

# Impact of Short Sleep Duration on the Incidence of Obesity and Overweight among Children and Adolescents

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**Abstract:** *Background and Objectives:* The prevalence of obesity among children is increasing and is highlighting many problems. Lack of sleep is common among children and adolescents. Although several studies have investigated sleep duration and overweight and obesity from a sex perspective, data regarding age and sex effects remain limited and inconclusive. This study aimed to evaluate the risk(s) for overweight or obesity according to sleep duration among children and adolescents; to evaluate the effect of short sleep duration on the incidence of overweight/obesity among children and adolescents; and to evaluate sex differences in the risk of overweight or obesity with shorter sleep durations. *Materials and Methods:* The PubMed database was searched for relevant studies published up to 30 June 2021. Odds ratios for obesity/overweight were estimated for short compared with long sleep duration. Subgroup analysis based on sleep duration, sex, and study location was also performed. *Results:* The estimated odds ratio for combined obesity and overweight was 1.171 (95% confidence interval (CI) 1.092–1.256) according to short sleep duration. Obesity/overweight with short sleep duration was significantly prevalent in the <6 and 6–10 years' subgroups (odds ratio 1.226 (95% CI 1.083–1.387) and 1.341 (95% CI 1.175–1.530), respectively). Among boys, short sleep duration was significantly correlated with a high occurrence of obesity/overweight (odds ratio 1.294 (95% CI 1.153–1.452)); no such correlation was found among girls. *Conclusions:* Short sleep duration may increase risk of obesity among children and adolescents, especially those <6 and 6–10 years of age. In the subgroup analysis, the incidence of obesity/overweight for short sleep time revealed significant results among Asians and boys.

**Keywords:** sleep; obesity; overweight; body mass index; meta-analysis



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## 1. Introduction

According to the World Health Organization, the global prevalence of obesity nearly tripled between 1975 and 2016. In 2016, 39% of adults  $\geq 18$  years of age were overweight, 13% were obese, and >340 million children and adolescents 5–19 years of age were overweight or obese. In 2020, 39 million children < 5 years of age were overweight or obese [1]. BMI is often used to measure the degree of obesity. BMI was calculated as weight in kilograms divided by height in meters squared. According to the World Health Organization (WHO) criteria, obesity is defined as a BMI  $\geq 30$  kg/m<sup>2</sup> (normal weight < 25.0, overweight = 25.0–29.9, obesity  $\geq 30$  kg/m<sup>2</sup>).

The prevalence of obesity among children is increasing and, as a result, many problems are being highlighted. Overweight and obesity among children and adolescents contribute to the onset of chronic diseases, cognitive decline, and the onset of psychological disorders, such as mental stress and feelings of inferiority, which lowers self-esteem and leads to a passive attitude in interpersonal relationships [2,3]. This may adversely affect normal development into adulthood [3,4].

Humans devote a significant portion of the day to sleep. Sleep duration varies among individuals and with age. However, according to the American Academy of Sleep Medicine, for optimal health, children 3–5 years of age should sleep 10–13 h per day and those 6–12 years, 9–12 h and, for adolescents 13–18 years of age, 8–10 h is recommended [5]. Data from the United States demonstrated that the prevalence of short sleep duration among middle-school students was 57.8% and 72.7% among high school students [6]. In 2010, an epidemiological study involving primary and secondary students 9–18 years of age, from 30 provinces across China, reported that <39.09% of students reported having >8 h of sleep per night; the prevalence reached 93.64% of all students [7]. In modern society, lack of sleep is common among children and adolescents. Inadequate sleep among children and adolescents is associated with an increased risk of obesity, diabetes, injuries, poor mental health, attention and behavioral problems, and poor academic performance [8–10].

Men and women have different lifestyles, hormonal influences, and social concepts, suggesting the possibility of different gender-related effects on sleep patterns and obesity. Women may experience severe sleep problems as well as increases in obesity and waist circumference due to menopause, and there are objective sleep disturbances in elderly men and women [11,12].

Although several studies have investigated sleep duration and overweight and obesity from a sex perspective, data regarding age and sex effects remain limited and inconclusive [13–16]. Given this background, we aimed to account for adequate sleep duration among children and adolescents and to investigate whether short sleep duration is an independent risk factor for overweight and obesity and/or for sex- and age-specific effects. Despite its public health importance, there are few reports describing the association between overweight/obesity and short sleep duration across various age groups.

More specifically, the goals of the present study were to evaluate the risk(s) for overweight or obesity according to sleep duration among children and adolescents; to evaluate the effect of short sleep duration on the incidence of overweight/obesity among children and adolescents; and to evaluate sex differences in the risk of overweight or obesity with shorter sleep durations.

## 2. Materials and Methods

### 2.1. Literature Search and Study Selection Criteria

A literature search of the PubMed and MEDLINE databases for relevant studies published up to 30 June 2021 was performed. The database was searched using the following keywords: “Sleep duration”; “obesity or body weight or body mass index”; “children or adolescent”; and “prospective or cohort or observational”. The titles and abstracts of all retrieved articles were screened for eligibility. Review articles were also screened to identify additional potentially eligible studies. Studies involving children and/or adolescents and reporting information regarding obesity or overweight according to sleep duration were included. Case reports, nonoriginal articles, and those not published in English were excluded. This study was registered in RSPERO.

### 2.2. Data Extraction

Data were extracted from each eligible study by two researchers [15–33]. Extracted data included the following: first author’s name; year of publication; study location; number of children and adolescents analyzed; and the risk of obesity or overweight. To perform subgroup analysis, information regarding the risk of obesity and overweight according to sleep duration, sex, and study location was investigated.

### 2.3. Statistical Analyses

Meta-analysis was performed using the Comprehensive Meta-Analysis software package (Biostat, Englewood, NJ, USA). The odds ratios for obesity/overweight were estimated for short sleep duration compared with long sleep duration. Subgroup analysis according to sleep duration, sex, and study location was also performed. Heterogeneity among

studies was assessed using the Q and I<sup>2</sup> statistics and expressed as p-values. Additionally, sensitivity analysis was conducted to assess the heterogeneity of eligible studies and the impact of each study on the combined effect. In addition, to compare between boy and girl subgroups, the metaregression test was performed. Because eligible studies reported various sleep durations and differing populations, the application of the random-effect model, rather than the fixed-effect model, was more suitable. To assess publication bias, Begg’s funnel plot and Egger’s test were used. If significant publication bias was detected, the fail-safe N and trim-fill tests were additionally performed to confirm the degree of publication bias. The risk of bias was assessed through ROBINS-I tool. Differences with  $p < 0.05$  were considered to be statistically significant.

### 3. Results

#### 3.1. Selection and Characteristics of the Included Studies

The initial literature search retrieved 519 articles from the database. On primary screening, 369 articles were excluded due to the absence of or insufficient information ( $n = 324$ ), nonoriginal studies ( $n = 41$ ), and non-English publications ( $n = 8$ ). The full text of 150 articles was reviewed, with 131 excluded due to the absence of or insufficient information. Ultimately, therefore, 19 articles were included in the meta-analysis. Detailed information regarding the included and excluded studies is shown in Figure 1 and summarized in Table 1.

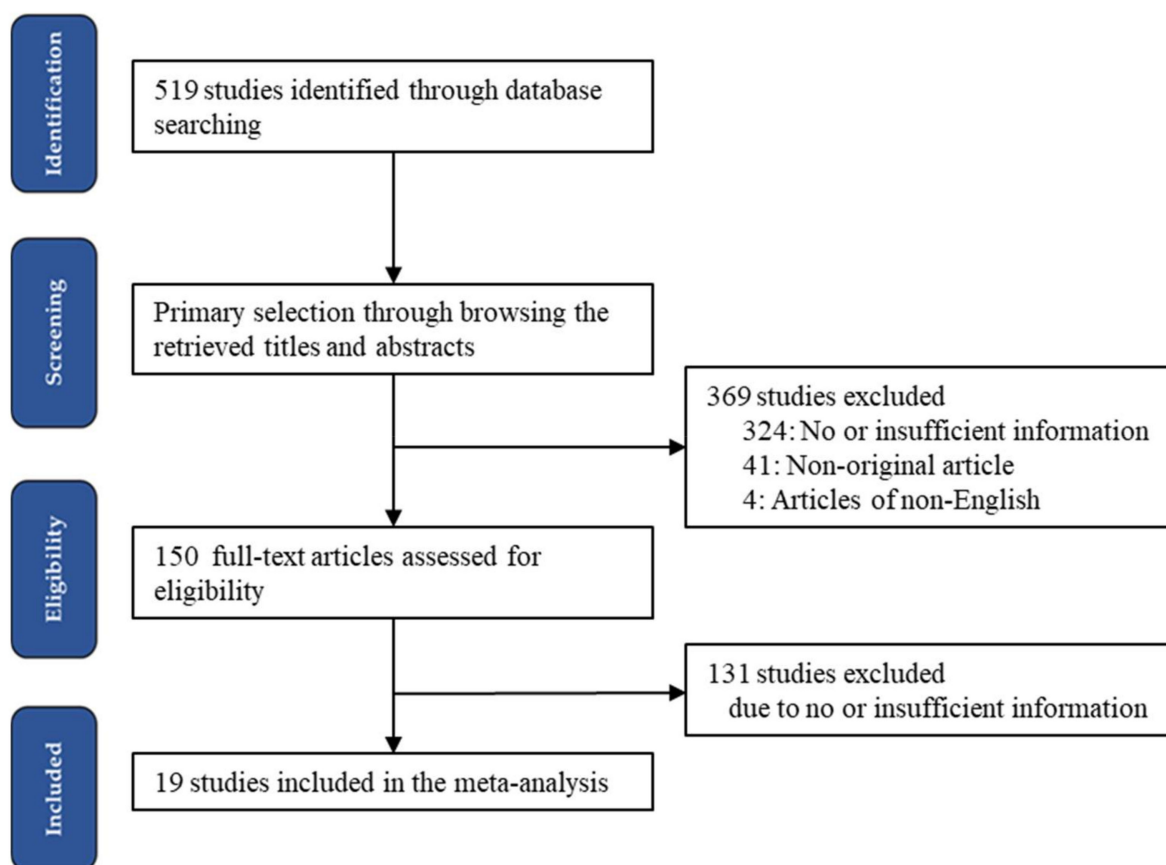


Figure 1. Flow diagram illustrating the study search and selection methods.

**Table 1.** Main characteristics of eligible studies.

First Author	Location	No of Patients	Age Group	Parameter	Comparison	Reference
Anujoo 2016	Various	2384	5 yrs	OS/OW	<10 h	>10 h
Azadbakht 2013	Iran	5528	10–18 yrs 10–14 yrs	OS, OW	<5 h <5 h	5–8 h >8 h
Breitenstein 2019	USA	382	12–13 yrs	OS/OW	8 h	ND
Calamaro 2010	USA	13,568	15.96 yrs	OS	<6 h 6–8 h 8–11 h	8–11 h 8–11 h 11–14 h
Cao 2018	China	18,302	6–17 yrs	OW	<7 h 7–9 h	>9 h >9 h
Carrillo-Larco 2014	Various	1929	7.9 yrs	OS, OW	<10 h	10–11 h
Chaput 2006	Canada	422	5–10 yrs	OS/OW	8–10 h 10.5–11.5 h	12–13 h 12–13 h
Chaput 2011	USA	550	9.6 yrs	OS/OW	<10 h 10–10.9 h 11–11.9 h	11–11.9 h 11–11.9 h >12 h
Gong 2020	China	3411	12–13 yrs	OW	Short	ND
Ievers-Landis 2008	USA	819	9.5 yrs	OS		1 h reduction
Malihi 2021	New Zealand	5734	2 yrs	OS	<11.5 h	>11.5 h
Mercado-Gonzales 2019	Various	1945	4–5 yrs	OS	<10 h	10–13 h
Suglia 2013	USA	1589	5 yrs	OS	<9 h	>9 h
Suglia 2014	USA	10,076	16 yrs	OS	<6 h 6–8 h	>8 h >8 h
Sun 2009	Japan	5753	12–13 yrs	OW	<7 h 7–8 h 8–9 h	8–9 h 8–9 h >9 h
Touchette 2008	Canada	2223	6 yrs	OS/OW	10 h	11 h
Wang 2016	Singapore	48,922	5 yrs	OS, OW	<10 h 11–12 h	11–12 h >13 h
Wang 2019	Hong Kong	3614	9–11 yrs 11–16 yrs	OS/OW	<9 h <9 h	>9 h >9 h
Wing 2009	China	5159	9.25 yrs	OS/OW	9–10 h 8–9 h <8 h	>10 h >10 h >10 h

yrs, years; OS, obesity; OW, overweight; h, hour

### 3.2. Estimated Risks for Obesity and Overweight According to Short Sleep Duration

The estimated odds ratio for combined obesity and overweight was 1.171 (95% confidence interval (CI) 1.092–1.256) according to short sleep duration in the overall cases (Table 2).

The odds ratios for obesity and overweight were 1.191 (95% CI 1.055–1.344) and 1.098 (95% CI 0.976–1.234), respectively. In the subgroup analysis based on age, obesity/overweight with short sleep duration was significantly prevalent in the <6 and 6–10 years' subgroups (odds ratio 1.226 (95% CI 1.083–1.387) and 1.341 (95% CI 1.175–1.530), respectively). There was no significant difference between short and long sleep duration in the >10 years' subgroup. A significant correlation between obesity/overweight and short sleep duration was found in the Asian but not in the North American subgroups (odds ratio 1.161 (95% CI 1.060–1.398) and 1.161 (95% CI 0.964–1.398), respectively). Subsequently, subgroup analysis based on sex was performed. In boys, short sleep duration

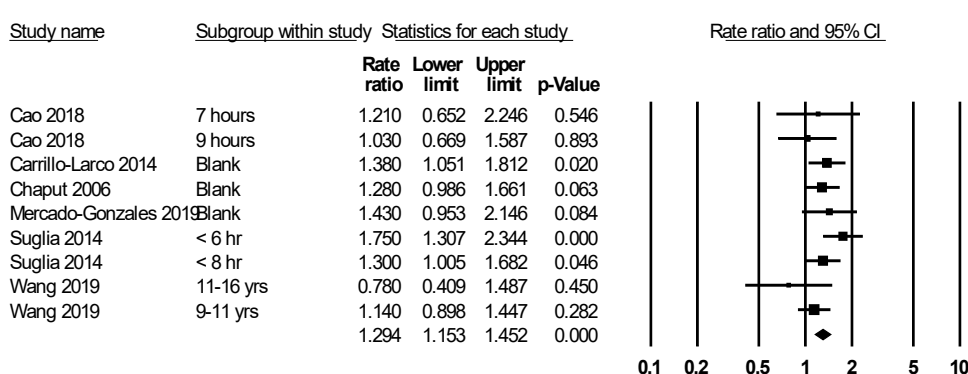
was significantly correlated with a high occurrence of obesity/overweight (odds ratio 1.294 (95% CI 1.153–1.452)) (Figure 2A). However, in the girls’ subgroup, there was no significant correlation between obesity/overweight and short sleep duration (Figure 2B).

**Table 2.** Meta-analysis for the odds ratio of obesity/overweight according to the short sleep duration.

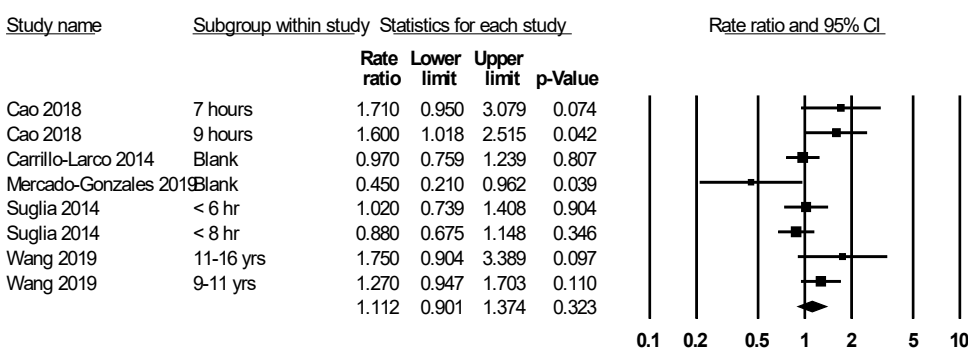
	Number of Subset	Fixed Effect (95% CI)	Heterogeneity Test (p-Value)	Random Effect (95% CI)	Egger’s Test
Obesity/overweight	54	1.169 [1.130, 1.210]	<0.001	1.171 [1.092, 1.256]	0.832
Obesity	17	1.225 [1.146, 1.310]	0.001	1.191 [1.055, 1.344]	0.294
Overweight	19	1.118 [1.068, 1.171]	<0.001	1.098 [0.976, 1.234]	0.669
<6 years	14	1.172 [1.119, 1.227]	<0.001	1.226 [1.083, 1.387]	0.516
6–10 years	9	1.341 [1.219, 1.474]	0.093	1.341 [1.175, 1.530]	0.771
>10 years	26	1.055 [0.980, 1.134]	<0.001	1.034 [0.904, 1.183]	0.489
North America	14	1.191 [1.089, 1.302]	<0.001	1.161 [0.964, 1.398]	0.587
Asia	30	1.158 [1.113, 1.206]	<0.001	1.161 [1.060, 1.271]	0.817

CI, confidence interval.

A



B



**Figure 2.** Forest plots of odds ratios for obesity/overweight according to short sleep duration in boys (A) and girls (B).

Next, to evaluate appropriate sleep duration, a subgroup analysis based on sleep time was performed. Among various sleep times, the most common criterion was 10 h. In the 10 h subgroup, the odds ratio for obesity/overweight was 1.328 (95% CI 1.185–1.489) (Table 3). In addition, the odds ratios for obesity and overweight were 1.304 (95% CI 1.006–1.690) and 1.239 (95% CI 1.042–1.475), respectively. In the <6 and 6–10 years’ subgroups, there were significant correlations between short sleep duration and risk of obesity and overweight. In addition, significant correlations were found in the North American and Asian 10 h subgroups.

**Table 3.** Meta-analysis for the odds ratio of obesity/overweight according to the sleep time.

	Number of Subset	Fixed Effect (95% CI)	Heterogeneity Test ( <i>p</i> -Value)	Random Effect (95% CI)	Egger's Test
<10 h					
Obesity/overweight	14	1.212 [1.156, 1.270]	0.001	1.328 [1.185, 1.489]	0.094
Obesity	3	1.274 [1.149, 1.413]	0.040	1.304 [1.006, 1.690]	0.879
Overweight	3	1.169 [1.106, 1.236]	0.009	1.239 [1.042, 1.475]	0.535
<6 years	11	1.205 [1.147, 1.266]	0.001	1.326 [1.159, 1.518]	0.221
6–10 years	3	1.280 [1.095, 1.495]	0.094	1.365 [1.042, 1.789]	0.035
>10 years	0				
North America	2	1.966 [1.367, 2.826]	0.591	1.966 [1.367, 2.826]	-
Asia	5	1.203 [1.144, 1.265]	0.002	1.325 [1.154, 1.520]	0.038

CI, confidence interval.

#### 4. Discussion

The present investigation was a comprehensive systematic review and meta-analysis of the relationship between short sleep duration and the incidence of overweight and/or obesity among children and adolescents. Results reveal that short sleep duration increased the risk of overweight and/or obesity among children and adolescents, especially those <6 years and 6–10 years of age. Moreover, subgroup analyses revealed the difference of risk between geographical region, age, and sex.

Our study had several strengths. First, the odds ratio for obesity and overweight according to various sleep durations (from 5 h to 12 h in 1 h intervals) (data not shown) was investigated. Among various sleep times, the most common criterion was 10 h. In the 10 h subgroup, the odds ratio for obesity/overweight was 1.328 (95% CI 1.185–1.489) (Table 3). Second, the analysis investigated the odds ratio for obesity and overweight according to sleep time separately and in an integrated manner, and meaningful results were obtained. Third, in the current meta-analysis, we observed associations between increased age and obesity and overweight among children and adolescents according to short sleep duration, further reinforced by subgroup analysis according to age interval. We observed that short sleep duration may significantly increase the risk of overweight and/or obesity in the <6 and 6–10 years of age groups (Table 2). In addition, statistically significant results were obtained for boys and nonsignificant results for girls.

A study by Guo et al., reported that short sleep duration increased the risk of developing overweight or obesity by 35–41% among Chinese children and adolescents [34], which is consistent with our results. The association between short sleep duration and overweight/obesity varies according to age and sex. Several studies have investigated sleep duration and overweight/obesity in terms of sex [13,14]. For example, several studies have reported that the effect of sleep duration on obesity is an increased risk of obesity among women who sleep less [21,35,36]. Conversely, it was reported that girls had a lower risk of obesity due to short sleep duration than boys [16] and, although there was a difference according to age, it was reported that men had a higher risk of obesity due to shorter sleep duration than women [14]. In our study, shorter sleep duration was significantly correlated with a higher incidence of obesity/overweight among boys (odds ratio 1.294 (95% CI 1.153–1.452)); however, no such correlation was found among girls.

In the <6 years' subgroup, the incidence of obesity/overweight was significantly increased in the <10 h group. In >10 years' subgroup, the incidence of obesity/overweight was significantly increased in the <7 h subgroup. However, in the 6–10 years' subgroup, statistical differences in the incidence of obesity/overweight were found at 8, 9, and 10 h. According to our results, recommendations for appropriate sleep duration to reduce obesity/overweight are different among various age groups.

The observation that long sleep time was associated with greater increases in adiposity is in line with some previous data [37,38]. In this regard, the first possibility is that long-duration sleepers are characterized by reduced energy expenditure due to increased time in



bed. In addition, long-duration sleepers were more likely to gain weight during the study period because they had higher BMIs at baseline [39]. Another possibility pertains to the fact that obesity is associated with increased proinflammatory cytokines, which promote sleep [40].

In a subgroup analysis of sleep duration, Deng et al., reported that the objective method (actigraphy) demonstrated a greater effect on childhood obesity than subjective report [41]. In further studies, to determine the impact of overweight and obesity, objective measurement methods, such as actigraphy, rather than subjective reports, should be performed. In addition, the measurement of sleep duration should be more accurate and objective, taking into account naps, sleep quality, and other possible confounding factors that could affect sleep.

There were some limitations to this study that should be addressed. First, because this study was limited to North America and Asia, racial differences could not be compared; as such, further investigation is required. Second, we only considered sleep duration, while some important subgroup factors, such as naps, socioeconomic status, and other lifestyle factors, were not considered in all relevant studies. Third, long sleep time is an important factor in childhood and adolescent obesity and/or overweight; however, sufficient analysis has not been performed due to the lack of relevant data.

The present study provides evidence to the effect that both short and long sleep duration predict obesity/overweight. These results emphasize that sleep duration must now be considered as a new and potentially important determinant of obesity in current lifestyles.

In future studies, we will examine how sleep and obesity/overweight vary according to age and gender and prevent the development of obesity/overweight in individuals with either very long or very short sleep duration.

## 5. Conclusions

Our findings suggest that short sleep duration may increase the risk of obesity among children and adolescents, especially those <6 and 6–10 years of age, and long sleep duration did not yield any significant results. Odds ratio analysis of obesity/overweight for short sleep time revealed statistically significant results among Asians and boys.

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## References

1. World Health Organization. Facts and Figures on Childhood Obesity. Available online: <http://www.who.int/end-childhood-obesity/facts/en/> (accessed on 12 November 2021).
2. Wang, G.; Dietz, W.H. Economic Burden of Obesity in Youths Aged 6 to 17 Years: 1979–1999. *Pediatrics* **2002**, *109*, e81. [[CrossRef](#)] [[PubMed](#)]
3. Yu, Z.; Han, S.; Chu, J.; Xu, Z.; Zhu, C.; Guo, X. Trends in Overweight and Obesity among Children and Adolescents in China from 1981 to 2010: A Meta-Analysis. *PLoS ONE* **2012**, *7*, e51949. [[CrossRef](#)] [[PubMed](#)]
4. Umer, A.; Kelley, G.A.; Cottrell, L.E.; Giacobbi, P., Jr.; Innes, K.E.; Lilly, C.L. Childhood obesity and adult cardiovascular disease risk factors: A systematic review with meta-analysis. *BMC Public Health* **2017**, *17*, 683. [[CrossRef](#)] [[PubMed](#)]
5. Paruthi, S.; Brooks, L.J.; D’Ambrosio, C.; Hall, W.; Kotagal, S.; Lloyd, R.M.; Malow, B.A.; Maski, K.; Nichols, C.; Quan, S.F.; et al. Consensus Statement of the American Academy of Sleep Medicine on the Recommended Amount of Sleep for Healthy Children: Methodology and Discussion. *J. Clin. Sleep Med.* **2016**, *12*, 1549–1561. [[CrossRef](#)]

6. Wheaton, A.G.; Jones, S.E.; Cooper, A.C.; Croft, J.B. Short Sleep Duration Among Middle School and High School Students—United States, 2015. *MMWR Morb. Mortal. Wkly. Rep.* **2018**, *67*, 85–90. [[CrossRef](#)]
7. Song, Y.; Zhang, B.; Hu, P.; Ma, J. Current situation of sleeping duration in Chinese Han students in 2010. *Zhonghua Yu Fang Yi Xue Za Zhi [Chin. J. Prev. Med.]* **2014**, *48*, 596–601.
8. Owens, J.; Adolescent Sleep Working Group; Committee on Adolescence. Insufficient sleep in adolescents and young adults: An update on causes and consequences. *Pediatrics* **2014**, *134*, e921–e932. [[CrossRef](#)]
9. Lowry, R.; Eaton, D.K.; Foti, K.; McKnight-Eily, L.; Perry, G.; Galuska, D.A. Association of Sleep Duration with Obesity among US High School Students. *J. Obes.* **2012**, *2012*, 476914. [[CrossRef](#)]
10. Fitzgerald, C.T.; Messias, E.; Buysse, D.J. Teen Sleep and Suicidality: Results from the Youth Risk Behavior Surveys of 2007 and 2009. *J. Clin. Sleep Med.* **2011**, *7*, 351–356. [[CrossRef](#)]
11. Ford, E.S.; Li, C.; Wheaton, A.G.; Chapman, D.P.; Perry, G.S.; Croft, J.B. Sleep duration and body mass index and waist circumference among U.S. adults. *Obesity* **2014**, *22*, 598–607. [[CrossRef](#)]
12. Cho, K.-H.; Cho, E.-H.; Hur, J.; Shin, D. Association of Sleep Duration and Obesity According to Gender and Age in Korean Adults: Results from the Korea National Health and Nutrition Examination Survey 2007–2015. *J. Korean Med. Sci.* **2018**, *33*, e345. [[CrossRef](#)]
13. Garaulet, M.; Ortega, F.B.; Ruiz, J.R.; Rey-López, J.P.; Béghin, L.; Manios, Y.; Cuenca-García, M.; Plada, M.; Diethelm, K.; Kafatos, A.; et al. Short sleep duration is associated with increased obesity markers in European adolescents: Effect of physical activity and dietary habits. The HELENA study. *Int. J. Obes.* **2011**, *35*, 1308–1317. [[CrossRef](#)]
14. Ames, M.E.; Holfeld, B.; Leadbeater, B.J. Sex and age group differences in the associations between sleep duration and BMI from adolescence to young adulthood. *Psychol. Health* **2016**, *31*, 976–992. [[CrossRef](#)]
15. Gong, Q.-H.; Li, S.-X.; Wang, S.-J.; Wu, Y.-H.; Han, L.-Y.; Li, H. Sleep duration and overweight in Chinese adolescents: A prospective longitudinal study with 2-year follow-up. *Sleep Breath.* **2020**, *24*, 321–328. [[CrossRef](#)]
16. Mercado-Gonzales, S.I.; Carpio-Rodríguez, A.N.; Carrillo-Larco, R.M.; Bernabé-Ortiz, A. Sleep Duration and Risk of Obesity by Sex: Nine-Year Follow-Up of the Young Lives Study in Peru. *Child. Obes.* **2019**, *15*, 237–243. [[CrossRef](#)]
17. Anujuo, K.O.; Vrijkotte, T.G.; Stronks, K.; Jean-Louis, G.; Agyemang, C.O. Ethnic differences in sleep duration at 5 years, and its relationship with overweight and blood pressure. *Eur. J. Public Health* **2016**, *26*, 1001–1006. [[CrossRef](#)]
18. Azadbakht, L.; Kelishadi, R.; Khodarahmi, M.; Qorbani, M.; Heshmat, R.; Motlagh, M.E.; Taslimi, M.; Ardalan, G. The association of sleep duration and cardiometabolic risk factors in a national sample of children and adolescents: The CASPIAN III Study. *Nutrition* **2013**, *29*, 1133–1141. [[CrossRef](#)]
19. Breitenstein, R.S.; Doane, L.D.; Lemery-Chalfant, K. Early life socioeconomic status moderates associations between objective sleep and weight-related indicators in middle childhood. *Sleep Health* **2019**, *5*, 470–478. [[CrossRef](#)]
20. Calamaro, C.J.; Park, S.; Mason, T.B.A.; Marcus, C.L.; Weaver, T.E.; Pack, A.; Ratcliffe, S.J. Shortened sleep duration does not predict obesity in adolescents. *J. Sleep Res.* **2010**, *19*, 559–566. [[CrossRef](#)]
21. Cao, M.; Zhu, Y.; Li, X.; Chen, Y.; Ma, J.; Jing, J. Gender-dependent association between sleep duration and overweight incidence in CHINESE school children: A national follow-up study. *BMC Public Health* **2018**, *18*, 615. [[CrossRef](#)]
22. Carrillo-Larco, R.M.; Bernabé-Ortiz, A.; Miranda, J.J. Short Sleep Duration and Childhood Obesity: Cross-Sectional Analysis in Peru and Patterns in Four Developing Countries. *PLoS ONE* **2014**, *9*, e112433. [[CrossRef](#)]
23. Chaput, J.-P.; Brunet, M.; Tremblay, A. Relationship between short sleeping hours and childhood overweight/obesity: Results from the ‘Québec en Forme’ Project. *Int. J. Obes.* **2006**, *30*, 1080–1085. [[CrossRef](#)]
24. Chaput, J.-P.; Lambert, M.; Gray-Donald, K.; McGrath, J.; Tremblay, M.S.; O’Loughlin, J.; Tremblay, A. Short Sleep Duration Is Independently Associated with Overweight and Obesity in Quebec Children. *Can. J. Public Health* **2011**, *102*, 369–374. [[CrossRef](#)]
25. Ievers-Landis, C.E.; Storfer-Isser, A.; Rosen, C.; Johnson, N.L.; Redline, S. Relationship of Sleep Parameters, Child Psychological Functioning, and Parenting Stress to Obesity Status Among Preadolescent Children. *J. Dev. Behav. Pediatr.* **2008**, *29*, 243–252. [[CrossRef](#)]
26. Malihi, Z.; Portch, R.; Hashemi, L.; Schlichting, D.; Wake, M.; Morton, S.; Fa’Alili-Fidow, J.; Mensah, F.; Olds, T.; Carr, P.A.; et al. Modifiable Early Childhood Risk Factors for Obesity at Age Four Years. *Child. Obes.* **2021**, *17*, 196–208. [[CrossRef](#)]
27. Suglia, S.F.; Duarte, C.S.; Chambers, E.C.; Boynton-Jarrett, R. Social and Behavioral Risk Factors for Obesity in Early Childhood. *J. Dev. Behav. Pediatr.* **2013**, *34*, 549–556. [[CrossRef](#)]
28. Suglia, S.F.; Kara, S.; Robinson, W.R. Sleep Duration and Obesity among Adolescents Transitioning to Adulthood: Do Results Differ by Sex? *J. Pediatr.* **2014**, *165*, 750–754. [[CrossRef](#)]
29. Sun, Y.; Sekine, M.; Kagamimori, S. Lifestyle and Overweight Among Japanese Adolescents: The Toyama Birth Cohort Study. *J. Epidemiol.* **2009**, *19*, 303–310. [[CrossRef](#)]
30. Touchette, E.; Petit, D.; Tremblay, R.E.; Boivin, M.; Falissard, B.; Genolini, C.; Montplaisir, J.Y. Associations Between Sleep Duration Patterns and Overweight/Obesity at Age 6. *Sleep* **2008**, *31*, 1507–1514. [[CrossRef](#)]
31. Wang, F.; Liu, H.; Wan, Y.; Li, J.; Chen, Y.; Zheng, J.; Huang, T.; Li, D. Sleep Duration and Overweight/Obesity in Preschool-Aged Children: A Prospective Study of up to 48,922 Children of the Jiaying Birth Cohort. *Sleep* **2016**, *39*, 2013–2019. [[CrossRef](#)]
32. Wang, J.; Li, A.M.; Lam, H.S.; Leung, G.M.; Schooling, C.M. Sleep Duration and Adiposity in Children and Adults: Observational and Mendelian Randomization Studies. *Obesity* **2019**, *27*, 1013–1022. [[CrossRef](#)] [[PubMed](#)]



33. Wing, Y.K.; Li, S.X.; Li, A.M.; Zhang, J.; Kong, A.P.S. The Effect of Weekend and Holiday Sleep Compensation on Childhood Overweight and Obesity. *Pediatrics* **2009**, *124*, e994–e1000. [[CrossRef](#)] [[PubMed](#)]
34. Guo, Y.; Miller, M.A.; Cappuccio, F.P. Short duration of sleep and incidence of overweight or obesity in Chinese children and adolescents: A systematic review and meta-analysis of prospective studies. *Nutr. Metab. Cardiovasc. Dis.* **2021**, *31*, 363–371. [[CrossRef](#)] [[PubMed](#)]
35. Eisenmann, J.C.; Ekkekakis, P.; Holmes, M. Sleep duration and overweight among Australian children and adolescents. *Acta Paediatr.* **2006**, *95*, 956–963. [[CrossRef](#)]
36. Cao, M.; Zhu, Y.; He, B.; Yang, W.; Chen, Y.; Ma, J.; Jing, J. Association between sleep duration and obesity is age- and gender-dependent in Chinese urban children aged 6–18 years: A cross-sectional study. *BMC Public Health* **2015**, *15*, 1029. [[CrossRef](#)]
37. Taheri, S.; Lin, L.; Austin, D.; Young, T.; Mignot, E. Short Sleep Duration Is Associated with Reduced Leptin, Elevated Ghrelin, and Increased Body Mass Index. *PLoS Med.* **2004**, *1*, 210–217. [[CrossRef](#)]
38. Chaput, J.-P.; Després, J.-P.; Bouchard, C.; Tremblay, A. Short Sleep Duration is Associated with Reduced Leptin Levels and Increased Adiposity: Results from the Québec Family Study. *Obesity* **2007**, *15*, 253–261. [[CrossRef](#)]
39. Chaput, J.-P.; Després, J.-P.; Bouchard, C.; Tremblay, A. The Association Between Sleep Duration and Weight Gain in Adults: A 6-Year Prospective Study from the Quebec Family Study. *Sleep* **2008**, *31*, 517–523. [[CrossRef](#)]
40. Santos, R.; Tufik, S.; De Mello, M. Exercise, sleep and cytokines: Is there a relation? *Sleep Med. Rev.* **2007**, *11*, 231–239. [[CrossRef](#)]
41. Deng, X.; He, M.; He, D.; Zhu, Y.; Zhang, Z.; Niu, W. Sleep duration and obesity in children and adolescents: Evidence from an updated and dose–response meta-analysis. *Sleep Med.* **2021**, *78*, 169–181. [[CrossRef](#)]