in future research.

Lytle et al. (2013) conducted a longitudinal study that included 723 adolescents from Minnesota with an average age of 14.7 years at baseline. Their 24- hour recall of food intake, activity levels and sedentariness were among the behaviors assessed in both boys and girls, whose average body composition measures and sleep duration decreased slightly at the end of

two years. This study suggested that the decline in sleep duration has less impact on obesity, and is contrary to other studies. Drescher, Goodwin, Silva and Quan (2011) investigated the association between sleep duration and obesity risk factors among 319 Caucasian and Hispanic children aged 10-17 years. Lifestyle factors were measured through surveys that included electronic screen time, dietary and caffeine intake, exercise, and sleep habits as reported by parents. In addition, they also recorded anthropometric measures such as height and weight from which BMI could be calculated. Parental input in reporting sleep times was a factor for Hispanic participants, where ethnicity was significantly associated with lower reporting in terms of sleep duration and BMI z score. Age group differences were also evident, especially between younger and older adolescents in relation to dietary and sedentary behaviors. Caffeine consumption factored in sleep duration among older adolescents whereas young adolescents were more affected by electronic screen time.

Other studies have linked lack of sleep to adolescent and adult weight issues. Cappuccio et al. (2008) conducted a meta-analysis of short sleep duration using a literature search and found an "increased risk of obesity amongst short sleepers in children and adults". Lowry et al. (2012) suggested that in order to recommend sleep time alterations as a remedy for addressing the adolescent weight problem, better knowledge of factors regarding the obesity and sleep duration relationship is warranted. To thoroughly investigate healthy eating among high school students, studies like Lowry et al. (2012) suggested that sleep education should be considered, particularly in this technological and social media era. Teaching adolescents about topics such as late night snacking would be an addition to other topics related to health such as the importance of daily breakfast.

The purpose of this study was to obtain additional information about the sleep duration-overweight link by examining the relationship between sleep duration and overweight/obesity, as indicated by BMI percentile, in a large group of adolescents who took the 2013 YRBS.

Methods

Subjects and Setting

The data used in this study was from responses to the 2013 national Youth Risk Behavioral survey (YRBS) collected by the U.S. Center for Disease Control and Prevention (CDC) using a three stage cluster sample design. Responses by 9th to 12 th grade high school students from items about physical activity, food and other related health topics were selected. Participants were from selected private and public schools that were in the representative pool. Some of the schools chosen for the national sample might also have participated in the statewide YRBS and others might not. Initially 15,480 students were sampled. Of those 13,633 submitted their questionnaires and after data editing 13,583 were usable. The participants were both boys and girls with a varying racial and ethnic make-up. YRBS samples estimates are set at a ±5% range at the 95% confidence level. The response rate for the 2013 National YRBS was 77% for schools, 88% for students and an overall response rate of 68%. In this study, elimination of

missing cases was by listwise, which meant eliminating those participants' records who had a record of missing values. In addition, outliers at three standard deviations from the mean where also removed. There were 12,335 participants who were categorized in three main sleep categories.

Reliability and Validity

Internal reliability checks only identified low and acceptable percentages of untruthfulness among respondents. The CDC argues that truthfulness is based on the students' perception that the survey is important and that they are knowledgeable of devised measures to protect their privacy and allow anonymity. Test-retest reliability tests were conducted on the 1991 to 1999 questionnaire versions after the questionnaires were subjected to laboratory and field testing. Brener, McManus, Galuska, Lowry, and Wechsler (2003) conducted reliability and validity tests on self-reported variables of height, weight and sleep from YRBS. Flisher, Evans, Muller, and Lombard (2004) conducted a two-week test-retest on reliability of adolescent behaviors on two occasions within two weeks, and found consistency in the measures of agreement and thus reliable reporting. Though the self-reported sleep hours and the measures of BMI were very reliable, there were some discrepancies especially in estimating overweight in youth populations from the self reported height and weight as measures of BMI. This was due to under-reporting of weight and over-reporting of height that are common in many self- reported data.

Brener et al. (2003) also conducted reliability tests using the kappa statistic on the 1999 YRBS items and found that most of the YRBS questions were reliable. The physical activity and dietary behavior questions specifically were also reliable with kappa values greater than .60. Items that had very weak kappa values have since been replaced from the recurring YRBS. Landis and Koch (1977) argued that the higher the kappa value, the more reliable the question. On the other hand, Troped et al. (2007) insisted that YRBS questions underestimate the actual physical activity involvement in middle school children, but according to Brener et al. (2003), high school students were more likely to reliably report on health risk behaviors.

Permissions

Approval for conducting the study was obtained from the University of Missouri – St. Louis Institutional Review Board. The CDC provided the researcher with the YRBS data for further analysis. There were no human participants to be engaged directly for this study, and therefore no need for informed consent to conduct the study, since the study only involved analysis of an existing database.

Sleep Scores and Categories

YRBS contains a single item on sleep, asking only about sleep duration. The National Institute of Health (NIH) recommendations for adolescent health are in line with the CDC recommendations for healthy sleep. According to Hirshkowitz et al (2015), The National Sleep Foundations (2015) recommends that for good health teens get 8 to 10 hours of sleep daily. This study categorized sleep into three categories: 8 to 10+ hours as *Recommended Sleep*; between 6 and 8 hours as *Close to Recommended*;

and less than 6 as *Far from Recommended*. The YRBS responses for these corresponding sleep durations were assigned 5- 7 for the 8 to10+ hour category (Recommended), 4 for the 6 to 8 category (Close to recommended), and < 4 for the less than 6 hours category, as indicated in Table 1. From the above characterization of the different sleep categories, Recommended would be considered as the positive behavior while Close to Recommended and Far from Recommended were both considered negative behaviors. Only those who reported 8 to 10+ hours of sleep were considered to have engaged in a positive behavior, as this was in line with the sleep duration guidelines.

Table 1
Categorization for Sleep (N=12,335)

Sleep Score	Score Categories	Frequency Type	Type
5 to 7	Recommended (8-10+ hours)	3,771	Positive Behavior
4	Close to Recommended (6 <8 hours)	6,119	Negative Behavior
< 4	Far less than Recommended (< 6 hours)	2,445	Negative Behavior

Results And Discussion

To examine the relationship between sleep duration and BMI percentiles, Spearman's Rho correlation was calculated. In addition, other factors such as physical activity and dietary behaviors were considered with sleep duration in examining the relationship with these multiple factors using multiple linear regression. The hypothesis was that the more hours of sleep averaged by high school boys and girls, the lower their BMI percentiles. Upon conducting correlation analysis, 854 missing value cases were eliminated, such that data was available from 11,481 adolescents.

In order to test the hypothesis, Spearman's Rho correlations were performed first for the high school general population, irrespective of gender, then subsequently for the gender categories of male and female.

Table 2
Spearman's Rho Correlation between Sleep score and BMI Percentile
(N=11,481)

		Sleep Score
Body Mass Index Percentiles	Correlation Coefficient	-.031
	Sig. (2-tailed)	.001

Spearman's Rho yielded an inverse, negative and weak correlation that was yet significant at the set p value (r = -.031, p = .001). This result suggests that the longer the sleep duration, the lower the BMI percentiles of high school students. In order to examine this association for boys and girls, the data were split by gender.

Table 3
Spearman's Rho Correlation Between Sleep Score And BMI Percentile In High School Boys And Girls

Gender			**Sleep Score**
Male n = 5,656	BMI Percentile	Correlation r	-.047
		Sig (2-tailed)	.000
Female n = 5,825	BMI Percentile	Correlation r	-.019
		Sig (2-tailed)	.148

Spearman's Rho correlations for the relationship between sleep score and BMI percentile yielded gender differences between boys and girls (see Table 3). For boys, higher sleep scores were associated with lower BMI percentiles (r = -.047, p = .000) but in girls, although there was a similar relationship, the results were not significant (r = -0.19, p = .148).

The differences in correlations between boys and girls were tested for significance of the difference using a z-test, and at a p value of 0, this result was significant at $p < .05$. The results implied that the longer the sleep duration by high school boys, the lower their BMI percentiles, unlike their female counterparts. The hypothesis that the longer the sleep duration by high school boys and girls, the lower the BMI percentile was only partially supported.

From the results of the current study, there were noticeable gender differences in correlation coefficients in sleep score computations. First,

Spearman's Rho yielded correlations between high school students sleep scores and BMI percentiles that depicted considerable shifts after gender categorization. Spearman's Rho reported significant inverse relationships between sleep score and BMI percentiles among boys (r = -.047, $p < .05$), and non-significant indirect relationships among girls.

The results from the bivariate association between sleep score and BMI percentiles are equivocal with an implication that further research on sleep duration within different weight status categories is needed. This vagueness may also originate from the fact that there is merely a single question on the YRBS on sleep. Other studies have found associations between children's weight status and sleep. These studies have also addressed other aspects of sleep, rather than just mere sleep duration. Snell et al. (2007) found correlations between sleeping less than 8 hours with higher BMI in adolescents regardless of gender. The current study found that boys' longer sleep is associated with lower BMI percentiles, but girls' is not. This result was similar to that of Reither, Krueger, Hale, Reiter and Peppard (2014).

Recommendations

The guidelines for recommended sleep duration for adolescent and other individuals across the lifespan slightly differ between the National Sleep Foundation and the National Heart Lung and Blood Institute, which is grounds for misconceptions. An expert panel from these two organizations is required to clarify the confusion. In addition, CDC needs to reconsider designing the question on sleep to include aspects of sleep other than duration that are attracting more attention in the literature. Questions that address both sleep quality and quantity are necessary in future YRBS administrations.

The insights gained by this examination emphasize that sleep might have strong influence on adolescent BMI percentiles. This study was able to establish and emphasize previous findings from similar research studies that have been highly contentious in terms of establishing links to weight status. The insights gained from this particular study might provide the needed guidance to understand the role of *more* versus *less* number of sleep hours on BMI percentiles particularly in adolescents. In addition, parents might be further informed of the role they need to play in promoting adequate adolescent sleep and general wellbeing, and more health educators to emphasize the need for youths to get the recommended sleep hours on a daily basis.

References

Bass, J., & Takahaushi, J.S. (2010). Circadian integration of metabolism and energetics. *Science, 330*, 1349-1354.

Brener, N. D., McManus, T., Galuska, D. A., Lowry, R., & Wechsler, H. (2003). Reliability and validity of self-reported height and weight among high school students. *Journal of Adolescent Health*, *32*(4), 281-287.

Cappuccio, F. P., Taggart, F. M., Kandala, N.-B., Currie, A., Peile, E., Stranges, S., & Miller, M. A. (2008). Meta-analysis of short sleep duration

and obesity in children and adults. *Sleep*, *31*(5), 619-626.
Cauter, E. V, Knutson, K. L. (2008). Sleep and the epidemic of obesity in children and adults. *European Journal of Endocrinology*, *159*(S59-S66).
Drescher, A. A., Goodwin, J. L., Silva, G. E., & Quan, S. F. (2011). Caffeine and screen time in adolescence: Associations with short sleep and obesity. *Journal of Clinical Sleep Medicine*, *7*(4), 337-342.
Flisher, A. J., Evans, J., Muller, M., & Lombard, C. (2004). Brief report: Test-retest reliability of self-reported adolescent risk behaviour. *Journal of Adolescence*, *27*(2), 207-212.
Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., et al. (2015). National Sleep Foundation's updated sleep duration recommendations: Final report. *Sleep Health*, *1*(4), 233-243.
Jarrin, D. C., McGrath, J. J., & Drake, C. L. (2013). Beyond sleep duration: distinct sleep dimensions are associated with obesity in children and adolescents. *International Journal of Obesity*, *37*(4), 552-558
Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159-174.
Leproult, R., Copinschi, G., Buxton, O., & Van Cauter, E. (1997). Sleep loss results in an elevation of cortisol leels the next evening. *Sleep, 20*(10), 865-870.
Lowry, R., Eaton, D. K., Foti, K., McKnight-Eily, L., Perry, G., & Galuska, D. A. (2012). Association of sleep duration with obesity among US high school students. *Journal of Obesity*, 2012.
Lytle, L. A., Murray, D. M., Laska, M. N., Pasch, K. E., Anderson, S. E., & Farbakhsh, K. (2013). Examining the longitudinal relationship between change in sleep and obesity risk in adolescents. *Health Education & Behavior*, *40*(3), 362-370.
Patel, S. R., & Hu, F. B. (2008). Short sleep duration and weight gain: a systematic review. *Obesity* (Silver Spring, Md.), *16*(3), 643–653
Reither, E. N., Krueger, P. M., Hale, L., Reiter, E. M., & Peppard, P. E. (2014). Ethnic variation in the association between sleep and body mass among US adolescents. *International Journal of Obesity*, (January), 1-6.
Snell, E. K., Adam, E. K., & Duncan, G. J. (2007). Sleep and the body mass index and overweight status of children and adolescents. *Child Development*, *78*(1), 309- 323.
Troped, P. J., Wiecha, J. L., Fragala, M. S., Matthews, C. E., Finkelstein, D. M., Kim, J., & Peterson, K. E. (2007). Reliability and validity of YRBS physical activity items among middle school students. *Medicine and Science in Sports and Exercise*, *39*(3), 416-425.
Vyazovskiy, V.V. (2015). Sleep, recovery, and metaregulation: Explaining the benefits of sleep. *Nature and Science of Sleep, 7*, 171-184.

***TIMOTHY MAKUBUYA**, Ph.D., is an Assistant Teaching Professor of Health and Physical Education at University of Missouri- St. Louis. He received a B.A in Environmental Management from Makerere University in Kampala, Uganda and a B.S. in Sports Medicine, M.S. Sport Management from Missouri Baptist University. His Ph.D. in Teaching and Learning Processes is from University of Missouri- St. Louis.*