

Association Between Sleep Duration, Obesity, and School Failure Among Adolescents

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Abstract

The aim of this study was to investigate the association between sleep duration, overweight/obesity, and school failure using data obtained from self-reported questionnaires completed by 13- to 15-year-olds in Sweden ($n = 1,363$; 50.7% female). The height and weight of the participants were measured by school nurses. A multiple logistic regression analysis was used to analyze the association between sleep duration and overweight/obesity, school failure, and perceived economic situation. A short sleep duration (<7 hr) was associated with overweight/obesity ($p = .001$), school failure ($p = .007$), and poorer perceived economic situation ($p = .004$). Modifying the sleep habits of adolescents is a potential target for obesity intervention as well as for improving school success. This information is particularly well suited for school nurses to disseminate to students and their parents.

Keywords

sleep, obesity, school success, adolescents, cross-sectional

Globally, children and adolescents have been sleeping less over the past century (Basch et al., 2014; Matricciani et al., 2012). Adolescents generally require 8–10 hr of sleep each night (Hirshkowitz et al., 2015), but epidemiological studies in the United States have shown that a third of 12- to 14-year-olds and over half of 15- to 17-year-olds sleep fewer than 7 hr on an average school night (Basch et al., 2014; Taveras et al., 2008). Only 10% of 15- to 17-year-olds and 29% of 12- to 14-year-olds sleep more than 9 hr on an average school night (Hirshkowitz et al., 2015). Fuligni et al. (2018) argue that optimal sleep duration differs for different developmental outcomes among adolescents. For example, peak levels for mental health were found among adolescents who slept 8.75–9.00 hr per night, but the limits that affected academic success were 7.00–7.50 hr. Sleep is important for memory consolidation and creativity, and sleep deprivation causes learning problems, including problems with concentration and discipline (Kryger et al., 2011).

Obesity in adolescents is a public health concern, and its prevalence has increased globally (World Health Organization, 2017). In Swedish 14-year-olds, 22% of boys and 20% of girls are overweight, with 5% of boys and 4% of girls considered obese (Eriksson et al., 2018). Obesity and overweight in childhood and adolescence can lead to several health complications such as diabetes, cardiovascular disease, obstructive sleep apnea, a higher risk of obesity in adulthood (Silva et al., 2011; Taveras et al., 2008; Yanovski,

2015), and psychosocial problems such as depression (Daniels, 2009a).

The relationship between sleep duration and body weight is complex, but prior studies suggest both biological and behavioral involvement (Miller et al., 2015). Biologically, short sleep duration is associated with changes in metabolic hormones such as reduced leptin and increased ghrelin levels (Boeke et al., 2014; Leproult & Van Cauter, 2010). Changes in the levels of these hormones are associated with increased appetite, which in turn may lead to overeating and body mass index (BMI) increases (Hirotsu et al., 2015). Two prior meta-analyses have shown that short sleep duration is a risk factor for obesity in children and adolescents worldwide (Fatima et al., 2016; Felso et al., 2017), but the definition of short sleep was inconsistent and not always reported. Recent studies from North America (United States and Puerto Rico) and Asia (South Korea) have shown an association between sleeping <7 hr per night and high BMI in

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adolescents (Grandner et al., 2015; Koinis-Mitchell et al., 2017; Lee et al., 2016). However, a large study from the United States (Calamaro et al., 2010) failed to find an association between <6 hr sleep per night and obesity in adolescents. Rather, environmental factors such as watching television (TV) for more than 2 hr per day and depression were associated with obesity (Calamaro et al., 2010). The etiology of adolescent obesity is complex and characterized by several contributing factors (Lobstein et al., 2015), including psychosocial stress, poor eating habits, and reduced physical activity (Kumar & Kelly, 2017) as well as being socioeconomically disadvantaged (Buzek et al., 2019; Kelly et al., 2016).

Aim

This study aimed to investigate the associations between sleep duration, overweight/obesity, and school success among 13- to 15-year-old adolescents.

Method

This study is part of a larger project called “Sleep and lifestyle in school age children” (Trial Registry ISRCTN 17006300, BioMed Central, 2017). The study was approved by the Regional Ethical Review Board in Lund, Sweden. Prior to data collection, a letter containing information about the study was sent to the adolescents and their guardians to invite them to participate, and written informed consent was obtained. All procedures were conducted in accordance with the Declaration of Helsinki.

Sample and Data Collection

The sample consisted of students in Grades 7 and 8 (13–15 years old) in four municipalities in southern Sweden, with the data collected during the 2015–2017 academic years. Questionnaires were distributed to the school nurses in the included municipalities, and the participating students completed the questionnaires at individual routine appointments with the nurses during school hours.

Data Measures

The self-reported questionnaire used here has earlier been psychometrically tested and found to be valid and reliable for this age-group (Garmy et al., 2012). There is evidence supporting the validity of self-reported sleep from a study with 14- to 18-year-old adolescents that showed a high correlation between their self-reported sleep duration and objectively measured sleep duration using actigraphy (Wolfson et al., 2003). The questionnaire included the following questions: “When I have school the next day, I usually sleep around...” (hours and minutes), “How financially well off do you think your family is?,” with five response options: “very well off,” “rather well off,” “average,” “not that good,” and “not good at all.” In Table 1,

Table 1. Association Between Short Sleep Duration (<7 hr) and Sex, Age, Economic Situation, School Failure, and Overweight/Obesity Among Students Aged 13–15.

	Sleep		χ^2 (df)	p Value
	<7 hr	Sleep ≥7 hr		
	n = 117 (8.4%)	n = 1,246 (89.8%)		
	n (%)	n (%)		
Sex				
Girl	67 (9.6)	630 (90.4)	1.92 (1)	.176
Boy	50 (7.5)	616 (92.5)		
Age				
13 Years	5 (3.0)	164 (97.0)	8.6 (2)	.014
14 Years	110 (9.3)	1,072 (90.7)		
15 Years	2 (16.7)	10 (83.3)		
Perceived economic situation ^a				
Good	85 (7.6)	1,028 (92.4)	12.59 (2)	.002
Average	21 (11.7)	158 (88.3)		
Poor	6 (26.1)	17 (73.9)		
School failure ^b				
No failed subjects	89 (7.6)	1,081 (92.4)	14.86 (2)	.001
1–2 Failed subjects	18 (12.9)	121 (87.1)		
≥ 3 Failed subjects	10 (21.7)	36 (78.3)		
BMI				
Normal weight	89 (7.7)	1,071 (92.3)	13.0 (2)	.001
Overweight	18 (11.5)	139 (88.5)		
Obese	10 (21.7)	36 (78.3)		

Note. n = 1,363. χ^2 = Pearson’s chi-square; df = degrees of freedom; BMI = body mass index. p < .05 was considered significant and is marked in boldface.

^aMissing data: 48 (3.5%). ^bMissing data: 8 (0.6%).

Table 2. Factors Associated With Short Sleep Duration (<7 hr).

	Wald Value	Odds Ratio	95% CI	p Value
Sex (boy)	3.3	.70	[0.47, 1.03]	.071
Age (14–15 years)	7.7	3.7	[1.47, 9.30]	.005
Poor economic situation	5.0	1.7	[1.07, 2.66]	.025
Overweight/obesity	7.4	1.9	[1.20, 3.08]	.006
School failure (≥ 1 failed subject)	8.8	2.1	[1.28, 3.30]	.003

Note. n = 1,363. Hosmer and Lemeshow’s goodness-of-fit test, p = .802; Nagelkerke R² = .055; tolerance > 0.9. CI = confidence interval. p < .05 was considered significant and is marked in boldface.

the response options “very well off” and “rather well off” are grouped as a “good” economic situation, whereas the responses “not good” and “not good at all” are grouped as a “poor” economic situation. In Table 2, the responses are dichotomized, and “very well off” and “rather well off” were coded 0 and all other options were coded 1.

The students also described whether they had failed any subjects during the previous school year (“Have you failed in a subject during the last year?”) with response options: 0,

1–2, and ≥ 3 subjects. In Table 2, the responses were dichotomized, so that no failed school subjects during the last year were coded 0, and all other response options 1. The sex (girl/boy) and age (birth year) of each participant were also reported. In Table 2, age was dichotomized, so that 13 years were coded 0 and ages 14 and 15 were coded 1.

The BMI was calculated by dividing each student's weight (kg) by the square of their height (m). The school nurses measured the height and weight of the students while wearing light clothing without shoes. Height was measured on a manual height board to the nearest 0.1 cm, and weight was measured on a standard digital scale to the nearest 0.1 kg. Obesity was defined as a BMI exceeding 30, and overweight was defined as a BMI exceeding 25 on a curve with age- and sex-specific cutoff points corresponding to the definitions of overweight or obesity for age 18 (Cole et al., 2000; Daniels, 2009b). The BMI data were sorted into three groups: normal weight, overweight, and obesity. In Table 2, the BMI data were dichotomized, so that normal weight was coded 0 and overweight and obesity were coded 1.

Statistical Analysis

The statistical analyses were performed using IBM SPSS Version 24. The data were first analyzed using descriptive statistics with frequencies and percentages. Chi-square tests were used to investigate the association between short sleep duration and the following independent variables: sex, age, perceived economic situation, school failure, and overweight/obesity. A short sleep duration was defined as < 7 hr/night (Fuligni et al., 2018; Grandner et al., 2015; Koinis-Mitchell et al., 2017; Lee et al., 2016). A multiple logistic regression (enter method) was used to analyze the extent to which the independent variables could explain the dependent variable (sleep duration: ≥ 7 hr/night = 0, < 7 hr/night = 1). A p value $< .05$ was considered statistically significant, and 95% confidence intervals were estimated (Creswell & Creswell, 2017).

Results

All students at the schools ($n = 20$) in the included area were invited to participate. The response rate was 72.7% ($n = 1,518$). However, 131 (8.6%) participants were excluded for not providing the information required to calculate their BMI. The group that provided BMI-related information did not differ in gender, age, or sleeping habits from the group that did not ($p > .05$). An additional 24 participants did not respond to the questions regarding sleep duration. Therefore, the analysis is based on 1,363 participants.

The participants' ages ranged from 13 to 15 years, with a mean (SD) age of 13.9 (0.4) years. Most participants (94.3%) reported their families were financially "average," "rather well off," or "very well off." The prevalence of overweight/obesity was 14.7% among girls and 15.9% among boys, while the obesity rates were 3.5% among girls and 3.4%

among boys (Table 1). A sleep duration of < 7 hr was associated with overweight/obesity, school failure, a poorer perceived economic situation, and older age (Table 2). Whereas 7.7% of the students with normal weight slept < 7 hr, 11.5% and 21.7% of the students with overweight and obesity slept < 7 hr. A sleep duration < 7 hr was found among 7.6% of the students without any failed subjects, compared with 12.9% of the students with one to two failed subjects, and 21.7% among students with at least three failed subjects. Although we found significant associations between reduced sleep and all independent variables but sex, the Nagelkerke test suggests these variables explained only a minority of the odds of having a sleep duration < 7 hr.

Discussion

The aim of this study was to investigate the association between sleep duration, overweight/obesity, and school failure among adolescents aged 13–15. The key findings were that sleeping < 7 hr per night was associated with overweight/obesity, school failure, and a poor economic situation. Other studies from Sweden and the United States have also found associations between a short sleep duration and academic performance (Fuligni et al., 2018; Jakobsson et al., 2019; Titova et al., 2015; Wernette & Emory, 2017). Also, Titova et al. (2015) found that school failure was more common among students who slept < 7 –8 hr, and their study also found an association between sleep quality and school failure, especially among girls, that is, girls complaining of sleep problems are at risk for failing school subjects.

There is a need to support adolescents in promoting healthy sleep habits. While the adolescent brain is developing, a pervasive issue is acquiring sufficient sleep. Importantly, insufficient sleep is associated with attention deficits, a lack of concentration, reduced cognitive functioning, and risk-taking behaviors (Kryger et al., 2011). Continued sleep deficiency among adolescents is likely due to a combination of puberty changes, school and after-school commitments, and lifestyle habits, including the lack of a bedtime routine and technology usage (Short et al., 2019). For example, sending and receiving text messages at night has been found to be associated with reduced sleep and tiredness during the school day (Garmy & Ward, 2018; Garmy et al., 2019). Adolescents who went to bed when they were tired, rather than when they have finished their electronic media use (messaging/socializing) or when the TV show was over, went to bed earlier and had a longer sleep duration on school nights (Short et al., 2019). There is a need to encourage adolescents to use their bodily cues to indicate when it is time for bed, rather than relying on an external cue (Short et al., 2019).

Less than 7 hr of sleep was more common among students with a self-reported poor economic situation, compared with students who reported their family financial

status as average or good in our study. Sleep problems among Danish students aged 11–15 were found to be more common among students in families with lower socioeconomic status (Holstein et al., 2019). We do not know the reasons for this, but a hypothesis is that more presleep worries shorten sleep duration and increase sleep problems.

Our observed association between obesity and <7 hr sleep replicates findings from other studies (Grandner et al., 2015; Koinis-Mitchell et al., 2017; Lee et al., 2016). However, Calmaro et al. (2010) did not find an association between short sleep (<6 hr) and obesity, suggesting that obesity has many different causes and mechanisms. Obesity among adolescents is a public health concern, and its prevention is urgent due to the health consequences (e.g., high blood pressure, diabetes, inflammation), as well as increased health-care costs (Aggarwal & Jain, 2018). In conjunction with healthy food habits and physical activity, adequate sleep and healthy sleep habits are important factors to consider in preventing obesity.

Implications for School Nursing

The rationale for this study was to provide school nurses with empirical evidence about the associations between sleep duration, overweight/obesity, and school success. This evidence could aid school nurses in counseling adolescents and their parents. The prevention and reduction of obesity are important challenges in public health, and sleep habits could represent a modifiable lifestyle variable that is free and fairly simple to change. The parental enforcement of bedtime rules has been found to increase sleep duration on weeknights by 1 hr, and the enforcement of rules regarding watching TV or using smartphones at night has been shown to increase sleep duration by 0.6 and 0.9 hr, respectively (Buxton et al., 2015). Therefore, school nurses should encourage parents and guardians to discuss bedtimes and access to screens at night.

Limitations

One limitation of this study is its cross-sectional design, which means that it cannot determine causal relationships (Creswell & Creswell, 2017). The dependent variable in this study was sleep duration, whereas obesity and academic success were independent variables. There is the possibility that obesity itself could result in sleep difficulties by causing obstructive sleep apnea, which can lead to poor sleep quality (Hamilton & Joosten, 2017). A large study has identified a variety of sleep predictors, including some that were not investigated in this study such as ethnicity, cigarette smoking, and alcohol consumption (Kruger et al., 2014). Another limitation is that we did not control for exercise and dietarian patterns. Considering these variables as covariates in future studies could yield a more detailed picture of how sleep quality and being overweight are associated.

Some participants did not agree to provide their height or weight, which made it impossible to calculate their BMI. We did not investigate why these individuals declined to have their height or weight measured. However, because the group that did provide their BMI-related data was similar in all other respects to the group that did not, we have assumed that the latter group's BMI values were similar to those recorded.

We only asked about sleep duration on school nights and did not ask any questions regarding sleep quality, which may be important to consider in future studies. Another limitation is that the sleep duration was self-reported, which poses a risk of recall bias and social desirability.

Conclusion

The results of this study indicate that sleep habits should be taken into consideration as a part of the prevention and treatment of overweight/obesity as well as for promoting school success. Sleeping <7 hr per night was shown to be linked with overweight/obesity and school failure. School nurses can play an important role in conveying information about the benefits of adequate sleep and its association with a healthy weight and school success to parents and adolescents alike.

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Author Contribution

P. Hagell and P. Garmy contributed to the design of the manuscript. All authors contributed to the acquisition and interpretation of the data, revisions, gave final approval, and agreed to be accountable for all aspects of work ensuring integrity and accuracy. The manuscript was drafted by S. Litsfeldt and P. Garmy.

Declaration of Conflicting Interests

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