J Behav Health 2013; 2(3):236-242 *ISSN: 2146-8346*

GESDAV

Journal of Behavioral Health

available at www.scopemed.org

Original Research

Associations between Anthropometric and Sleep Parameters among Adolescents: Considerations by Gender

Paul D. Loprinzi, Laura C. Stigler, Kathy K. Hager

Bellarmine University, Department of Exercise Science, Donna & Allan Lansing School of Nursing & Health Sciences
Bellarmine University, Doctor of Physical Therapy Program, Donna & Allan Lansing School of Nursing & Health Sciences
Bellarmine University, Department of Nursing, Donna & Allan Lansing School of Nursing & Health Sciences

Received: April 08, 2013

Accepted: July 03, 2013

Published Online: July 12, 2013

DOI: 10.5455/jbh.20130703061438

Corresponding Author:
Paul D. Loprinzi,
Bellarmine University, Department of Exercise Science, Donna & Allan Lansing School of Nursing & Health Sciences, Louisville, KY 40205
ploprinzi@bellarmine.edu

Key words: Adiposity, body mass index, epidemiology, obesity, population, weight status, sleep duration, sleep latency

Abstract

Background: The purpose of this study was to examine the associations between anthropometric (e.g., body mass index, waist circumference) and sleep parameters (e.g., sleep latency, sleep duration, frequency of leg cramps and snoring while sleeping) in boy and girl adolescents.
Methods: Data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES) were used with a sample of 339 NHANES adolescent participants between 16 and 17 years of age examined in the analysis. Anthropometric data was measured with sleep parameters self-reported.
Results: In general, girls with higher levels of anthropometric indices slept for longer durations. For girls, those with higher levels of anthropometric indices were more likely to snore and have leg cramps. No associations were significant for boys.
Conclusion: The results from this study suggest that, for girls, unfavorable levels of anthropometric indices may negatively influence quality of sleep.

INTRODUCTION

A United States (U.S.) national survey distributed by the National Sleep Foundation [1] showed that only 31% of adolescents engaged in the recommended 8-9 hours of sleep. This is particularly concerning, as unfavorable levels of sleep may negatively influence multiple domains and levels of functioning [2], including school work efficiency [3]. Consequently, identification of factors that influence sleep quality and duration in adolescents is important.

Taheri [4] recently developed a theoretical framework to describe how obesity may influence sleep. In this framework, the author indicates that sleep, particularly sleep loss, is associated with obesity through a variety of mechanisms. Although not fully understood, these mechanisms include sleep-induced changes in levels of energy, hormones (e.g., leptin, adiponectin), and opportunities to eat, with these mechanisms increasing obesity risk through changes in activity levels and energy intake. For example, insufficient sleep may reduce energy levels, which in turn may reduce daily physical activity, and ultimately, influence levels of adiposity. The obesity-sleep link could also be considered bi-directional, with sleep loss influencing obesity, or obesity influencing sleep duration and quality (e.g., obesity-induced sleep apnea, which may reduce sleep quality).

Based on this theoretical framework, studies have examined the association between obesity and sleep among adolescents, with obese youth typically sleeping fewer hours than their non-obese counterparts [5]. Importantly, most studies have relied primarily on the

use of body mass index (BMI)[5]; fewer studies have examined this association using other indices of weight status (e.g., waist circumference or tricep skinfold) among adolescents, thereby providing only a partial picture of this association. A more comprehensive examination using other anthropometric indices is warranted, as some measures (e.g., tricep skinfold) may provide a better measure of upper body fat composition, which may have differential effects on sleep (e.g., increased upper body fat may diminish lung mechanics which may influence sleep apnea). Additionally, few studies have examined the association between BMI and other sleep-related parameters (e.g., sleep latency and frequency of snoring, ceased breathing while asleep, leg cramps, and taking pills to help aid sleep) among adolescents.

To address these gaps in the literature, the aim of this study was to examine the association between weight status and sleep in a nationally representative sample of older adolescents using numerous indices of weight status (e.g., i.e., body mass index, waist circumference, thigh circumference, arm circumference, tricep skinfold and subscapularis skinfold) and several sleep-related parameters (i.e., sleep duration, sleep latency, and frequency of snoring, ceased breathing while asleep, leg cramps, and taking pills to help aid sleep). Additionally, given the emerging evidence that gender may be influencing the obesity-sleep relationship [6], another aim was to examine these associations across both genders.

METHODS

Design and Participants

For this study we used data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES). NHANES is an ongoing survey conducted by the Centers for Disease Control and Prevention that uses a representative sample of non-institutionalized U.S. civilians, selected by a complex, multistage probability design. The multistage design consists of 4 stages, including the identification of counties, segments (city blocks), random selection of households within the segments, and lastly, random selection of individuals within the households. The survey examines a nationally representative sample of approximately 5,000 individuals each year, with data collected in 15 counties across the country each year. The survey consists of two primary components, including participants being interviewed in their homes and subsequently examined in mobile examination centers (MEC) across the selected counties. Ultimately, information collected from NHANES is used for a variety of objectives, including determining the prevalence of major diseases and identifying risk factors for these diseases. Information from NHANES participants is collected on infants up to adults 85 years of age.

NHANES study procedures were approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection. There were 576 NHANES adolescent participants eligible to complete the sleep-questionnaire. After excluding adolescents who had missing sleep data, missing anthropometric data, were pregnant or breast feeding a child, or had missing data on the covariates, the analyzed sample included 339 NHANES adolescent participants between 16 and 17 years of age (177 boys and 162 girls).

Measurement of Sleeping Variables

In the NHANES sample, participants 16 and older completed questions on a variety of sleeping patterns and outcomes that were measured using the Functional Outcomes of Sleep Questionnaire [7]. The present study restricted the focus to adolescent participants (i.e., 16 and 17 years), as their sleeping patterns are different than adults [8, 9]. In the present study, 6 self-reported sleep-related questions were assessed, including two continuous variables and 4 categorical variables. The two continuous variables are sleep duration (hours) and sleep latency (minutes to fall asleep). The 4 self-reported categorical variables referred to when they were asleep and included the participants' frequency (in past month) of snoring, snorting/gasping/or stopped breathing, leg cramps, and taking pills or other medications to help sleep.

With respect to frequency of snoring and snorting/gasping, possible responses included *never*, *rarely* (1-2 nights/week), *occasionally* (3-4 nights/week), and *frequently* (5 or more nights/week). With respect to having leg cramps while trying to sleep and taking pills to help sleep, responses included *never*, *rarely* (1 time/month), *sometimes* (2-4 times/month), *often* (5-15 times/month) and *almost always* (16-30 times/month). Due to the insufficient number of observations across each possible response option, frequency of snorting/gasping/stopped breathing was dichotomized into the event occurring *never* and *rarely or more.* For the variable having leg cramps while trying to sleep, responses options were re-categorized into *never, rarely* and *sometimes or more*. Similarly, the sleeping variable assessing the frequency of taking pills was re-categorized as *never* and *rarely or more*.

Measurement of Anthropometric Parameters

While attending the MEC, participants underwent a variety of body assessments, with the present study utilizing the objective measurements of weight, height,

waist circumference, thigh circumference, arm circumference, tricep skinfold and subscapularis skinfold. All measurements were collected by trained health technicians per the Anthropometric Standardization Reference Manual guidelines. During examination at the MEC, BMI was calculated from measured weight and height (weight in kilograms divided by the square of height in meters). Using CDC growth curves, participants were categorized as overweight or not overweight with overweight defined as $\geq 85^{th}$ BMI percentile for age and gender [10].

Measurement of Covariates

During a household interview, an interview-administered questionnaire assessed information on age, gender, race-ethnicity, annual household income, and poverty income ratio. Annual family income was reported in increments of $5,000 starting at $0 and up to $75,000 or more. Socioeconomic status was evaluated using the poverty to income ratio. Ranging from 0 to 5, poverty to income ratio was defined as the ratio of the family individual income to their poverty threshold, with values below 1 indicating they are below the poverty threshold. At the MEC, participants completed a questionnaire on their current health status, with possible responses including *excellent, very good, good, fair, or poor*. Physical activity was self-reported by asking participants whether they engaged in any moderate or vigorous-intensity physical activity over the past 30 days for at least 10 minutes. As a marker of active *smoking status* or as an index of environmental exposure to tobacco (i.e., passive smoking), serum cotinine was measured. Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry. To exclude participants who were breast feeding or pregnant, participants answered questions on whether they were pregnant or breast feeding. Given that some of the female participants may not have known they were pregnant, pregnancy status was also identified using a urine sample. If the urine test results were positive for pregnancy, a serum pregnancy test was also performed.

Data Analysis

Analyses were performed using procedures from sample survey data in STATA (version 12.0, College Station, TX) to account for the complex survey design used in NHANES. To account for oversampling, non-response, non-coverage, and provide nationally representative estimates, all analyses included the use of appropriate sample weights, clustering variables, and primary sampling units. Means and standard errors were calculated for continuous variables and proportions were calculated for categorical variables. An adjusted Wald test was used to examine differences across the continuous and categorical variables (e.g., age across gender), and a design-based category ratio test was used to examine differences across the categorical variables (e.g., frequency of snoring across gender). Beyond probability testing, the magnitude of associations was estimated using eta-squared (η^2).

Linear regression analysis was used to examine the association between each of the anthropometric variables and sleep duration and sleep latency. Logistic and polytomous regression models were used to examine the association between each of the anthropometric variables and the dependent categorical sleeping variables (e.g., frequency of snoring). Unstandardized coefficients are reported for the models. All models were stratified by gender. All models were adjusted for health status, household income, poverty status, race-ethnicity, age, physical activity, and smoking. Statistical significance was established as a $p < 0.05$.

RESULTS

Based on the study design and use of sample weights, the 177 boys in the analyzed sample are representative of 2,780,963 U.S. boys between 16 and 17 years of age. The 162 girls are representative of 2,949,913 U.S. girls between 16 and 17 years of age. Demographic characteristics of the sample are displayed in Table 1. There were no gender differences across the demographic and behavioral characteristics, with the exception of physical activity; boys reported more physical activity than girls. Weighted means and percentages for the anthropometric variables are shown in Table 2. Results showed that girls, compared to boys, had a greater tricep skinfold and subscapularis skinfold, with a lower arm and thigh circumference. The mean sleep duration and latency, and proportion for each response to the sleep-related categorical variables are shown on Table 3. Results showed that girls, compared to boys, reported being more likely to have leg cramps while sleeping.

Anthropometric Indices and Sleep Latency and Duration

No anthropometric variables were associated with sleep latency for boys or girls; thus, these results are not shown. For girls, and after adjusting for current health status, income, poverty level, race-ethnicity, age, physical activity, and smoking, those with a larger subscapularis skinfold slept for a longer duration (coefficient = 0.04 [95% CI: 0.008 to 0.09], p = 0.02).

Table 1. Weighted means and proportions (standard error) for selected characteristics of the NHANES 2005-2006 sample (n = 339).

Variable	Mean/Proportion [standard error]	
	Boys (n = 177)	Girls (n = 162)
Age (yrs) (range = 16-17)	16.4 (.05)	16.3 (.04)
Ethnicity		
% Mexican American (n = 48 boys; n = 44 girls)	9.1 (1.6)	7.5 (1.8)
% Other Hispanic (n = 5 boys; n = 7 girls)	2.8 (.6)	8.4 (4.1)
% Non-Hispanic White (n = 52 boys; n = 58 girls)	69.1 (5.5)	69.1 (5.6)
% Non-Hispanic Black (n = 61 boys; n = 48 girls)	13.4 (2.5)	9.9 (2.2)
% Other Race (n = 11 boys; n = 5 girls)	5.3 (2.6)	4.8 (3.0)
Poverty Income Ratio (range = 0-5)	3.0 (.1)	3.0 (.2)
Current Health Status		
% Excellent (n = 37 boys; n = 24 girls)	19.6 (4.6)	16.1 (3.8)
% Very Good (n = 56 boys; n = 60 girls)	34.6 (4.6)	41.3 (5.6)
% Good (n = 69 boys; n = 15 girls)	40.7 (4.7)	33.3 (3.9)
% Fair (n = 15 boys; n = 19 girls)	4.9 (1.7)	8.7 (2.3)
% Poor (n = 0 boys; n = 2 girls)	0	0.4 (.3)
Cotinine (ng/mL)	27.6 (5.3)	28.5 (6.3)
% Engaging in any moderate-to-vigorous physical activity within last 30 days	86.8 (3.8)*	79.2 (4.3)

* Adjusted wald tests were used to examine differences across the continuous variables and gender, with design-based category ratio tests used across the categorical variables and gender. Only variable that was significant was % engaging in moderate-to-vigorous physical activity within last 30 days. Boys were more physical activity than girls (p = 0.04)

Table 2. Weighted mean and proportions (standard error) for the anthropometric variables, NHANES 2005-2006 (n = 339).

Variable	Mean/Proportion [standard error]		η^2
	Boys (n = 177)	Girls (n = 162)	
BMI (kg/m2)	23.2 (.4)	22.9 (.4)	0.01
Waist circumference (cm)	82.2 (.9)	79.7 (1.0)	0.12
Tricep skinfold (mm)	12.1 (.4)	18.1 (.8)	0.70
Subscapularis skinfold (mm)	12.4 (.4)	14.8 (.7)	0.28
Thigh circumference (cm)	52.2 (.5)	49.6 (.5)	0.44
Arm circumference (cm)	29.9 (.3)	27.4 (.4)	0.61
Calf circumference (cm)	37.4 (.4)	36.4 (.2)	0.19
% Overweight or Obese†	29.9 (3.3)	23.6 (4.0)	0.07

BMI = body mass index

† Greater than the 85th percentile for age and gender.

Adjusted Wald tests were used to examine differences across the continuous anthropometric variables and gender.

Bold indicates statistical significance (p < 0.05).

Table 3. Weighted means and proportions of sleeping-related variables, NHANES 2005-2006 (n = 339).

Sleeping Variables†	Mean/Proportion [standard error]		η^2
	Boys (n = 177)	Girls (n = 162)	
Sleep Duration (hrs)	7.6 (.1)	7.3 (.2)	0.06
Sleep Latency (min)	21.2 (1.9)	20.2 (1.2)	0.01
Frequency of snoring			
Never (n = 110 boys; n = 116 girls)	58.2 (5.8)	71.5 (3.1)	
Rarely (n = 32 boys; n = 21 girls)	23.0 (5.1)	13.3 (2.7)	0.12
Occasionally (n = 13 boys; n = 10 girls)	5.8 (2.4)	6.9 (2.4)	
Frequently (n = 22 boys; n = 15 girls)	12.8 (2.8)	8.1 (3.4)	
Frequency of snorting/gasping/stopped breathing			
Never (n = 155 boys; n = 166 girls)	93.6 (2.6)	97.4 (1.3)	0.11
Rarely or more (n = 7 boys; n = 11 girls)	6.3 (2.6)	2.5 (1.3)	
How often do you have leg cramps while sleeping?			
Never (n = 144 boys; n = 121 girls)	85.6 (2.3)	72.8 (3.8)	0.20
Rarely (n = 17 boys; n = 22 girls)	8.1 (2.1)	14.3 (3.7)	
Sometimes or more (n = 16 boys; n = 19 girls)	6.1 (1.9)	12.7 (2.8)	
How often do you take pills to help with sleep?			
Never (n = 166 boys; n = 147 girls)	88.5 (2.8)	92.2 (2.8)	0.03
Rarely or more (n = 11 boys; n = 15 girls)	11.4 (2.8)	7.7 (2.8)	

† Adjusted Wald tests were used to examine differences across the continuous variables and gender, with design-based category ratio tests used across the categorical variables and gender.

Bold indicates statistical significance (p < 0.05).

Anthropometric Indices and Categorical Sleep-Related Parameters

Regarding the association between the anthropometric indices and the categorical sleep-related variables (i.e., snoring, stopped breathing, leg cramps, and taking pills), no models were significant for boys; thus, these results are not shown. For girls, results are reported in Table 4. After adjusting for current health status, income, poverty level, race-ethnicity, age, physical activity, and smoking, all the anthropometric variables were associated with frequency of snoring with the exception of subscapularis skinfold and overweight. Girls with higher anthropometric variables were 6-37% (odds ratios ranged from 1.06-1.37) more likely to frequently snore than never snore. Additionally, girls with a larger calf circumference were 12% (OR = 1.12, 95% CI: 1.03-1.21) more likely to have leg cramps than never have leg cramps. Similarly, girls with a larger BMI were 15% (OR = 1.15; 95% CI: 1.00-1.32) more likely to have leg cramps than never have leg cramps.

DISCUSSION

Our findings showed no association between anthropometric indices and sleep latency; however, there was some evidence that anthropometric parameters are associated with sleep duration, with our analysis showing a positive association between subscapularis skinfold and sleep duration for girls. Additionally, the analyses showed that girls with larger anthropometric indices were more likely to snore and have leg cramps while asleep.

In general, most studies report an inverse association between obesity and sleep duration [5]. However, our results for girls are not in complete support of these findings, as these data show that girls with larger subscapularis skinfold slept for longer durations (i.e., a positive association). Given that this finding is inconsistent with other studies, it is difficult to explain this observed association. However, and although speculative, it is possible that sleeping longer may result in less time (and perhaps energy) to engage in health promoting behaviors during the day. Although numerous studies have reported an inverse association between obesity and sleep (i.e., obese adolescents sleep for shorter durations), most have not examined nationally representative samples, utilized additional anthropometric indices, or considered potential socio-demographic confounders [11].

Table 4. Association between anthropometric variables (independent variables) and categorical sleep-related parameters (dependent variables) for girls, NHANES 2005-2006 (n = 162).

	Odds Ratio (95% CI) †							
Sleeping Variables	BMI	Waist Circumference	Tricep	Subscapularis	Thigh circumference	Arm circumference	Calf circumference	Overweight
Frequency of snoring								
Never	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rarely	1.20 [1.03, 1.40]	1.04 [.96, 1.13]	1.09 [0.97, 1.22]	1.04 [.92, 1.19]	1.16 [1.05, 1.27]	1.24 [1.03, 1.50]	1.29 [1.05, 1.59]	1.96 [0.34, 11.25]
Occasionally	.87 [0.73, 1.03]	.94 [.88, 1.00]	.88 [.74, 1.05]	.94 [.85, 1.04]	.94 [.82, 1.08]	.95 [.81, 1.12]	1.00 [.79, 1.25]	.07 [.005, 1.20]
Frequently	1.19 [1.09, 1.31]	1.06 [1.01, 1.12]	1.17 [1.06, 1.30]	1.07 [.97, 1.17]	1.21 [1.11, 1.31]	1.37 [1.19, 1.58]	1.34 [1.14, 1.58]	2.34 [.60, 9.06]
Frequency of snorting/gasping/stopped breathing								
Never	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rarely or more	1.01 [.83, 1.23]	1.00 [.93, 1.07]	1.08 [.95, 1.24]	1.02 [.92, 1.12]	1.02 [0.90, 1.16]	1.23 [.91, 1.66]	1.07 [.80, 1.43]	.10 [.01, 1.12]
How often do you have leg cramps while sleeping?								
Never	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rarely	1.02 [.93, 1.12]	1.00 [.95, 1.06]	1.00 [.89, 1.11]	1.01 [.93, 1.09]	1.03 [0.97, 1.10]	1.03 [.92, 1.16]	1.12 [1.03, 1.21]	.89 [.21, 3.83]
Sometimes or more	1.15 [1.00, 1.32]	1.01 [.96, 1.07]	1.05 [.96, 1.14]	1.04 [.95, 1.15]	1.08 [0.94, 1.23]	1.13 [.99, 1.31]	1.15 [0.92, 1.44]	2.20 [.58, 8.28]
How often do you take pills to help with sleep?								
Never	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rarely or more	1.15 [.98, 1.36]	1.04 [.97, 1.12]	1.08 [.98, 1.20]	1.08 [.98, 1.19]	1.09 [.99, 1.21]	1.20 [.96, 1.49]	1.17 [.89, 1.53]	1.56 [.29, 8.31]

† Adjusted for current health status, income, poverty level, race-ethnicity, age, physical activity, and smoking.

Bold indicates statistical significance ($p < 0.05$).

Our examination of the association between anthropometric indices and sleep-related parameters, such as frequency of snoring, stopped breathing, leg cramps, and sleeping pill intake, adds to the literature,

as, to the best of our knowledge, no study to date has systematically examined these associations. Because of this, making comparisons to other studies is difficult. However, our finding that unfavorable anthropometric indices were associated with greater frequency of snoring is consistent with other emerging research indicating a link between obesity and sleep apnea in children and adolescents. Udomittipong et al. [12] showed that severe to morbid obesity was a predictor of severe obstructive sleep apnea in obese children. Hannon et al. [13] showed that in severely obese adolescents, BMI and waist circumference were inversely associated with oxygen saturation. With regard to the latter, increased adiposity in the chest and abdomen causes a reduction in lung volume and changes in breathing patterns, which is accentuated when lying in supine position [14]. Consequently, during sleep, hypoventilation occurs, ultimately resulting in a transient fall in oxygen arterial saturation [14]. In addition to the observed association between anthropometric indices and frequency of snoring, our findings indicate a link between unfavorable levels of anthropometric indices and leg cramps. Although our search failed to locate other studies examining the association between anthropometric indices and leg cramps in adolescents, this association is plausible given that obesity may lead to leg cramps through atherosclerotic-induced reduced blood flow. Of course, future studies are needed to confirm this speculation.

In summary, our findings in a nationally representative sample of older U.S. adolescents suggest null associations between anthropometric indices and sleep duration in boys, but a potential positive association for girls, with no association for sleep latency for either gender. Additionally, for girls only, anthropometric measures were associated with frequency of snoring and leg cramps while asleep. In particular, future studies employing a prospective or experimental study design are needed in order to establish cause-and-effect, which we are not able to render with our cross-sectional study design. Additional limitations include using subjective measures of sleep and the restricted age range of adolescent participants. Further studies using an objective-measure of sleep (e.g., polysomnography) among a larger age range of adolescent participants are needed to confirm our gender-specific findings and improve generalizability. Although speculative, and warranting research to confirm, the discrepant gender findings may be a result of the higher pubertal status of girls [15]. In addition to sex-hormonal related factors, other studies may wish to examine whether socio-environmental factors (e.g., family and occupational) may help to explain potential gender-related differences. Major strengths of the present study include a systematic examination of the association between various anthropometric indices and several sleep-related parameters, utilizing a nationally representative sample of adolescents, performing gender-stratified analyses, and controlling for potential socio-demographic confounders. Although prospective and experimental studies are needed to determine the direction of the relationships, based on these findings, along with those of others, a sensible strategy to improve parameters related to sleep may include the reduction of body fat among adolescents, particularly girls.

REFERENCES

1. National Sleep Foundation (2006). Sleep in Americal poll. Washington, DC.
2. Oginska H, Pokorski J. Fatigue and mood correlates of sleep length in three age-social groups: School children, students, and employees. Chronobiol Int. 2006;23:1317-28.
3. Carskadon MA. Sleep's effects on cognition and learning in adolescence. Prog Brain Res. 2011;190:137-43.
4. Taheri S. The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity. Arch Dis Child. 2006;91:881-4.
5. Hart CN, Cairns A, Jelalian E. Sleep and obesity in children and adolescents. Pediatr Clin North Am. 2011;58:715-33.
6. Lowry R, Eaton DK, Foti K, et al. Association of Sleep Duration with Obesity among US High School Students. J Obes. 2012;2012:476914.
7. Weaver TE, Laizner AM, Evans LK, et al. An instrument to measure functional status outcomes for disorders of excessive sleepiness. Sleep. 1997;20:835-43.
8. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31:619-26.
9. Iglowstein I, Jenni OG, Molinari L, et al. Sleep duration from infancy to adolescence: reference values and generational trends. Pediatrics. 2003;111:302-7.
10. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1240-3.
11. Hassan F, Davis MM, Chervin RD. No independent association between insufficient sleep and childhood obesity in the National Survey of Children's Health. J Clin Sleep Med. 2011;7:153-157.
12. Udomittipong K, Chierakul N, Ruttanaumpawan P, et al. Severe obesity is a risk factor for severe obstructive sleep apnea in obese children. J Med Assoc Thai. 2011;94:1346-51.

13. Hannon TS, Rofey DL, Ryan CM, et al. Relationships among obstructive sleep apnea, anthropometric measures, and neurocognitive functioning in adolescents with severe obesity. J Pediatr. 2012;160:732-5.

14. Kopelman PG. Obesity as a medical problem. Nature. 2000;404:635-43.

15. Dewald JF, Meijer AM, Oort FJ, et al. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. Sleep Med Rev. 2010;14:179-89.