p-ISSN 2086-6380
e-ISSN 2548-7949

Jurnal Ilmu Kesehatan Masyarakat, Nov2022, 13(3):261-277
DOI: https://doi.org/10.26553/jikm.2022.13.2.261-277
Available online at http://ejournal.fkm.unsri.ac.id/index.php/jikm

THE RELATIONSHIP BETWEEN SLEEP DURATION AND OBESITY IN CHILDREN AND ADOLESCENTS IN ASIA: A META-ANALYSIS

Nurul Ramadhayani, Feranita Utama*
Faculty of Public Health, Universitas Sriwijaya, Jl. Palembang-Prabumulih KM 32 Ogan Ilir, 30662, Indonesia

ABSTRACT

In recent years, short sleep duration has been proposed and received attention as a modifiable factor of obesity. Observational studies on the relationship between sleep duration and obesity in children and adolescents in the Asian region have been carried out. This study aims to determine the relationship between short sleep duration and obesity in children and adolescents in Asia. This study used a meta-analysis method. Search for articles using the Pubmed, Proquest, Science direct and Google Scholar databases. Article search is limited to research in English, publications from 2000 to 2020 and free full text articles. Data is processed using the Revman 5.3 application. There were 12 research articles that were systematically reviewed from 1,281 identified articles. Ten of these articles were included in the meta-analysis. The results of the study proved that there was a significant relationship between short sleep duration and obesity in children and adolescents with a pooled OR of 1.15 (95% CI: 1.04-1.28), and an analysis of the age subgroup also showed the same results as the pooled OR. 1.17 (95% CI: 1.02-1.35) in the age group before 3-4 years and combined OR 1.29 (95% CI: 1.14-1.48) in children aged 6-12 years. Avoiding short sleep duration can be considered as one way to reduce the risk of obesity in children and adolescents.

***Keywords**: sleep duration, obesity, meta-analysis*

ABSTRAK

Dalam beberapa tahun terakhir, durasi tidur singkat telah diusulkan dan mendapat perhatian sebagai faktor risiko obesitas yang dapat dimodifikasi. Penelitian observasional tentang hubungan durasi tidur dan obesitas pada anak dan remaja di wilayah Asia telah banyak dilakukan. Penelitian ini bertujuan untuk mengetahui hubungan antara durasi tidur singkat dengan obesitas pada anak dan remaja di Asia. Penelitian ini menggunakan metode meta-analisis. Penelusuran artikel menggunakan database Pubmed, Proquest, Science direct dan Google Scholar. Pencarian artikel dibatasi pada penelitian dengan bahasa Inggris, publikasi dari tahun 2000 hingga 2020 dan pada artikel free fulltext. Data diolah menggunakan aplikasi Revman 5.3. Terdapat 12 artikel penelitian yang ditelaah sistematis dari 1.281 artikel yang teridentifikasi. Sepuluh artikel di antaranya diikutsertakan dalam meta-analisis. Hasil penelitian membuktikan terdapat hubungan yang bermakna antara durasi tidur singkat dengan obesitas pada anak dan remaja dengan *pooled OR* 1,15 (95% CI: 1,04-1,28), dan analisis sub kelompok usia juga menunjukkan hasil yang sama dengan *pooled OR* 1,17 (95% CI: 1,02-1,35) pada seb kelompok usia 3-4 tahun dan *pooled OR* 1,29 (95% CI: 1,14-1,48) anak usia 6-12 tahun. Menghindari tidur dengan durasi yang singkat dapat dipertimbangkan sebagai salah satu cara untuk mengurangi risiko terjadi obesitas pada anak dan remaja.

Kata kunci:durasi tidur, obesitas, meta-analysis

* *Correspondence Address: Feranita Utama, Faculty of Public Health, Universitas Sriwijaya, Jl. Palembang-Prabumulih KM 32 Ogan Ilir, 30662, Indonesia, E-mail: feranita@fkm.unsri.ac.id*

Received : October 24, 2022 Accepted : December 13, 2022 Published: December 20, 2022

Introduction

The World Health Organization (WHO) defines overweight and obesity as conditions where there is abnormal or excessive accumulation of fat in the body, so it can interfere to health. The prevalence of obesity and overweight in children and adolescents aged 5-19 years has increased from 4% in 1975 to more than 18% in 2016. In 2019 it is estimated that more than 38 million children under the age of 5 years are overweight or obese and Asia is one of the largest contributing regions with almost half of the children under five being overweight or obese in Asia.[1]

Obesity in children and adolescents can increase the risk of obesity in adulthood [2,3] and increases the risk of various non-communicable diseases [2,3,4,5,6] such as hypertension, cardiovascular disease, diabetes mellitus, kidney failure, and cancer. Obesity is also closely related to adult death and premature death.[2] In addition, obesity in children is also associated with mental health problems and children's psychosocial development.[7] Therefore, obesity in children and adolescents needs to be prevented and controlled.

The increasing prevalence of childhood obesity in developing countries is associated with changing dietary practices and sedentary lifestyles.[6] An imbalance between food intake and energy expenditure can lead to obesity. This imbalance is caused by increased intake of processed or fast food and sugary drinks, decreased physical activity with increased time spent watching TV, surfing the internet or playing electronic games, and reduced sleep time.[8]

Several countries have shown a decrease in sleep duration in children. Short sleep duration has become a global phenomenon.[9] Short sleep duration is considered a modifiable risk factor for obesity. Several studies have proven a relationship between sleep duration and obesity.[9,10,11,12] A cross-sectional study conducted in Japan proved that there was a relationship between short sleep duration and the incidence of obesity after adjusting for age, gender, parents' history of obesity, and other lifestyle factors. Imbalance between energy intake and expenditure is considered as a logical cause in the increased risk of obesity in people with short sleep duration.[10] Sleep deprivation may also be associated with reduced appetite regulation in children, leading to an increased risk of overeating and obesity.[13] Energy intake is regulated by the hormones ghrelin and leptin. Based on laboratory studies, short sleep duration can increase ghrelin levels and decrease leptin levels in the body thereby increasing appetite and influencing eating habits which affect weight gain.[14]

The trend of increasing the body mass index of children and adolescents has increased rapidly in several countries in Asia.[15] Many studies have also been conducted on sleep duration and the incidence of obesity in children and adolescents. However, it is still questionable whether the results of the research that has been carried out can be concluded as a recommendation for the Asian region itself. Meta-analysis is a statistical technique used in synthesizing research results

obtained from quantitative data and producing a strong conclusion.[16] Several meta-analytic studies have been carried out [17,18,19], but those were not focused on research in the Asian region. This study aims to determine the relationship between short sleep duration and obesity in children and adolescents in the Asian region.

Methods

This systematic review study with meta-analysis conducted a literature search through the Pubmed Central, ProQuest, Science Direct and Google Scholar databases. With the following keywords: (Children OR Adolescents) AND ("Sleep duration" OR "Insufficient sleep" OR Sleep) AND Obesity AND Asia, MeSH (Medical Subject Headings) related to sleep duration and obesity are added to the Pubmed database. as follows: ("Adolescent"[Mesh] OR "Child"[Mesh]) AND ("Sleep" [Mesh] OR "Sleep Deprivation"[Mesh]) AND "Pediatric Obesity"[Mesh]. Study selection was carried out based on the following inclusion criteria: (i) research on children and adolescents aged 2-18 years; (ii) cross-sectional study design; (iii) minimum sample size of 100 ($n \geq 100$); (iv) measurement of obesity using BMI based on age, BMI based on age and sex, or BMI percentile based on age: (v) literature published between 2000 and 2020; and (vi) The research is conducted in the Asian region. Literature selection is a process of screening or selecting literature studies according to the PRISMA procedure and research inclusion criteria. All selected literature and fulfilling the research criteria were reviewed systematically by collecting research data and information. Data extraction was carried out by summarizing information containing the name of the researcher and year of study, location/country of study, age of participants, number of samples, definition of obesity, measurement of sleep duration and the main findings: aOR (95% CI). Assessment of the quality of selected literature studies was carried out using the Critical Appraisal Tools from The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for cross-sectional study designs.

The articles reviewed in this study contained various adjusted odds ratio (aOR) results with different categories of short sleep duration. In this study, the definition of short sleep duration was limited, namely sleep duration that was shorter or longer (with a difference of less than 1 hour) from the duration recommended by the National Sleep Foundation[20] and Centers for Disease Control and Prevention (CDC)[21]. Several articles need to recalculate the OR value so that the definition of short sleep can be in accordance with the operational definition of short sleep duration in this study. Two studies namely Shan et al.[22] and Zhang et al.[23] could not be included in the meta-analysis because the short sleep duration in the study did not fit the operational definition of this study and did not display table cell content data so it could not be reclassified. Only one article uses the aOR value, namely research by Cao et al.[9]

Obesity follows the operational definition used in the article reviewed, namely (i) Based on the International Obesity Task Force (IOTF), the BMI cut-off point based on age and sex for children aged 2-18 years has been adjusted for the BMI for obesity adults who are at 30 kg /m^2; or (ii) Based on local national growth chart references or international growth charts, the BMI percentile cut-off point by age is at the 95th percentile or more; or (iii) based on WHO growth reference data, the cut point for BMI based on age is at a Z-score >+2 SD.

Table 1. Results of Sleep Duration Reclassification

Study	Age (years)	Sleep Duration (hour)	Obesity (n)	Not Obese (n)
Jiang, et al., 2009 [27]	3-4	<10	53	492
		≥ 10	60	706
Kong, et al., 2011 [25]	6-12	<9.25	74	540
		≥ 9.25	10	155
Zhang, et al., 2016 [28]	7-12	<9	231	1,438
		≥ 9	115	837
Wu et al., 2015 [26]	10-18	<7	1,696	23,838
		≥7	3,383	31,698
Thasanasuwa, et al., 2016[29]	7-12	<9	49	179
		≥9	93	1,024
Sekine, Yamagami, Handa, et al., 2002 [24]	6-7			
	Boy	<9	166	858
		≥ 9	336	2,834
	Girl	<9	160	834
		≥ 9	406	2,680
Wang, et al., 2018 [30]	6-18			
	Boy	<8	114	2,670
		≥8	282	6,078
	Girl	<8	79	3,424
		≥8	145	5,611
Sekine, Yamagami, Hamanishi, et al.,2002 [31]	3-4	<10	319	3,328
		≥10	404	4,890
Fan et al., 2020 [11]	6-17	<9 (age 6-12) and <8 (age13-17)	1,080	10,525
		≥9 (age 6-12) and ≥8 hours (age 13-17)	1,699	18,374

This study used the Review Manager 5.3 application to analyze the data. Heterogeneity assessment is needed to determine the assumptions used in reading the results of the analysis. To assess heterogeneity, the value of I^2 becomes a reference. Data analysis for all age groups and children's subgroup analysis (6-12 years) used the assumption of a random effect model due to the high heterogeneity between studies (I^2 > 50%), while the preschool subgroup analysis used the assumption of a fixed effect model (I^2 <50%)). The results of the analysis are presented in a forest plot diagram. Sensitivity analysis was carried out by comparing the results of the analysis with the fixed effect model and the random effect model as well as the publication bias test presented in the funnel plot.

Results

The flow chart in Figure 1 shows that there are 1281 total articles taken from the 4 databases used. A total of 236 duplicate articles were excluded, 1197 other articles were reviewed based on title, abstract and inclusion and exclusion criteria. A total of 12 articles met the research inclusion criteria and met the feasibility of the study on the data quality test. Twelve articles were included in the systematic review.

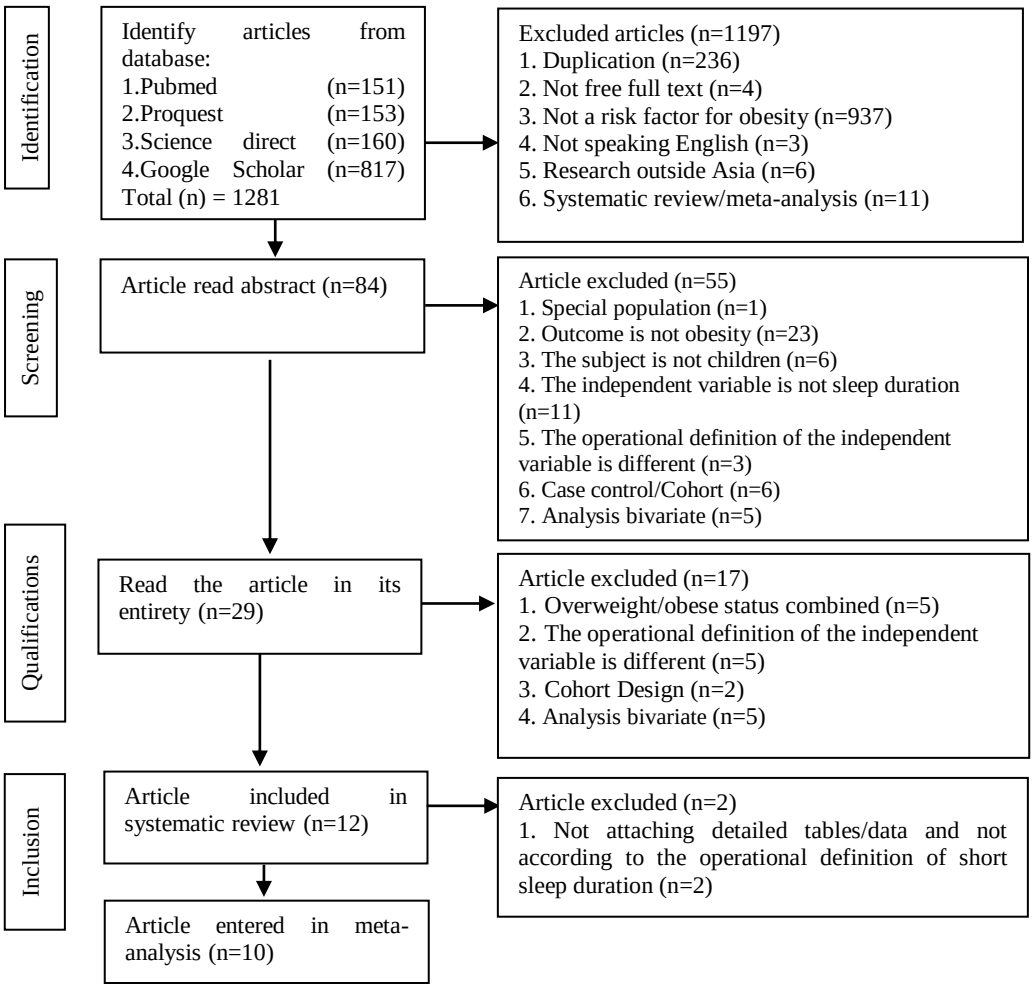

Figure 1. Study Selection Flowchart

Information obtained from the results of a systematic review can be seen in table 2. A study in Japan conducted on 8274 children aged 6-7 years showed a clear dose-response relationship between sleep duration and obesity.[24] The risk of experiencing obesity is higher the shorter the child's sleep duration. Similar results were shown from the results of Fan, et al's study of children aged 6-17 years[11] and research by Kong, et al for the age group of 6-12 years[25]. Several other studies have shown that there is no significant relationship between short sleep duration and obesity, such as the results of Kong et al's study in the 13-20 year old age group[25] and Wu, et al in the age group of 10-18 years[26]. The confounding factors that were commonly controlled for in the

twelve research studies were age, gender, father's and mother's education, parental history of obesity, parental income, physical activity, breakfast, diet, playing the internet or computer, watching TV, and mental health such as depression or anxiety. Of the 12 research studies reviewed, there were 2 research studies that were not included in the meta-analysis, namely research by Shan, et al.[22]; and Zhang, et al.[23]

Relationship between short sleep duration in children and adolescents

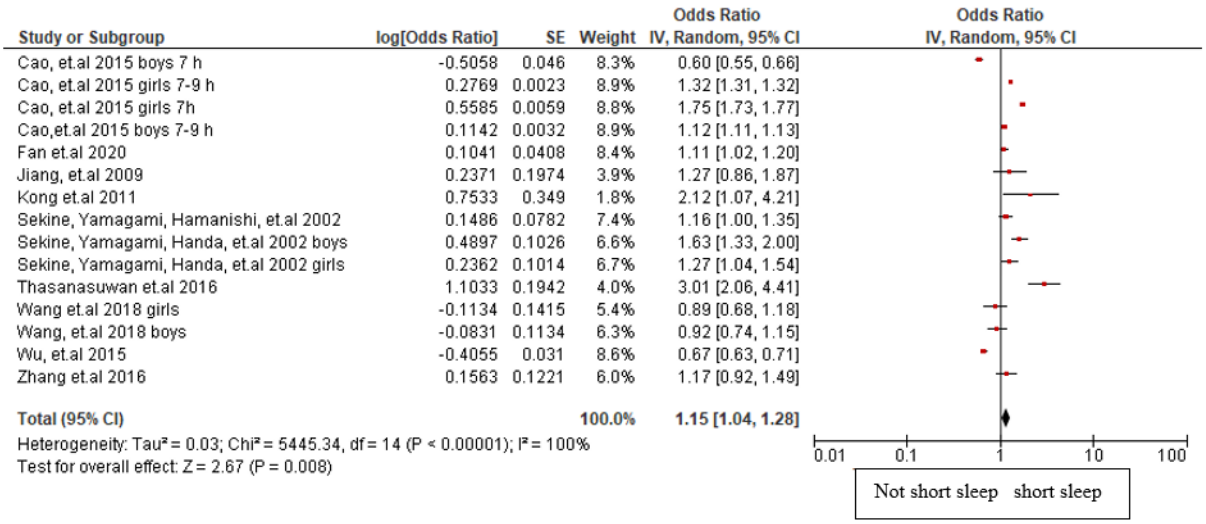

Figure 2. Forest plot of the relationship between short sleep duration and obesity in children and adolescents (3-18 years)

Analysis of the relationship between short sleep duration showed a pooled OR value of 1.15 with a confidence range of 1.04 -1.28 and a value of p = 0.008. So it can be concluded that there is a significant relationship between short sleep duration and the incidence of obesity. This study also conducted a subgroup meta-analysis to see the risk of short sleep in each age group. Sub group analysis was carried out in groups of pre-school children (3-4 years) and groups of elementary school children (6-12 years), while the group of high school youth was not possible because the available articles were inadequate for analysis.

Table 2. Results of Systematic Review of Articles

No	Author, Year	Location	Age	Sample	Obesity Definition	Measurement Sleep Duration	Main Finding: aOR (95% CI)	Notes
1.	Jiang et al., 2009 [27]	Sanghai, China	3-4 Years	1,311	Chinese Reference: Age-adjusted BMI Cutoff Point with BMI Percentile 95 or more	Report parent	All children: < 9 hours: 4.76 (1.28-17.69) 9 hours: 3.42 (1.12-10.46) 9.5 hours: 1.78 (0.55-5.82) 10 hours: 2.70 (0.92-7.97) 10.5 hours: 1.70 (0.47-6.24) ≥ 11 hours: 1.00 (ref)	Adjusted variables: age, sex, appetite, birth weight, mother's age at delivery, father's and mother's education, geographic area and household income.
2.	Kong et al., 2011 [25]	Hongkong	6-20 Years	2,053	Reference Hong Kong: BMI Intersection Point based on age, using BMI Percentile 95 or more	Middle school children self-reported, elementary school children reported by parents by recording the child's bedtime and wake time. Using active watch in some research subjects	Middle school kid (13-20 years): >8 hours(ref): 1.00 6.5-8 hours: 1.18 (0.58-2.39) <6.5 hours: 1.36 (0.57-3.25) Primary school children (6-12 years): >9.25 hours(ref): 1.00 8-9.25 hours: 2.36 (1.12-4.98) <8 hours: 2.88 (1.23-6.70)	1) Adjusted variables: age, gender, puberty status 2) The group of middle school children was not included in the meta-analysis, because the age used exceeded the study inclusion criteria
3.	Zhang et al., 2016 [28]	Guangzho u, China	7-12 Years	3,766	China Reference (WGOC): BMI cut points based on age and sex adjusted for the 95th BMI Percentile or more	Self-reported	All children: <7 hours: 0.93 (0.47-1.85) 9 -11 hours : 0.87 (0.62-1.22) >11 hours: 0.88 (0.26-2.91)	Adjusted variables: age, gender, only child or not, educational level of father and mother, occupation of father and mother, and monthly household income
4.	Shan et al., 2010 [22]	Beijing, China	2-18 Years	21,198	China Reference (WGOC): BMI cut points based on age and sex adjusted for the 95th BMI Percentile or more	People report parent/guardian for children aged 2-12 years and self-report for children over 13 years of age.	School age children (6-18 years): Short ((6-12 years: <10 hours), (13-18 years: <8.5 hours)): 1.36 (1.19-1.56) Long ((6-12 years: >11 hours),(13-18 years: > 9.5 hours)) : 0.94 (0.70-1.25)	1) Adjusted variables: age, sex, Tanner stage (growth stage), urban/rural residence. 2) 2) The article was excluded from the meta-analysis because there was no table cell content data, and short sleep duration did not fit the operational definition of this study
5.	Wu et al., 2015 [26]	China	10-18 Years	66,817	The IOTF BMI guidelines are based on those	Reported alone	All children: < 5 hours: 1.24 (0.97–1.57)	1) Correct self-reported BMI 2) Adjusted variables: age,

No	Author, Year	Location	Age	Sample	Obesity Definition	Measurement Sleep Duration	Main Finding: aOR (95% CI)	Notes
					adjusted for the adult obesity cut-off point		5-6.9 hours: 0.94 (0.87–1.01) 7-8.9 hours: 1.00(ref) ≥ 9 hours: 1.42 (1.24–1.63)	gender, parental education, smoking parents, coming from a single family, physical activity, time spent playing the internet, video games, homework, smoking and alcohol use, and mental health indicators such as depression and anxiety.
6.	Thasanasuwan et al., 2016 [29]	Thailand	7-12 Years	1,345	WHO reference standard: BMI by age with grades Z-score >+2 SD	Self-reported (child records sleep and wake times)	All children: <9 hours: 2.14 (1.17-3.90) 9 - 10 hours: 0.93 (0.541.61) >10 hours: 1.00(ref)	Adjusted variables: gender, place of residence, age, mother's education, income, and religion
7.	Sekine, Yamagami, Handa, et al., 2002 [24]	Japan	6-7 Years	8,274	IOTF Guidelines: BMI by age and sex adjusted for the cutoff point for adult obesity	Parent report	Boy: < 8 hours: 5.49 (2.20–16.7) 8-9 hours: 3.45 (1.86–6.37) 9-10 hours: 2.28 (1.25–4.15) ≥10 hours(ref): 1.00 Girl: < 8 hours: 2.13 (1.01–4.48) 8-9 hours: 1.28 (0.88–2.15) 9-10 hours: 1.23 (0.81–1.87) ≥10 hours(ref): 1.00	Adjusted variables: age, parental obesity, physical activity, watching TV, breakfast frequency and snack frequency.
8.	Cao et al., 2015 [9]	Guangzho u, China	6-18 Years	11,830	Chinese reference: BMI cut-off point by age and sex (Studies in populations that have been adjusted to WHO, IOTF and CDC standards	People report parent/guardian for children under 9 years of age and self-reported for children older than 9 years	Children aged 6-12 Years Boys: <7 hours: 0.603 (0.551–0.660) 7-9 hours: 1,121 (1,114–1,127) ≥ 9 hours: 1.00(ref) Girls <7 hours: 1,748 (1,728–1,768) 7-9 hours: 1,319 (1,313–1,325) ≥ 9 hours : 1.00(ref) Children aged 13-18 years Boys < 7 hours: 1.331 (1.297–1.365) 7-9 hours: 2,220 (2,192–2,249)	1) Adjusted variables: age, physical activity and inactivity, intake of fruits, vegetables, sugary drinks and meat 2) The age group of 13-18 years was not included in the meta-analysis because the definition of short sleep did not match the operational definition and there was no data cell content for reclassification.

No	Author, Year	Location	Age	Sample	Obesity Definition	Measurement Sleep Duration	Main Finding: aOR (95% CI)	Notes
							≥ 9 hours : 1.00(ref) Girls < 7 hours: 2,868 (2,826–2,909) 7-9 hours: 2,247 (2,217–2,277) ≥ 9 hours: 1.00(ref)	
9.	Wang, et al., 2018 [30]	Zejiang, China	6-18 Years	18,403	China Reference (WGOC)	Self-reported	Boy: <7 hours: 1.45 (0.97–2.16) 7 hours: 1.13 (0.81–1.57) 8 hours: 1.00(ref) 9 hours: 1.25 (0.89–1.74) ≥10 hours: 1.12 (0.81–1.54 Girl: <7 hours: 1.97 (1.15–3.38) 7 hours: 1.90 (1.18–3.04) 8 hours: 1.00(ref) 9 hours: 1.38 (0.86–2.20 ≥10 hours: 2.12 (1.22–3.67)	Adjusted variables: age group, gender, region, type of school, father, mother's level of education, cigarette use, alcohol use, breakfast consumption, fruit consumption, vegetable consumption, milk consumption, consumption of carbonated drinks, physical activity, screen time and loneliness
10.	Sekine, Yamagami, Hamanishi, et al., 2002 [31]	Japan	3-4 Years	8,941	IOTF Guidelines	Parents report	All children: < 9 hours: 1.57 (0.90-2.75) 9-10 hours: 1.34 (1.05-1.72) 10-11 hours: 1.20 (0.97-1.49) ≥ 11 hours: 1.00(ref)	Adjusted variables: age, gender, parental obesity, hours of outdoor play, and hours of sleep including naps
11.	Fan et al., 2020 [11]	China	6-17 Years	35,414	China Reference (WGOC)	Self-reported	Very short (Ages 6-13: <7 hours, Ages 14-17: <6 hours): 3.01 (2.19–4.15) Short (Ages 6-13: 7-8 hours, Ages 14-17: 6-7 hours): 1.24 (1.14-1.35) Recommended (Age 6-13: 9-10 hours, Age 14-17: 8-10 hours) :1.00(ref) Long(Age 6-13: >11 hours, Age 14-17: >10 hours) : 0.83 (0.46–1.51)	Adjusted variables: Gender, age, place of residence, family income, level of leisure time exercise, and level of sedentary time
12.	Zhang et al., 2018 [23]	Sanghai, China	6-10 Years	13,001	Chinese reference	Questionnaire (Not explained in detail)	Sleep duration on holidays: ≤10 hours: 1.50 (1.31-1.72) >10 hours: 1.00(ref)	The article was excluded from the meta-analysis because the definition of short sleep duration did not fit the operational definition and did not report the detailed data used in the analysis

Table 3. Subgroup analysis of short sleep duration on obesity

Age	Study	OR	95% CI	*p* value
3-4 years	2	1.17	1.02-1.35	0.03
6-12 years	5	1.30	1.14-1.48	<0.0001

The results of the sub-group analysis showed that there was a significant relationship between short sleep duration and obesity in children aged 3-4 years and children aged 6-12 years. Pre-school aged children (3-4 years) with short sleep duration are at risk of developing obesity 1.17 times compared to children with sufficient or more sleep duration and children aged 6-12 years with short sleep duration have a risk of developing obesity 1.3 times compared to children with sufficient sleep duration or more.

Sensitivity analysis and publication bias

Sensitivity test was performed to identify heterogeneity, and prove whether the results of a meta-analysis are stable or not. Comparison of the results of the pooled odds ratio between the assumptions of the fixed effect model (FEM) and the random effect model (REM) combined analysis at ages 3-18 years and subgroup analysis based on age group can be seen in table 4.

Table 4. Comparison of pooled odds ratio estimate between FEM and REM

Group	N	Fixed effect model		P	Random effect model	
		OR	95% CI	heterogeneity	OR	95% CI
Combined (ages 3-18)	10	1.28	1.28-1.29	<0.00001	1.15	1.04-1.28
3-4 years-old subgroup	2	1.17	1.02-1.35	0.68	1.17	1.02-1.35
6–12 years-old subgroup	5	1.29	1.28-1.29	<0.00001	1.30	1.14-1.48

Table 4 shows that the variation between studies has a significant effect on the association between short sleep duration and obesity in the combined analysis of the 3–18-years age range. This can be seen from the wider confidence interval (CI). But the two assumptions both show that short sleep duration is a risk factor for obesity. Subgroup analysis of children aged 3-4 years showed low (homogeneous) variation between studies as evidenced by the heterogeneity of the p value > 0.05, and the pooled OR and CI values on the assumption that FEM and REM were the same. So, it can be concluded, the meta-analysis results in the 3–4-year-old subgroup are stable. Variations between studies in the subgroup analysis of children aged 6-12 years had a significant effect. This can be seen from the increase in pooled OR from FEM to REM and wider CI values.

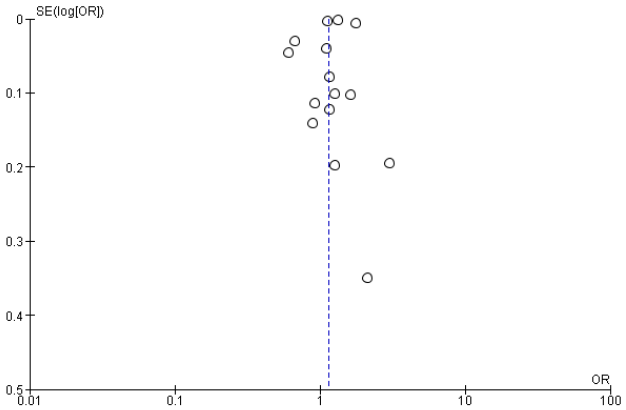

Figure 5. Funnel plot of the relationship between short sleep duration and obesity in children and adolescents

Figure 5 shows an asymmetrical funnel plot. This indicates that there was publication bias in this study.

Discussion

The results of the meta-analysis show that there is a significant association between short sleep duration and the incidence of obesity in children and adolescents in Asia. Children and adolescents with short sleep duration are 1.15 times at risk of developing obesity compared to children and adolescents who have sufficient or more sleep duration. This shows a 15% higher risk of obesity in children and adolescents with short sleep duration compared to children and adolescents with non-short sleep duration. The results of this study are in line with several other meta-analytic studies.[17,32,33,18] The results of a study conducted by Fatima, Doi and Mamun stated that children and adolescents who have shorter sleep duration are about twice as likely to be overweight/obese. The strength and direction of the prospective association found between short sleep duration and obesity remained stable even after adjusting for confounding and also remained stable for sensitivity analysis.

Laboratory studies in young adults suggest that sleep disturbances are associated with adverse changes in obesity-regulating hormones and appetite. Decreased leptin and increased ghrelin, insulin, and cortisol increase food intake and fat deposition. The decrease in growth hormone will limit the breakdown of fat. These changes allow the development of obesity and insulin resistance. [34] Short sleep duration can also cause emotional disturbances, fatigue and daytime sleepiness which can limit physical activity during the day. Reduced physical activity has the potential to increase body weight [34]. This assumption is validated by findings in the population from research by Wang, et al in China which states that students with short sleep duration have less active physical activity when compared to students with short sleep duration. [30]

Physiologically, sleep duration decreases from infancy to childhood and to adolescence. Research conducted on children aged 6 to 20 years in Hong Kong, found a tendency for shorter sleep duration in high school children compared to elementary and junior high school children.[25]

Research conducted on children and adolescents aged 6 to 17 years, found that children in China who had less sleep than the recommended bedtime range were more likely to be overweight or obese.[11] Other findings found that girls who sleep 7 hours per day have a 90% higher risk of obesity when compared to children who sleep 8 hours per day. This suggests that sleep duration of less than 8 hours per day is likely to have an adverse effect on the health of children and adolescents. This study found that sleeping for 8 hours is the minimum amount of sleep each day needed by junior high school and high school students to prevent the risk of developing obesity.[30] Other findings estimate that for every 1 hour of reduced sleep duration it is likely to increase the risk of obesity in adolescents by 80%.[18,12] In early childhood, parents' behavior and lifestyle have a direct influence on children's sleep patterns. Whereas in adolescents, sleep and wake patterns can be influenced by social demands outside the family environment and also mood.[35,36]

A cross-sectional study supports that teens who sleep late are more likely to have a higher BMI when compared to teens who go to bed early.[37] Ultimately, it is possible that sleep deprivation may be an epiphenomenon to risk for poorer health or lower quality of life than a risk factor for overweight/obesity.[18]

This study found that in the 3–4-year-old subgroup, children with sleep duration of less than 10 hours had 1.17 times the chance of developing obesity compared to children who slept more than 10 hours. This study is in line with a meta-analysis conducted on a study with a cohort study design by Li, et al. with a relatively stable sensitivity analysis, it proves that pre-school-age children with short sleep duration are 1.3 times more likely to be obese.[33] Research in Japan on children aged 3-4 years showed that there was a negative linear correlation between sleep duration and the risk of obesity. The shorter the duration of sleep, the greater the risk of obesity.[31] Although no laboratory studies have found a relationship between short sleep duration and obesity in children, studies in young adults can still explain that short sleep duration affects the production of the hormones leptin and ghrelin which have an impact on increasing appetite, as well as lack of sleep duration which causes a lack of physical activity.[34] so that the accumulation of fat which over time will make a person obese.

Early in life, the lifestyle and attitudes of parents may have a direct influence on a child's bedtime. Research on children aged 3-4 years who were conducted in urban areas and came from families with high levels of education and income found that the sleep time of caregivers or parents and mother's education is related to the duration of children's night sleep. Children who sleep with their parents have less sleep. This is caused by the educational or social demands of the night on parents which results in

parents going to bed later and directly affecting the child's sleep pattern. Likewise, children whose caregivers sleep later also cause the child's sleep time to decrease or shorten.[27] The growth and development of children in early childhood is greatly influenced by parents, especially in terms of the child's sleep duration. Increasing parental awareness about the importance of sleep and helping parents to set the right sleep schedule for their children can be useful in preventing obesity in children.

The results of a meta-analysis of the 6–12-year-old subgroup showed that children who slept short (slept less than 9 or 9.25 hours) had a 30% higher risk of developing obesity compared to children who slept enough or more. These results are in line with the research of a longitudinal study meta-analysis which states that children aged 6-12 years with short sleep duration are at risk of 1.4 times for obesity compared to children who sleep not short.[32]

Research in Thailand shows that children with short sleep duration are at double the risk of developing obesity than children with sufficient sleep duration. This research also shows that children who spend more time playing the internet or playing gadgets tend to have shorter sleep time too.[29] Research in Japan on children aged 6-7 years also showed a negative linear correlation between sleep duration and the risk of obesity. The shorter the duration of sleep, the higher the risk of obesity.[24] However, in Wu's research, et.al. showed a non-linear relationship between short sleep duration and the incidence of obesity in both male and female children and adolescents. Research by Wu, et.al states that in addition to children and adolescents who have short sleep duration, children and adolescents with longer sleep duration than recommended are also at higher risk of developing obesity compared to children and adolescents with sufficient sleep duration.[26]

Based on the results of the sensitivity analysis, it was concluded that the results of the study were not relatively stable at changes in . So if the same research is conducted on different populations, methods and characteristics of the participants, it is possible to show different results. So the results of this study still need to be strengthened with other studies in order to consistently assess the relationship between short sleep duration and obesity. This research also shows that there is a publication bias which is indicated by the distribution of research that is not symmetrical. So, it is not certain that short sleep duration causes obesity. However, the results of this meta-analysis are in line with the results of a previous meta-analysis that was conducted in a longitudinal study with a cohort study design. Previous meta-analyses provided evidence that there was a significant association between short sleep duration and obesity in pre-school aged children (3-5 years) and elementary school aged children (6-12 years) with the pooled Risk Ratio each being 1.30 (95 % CI: 1.17-1.44) and 1.40 (95% CI: 1.09-1.81).[33]

There are several limitations in this study, namely this study did not make contact with researchers, which resulted in several articles not being included in the meta-analysis because the data reported was inadequate for analysis. The results of the meta-analysis in this study could not adjust for confounding

factors, because the researchers set operational definitions of risk factors that were different from studies in the population so that the OR values in several articles were recalculated according to the operational definitions in this study. However, the recalculated ORs had a similar pattern to population studies. This meta-analysis was performed only on studies with a cross-sectional study design, thereby limiting the evidence for a causal relationship between sleep duration and obesity in children and adolescents. However, the bias of individual studies is relatively small and does not substantially affect the results of the meta-analysis as a whole because the included studies are subject to quality testing. Almost all of the selected studies had no mental health status such as depression and other co-morbid illnesses that could affect sleep. In addition, the results in this meta-analysis and the observed associations are consistent with the results of most of the previous studies.

Conclusion

Short sleep duration can increase the risk of children and adolescents developing obesity. There is a need for health programs in the form of counseling for children and adolescents to help improve sleep duration as well as increase parents' knowledge and awareness of the importance of adequate sleep-in children so that parents can monitor children's sleep duration and determine appropriate sleep duration since toddlers as one of the prevention efforts childhood obesities. It is hoped that future research can conduct laboratory studies to clarify the relationship between short sleep duration and the incidence of obesity in children.

Acknowledgement

No applicable

Funding

No funding for the research

Conflict of Interest

No conflict of interest.

Reference

1. World Health Organization. Obesity and overweight [Internet]. 2021 [cited 2022 Oct 19]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. Lee EY, Yoon KH. Epidemic obesity in children and adolescents: risk factors and prevention.

Front Med [Internet]. 2018 [cited 2022 Nov 23];12(6):658–666. Available from: https://doi.org/10.1007/s11684-018-0640-1

3. CDC. Consequences of Obesity | Overweight & Obesity | CDC [Internet]. 2022 [cited 2022 Nov 23]. Available from: https://www.cdc.gov/obesity/basics/consequences.html
4. Idris H, Hasyim H, Utama F. Analysis of Diabetes Mellitus Determinants in Indonesia: A Study from the Indonesian Basic Health Research 2013. Acta Med Indones. 2017;49(4):291–8.
5. Kosupa DZ, Utama F. Relationship Between Obesity and Diabetes Mellitus in People Above 40 Years Old in Indonesia: A Retrospective Cohort Study, Analysis of 2007 and 2014 Indonesian Family Life Survey Data. 2020;25(Sicph 2019):228–34.
6. Gupta N, Goel K, Shah P, Misra A. Childhood obesity in developing countries: Epidemiology, determinants, and prevention. Endocr Rev. 2012;33(1):48–70.
7. Pizzi MA, Vroman K. Childhood Obesity: Effects on Children's Participation, Mental Health, and Psychosocial Development. Occup Ther Heal Care [Internet]. 2013 Apr;27(2):99–112. Available from: https://pubmed.ncbi.nlm.nih.gov/23855569/
8. Aggarwal B, Jain V. Obesity in Children: Definition, Etiology and Approach. Indian J Pediatr. 2017;85:463–71.
9. Cao M, Zhu Y, He B, Yang W, Chen Y, Ma J, et al. 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 [Internet]. 2015;15(1):1–10. Available from: http://dx.doi.org/10.1186/s12889-015-2359-0
10. Reilly JJ, Ness AR, Sherriff A. Epidemiologic and physiologic approaches to understanding the etiology of pediatric obesity: Finding the needle in the haystack. Pediatr Res. 2007;61(6):646–52.
11. Fan J, Ding C, Gong W, Liu A, Yuan F, Zhang Y, et al.. Association of sleep duration and overweight/obesity among children in China. Int J Environ Res Public Health. 2020 Mar;17(6):2–9.
12. Lytle LA, Pasch KE, Farbakhsh K. The relationship between sleep and weight in a sample of adolescents. Obesity [Internet]. 2011;19(2):324–31. Available from: http://dx.doi.org/10.1038/oby.2010.242
13. Burt J, Dube L, Thibault L, Gruber R. Sleep and eating in childhood: a potential behavioral mechanism underlying the relationship between poor sleep and obesity. Sleep Med. 2014 Jan 1;15(1):71–5.
14. Prinz P. Sleep, appetite, and obesity - What is the link? PLoS Med. 2004;1(3):186–7.
15. NCD-RiskC. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million

children, adolescents, and adults. Lancet. 2017;390(10113):2627–42.

16. Nindrea RD. Pengantar Langkah-Langkah Praktis Studi Meta-Analisis. Yogyakarta: Gosyen Publishing; 2016.
17. Cappuccio FP, Taggart FM, Kandala NB, Currie A, Peile E, Stranges S, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31(5):619–26.
18. Wu Y, Gong Q, Zou Z, Li H, Zhang X. Short sleep duration and obesity among children: A systematic review and meta-analysis of prospective studies. Obes Res Clin Pract [Internet]. 2017 [cited 2022 Nov 25];11:140–50. Available from: http://dx.doi.org/10.1016/j.orcp.2016.05.0051871-403X/
19. Ruan H, Xun P, Cai W, He K, Tang Q. Habitual Sleep Duration and Risk of Childhood Obesity: Systematic Review and Dose-response Meta-analysis of Prospective Cohort Studies. Sci Rep. 2015;5(June):1–14.
20. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National sleep foundation's sleep time duration recommendations: Methodology and results summary. Sleep Heal [Internet]. 2015;1(1):40–3. Available from: http://dx.doi.org/10.1016/j.sleh.2014.12.010
21. CDC. How Much Sleep Do I Need? | CDC [Internet]. 2017 [cited 2022 Nov 2]. Available from: https://www.cdc.gov/sleep/about_sleep/how_much_sleep.html
22. Shan XY, Xi B, Cheng H, Hou DQ, Wang Y, Mi J. Prevalence and behavioral risk factors of overweight and obesity among children aged 2–18 in Beijing, China. Int J Pediatr Obes. 2010 Oct;5(5):383–9.
23. Zhang J, Zhang YT, Jiang YR, Sun WQ, Zhu Q, Ip P, et al. Effect of Sleep Duration, Diet, and Physical Activity on Obesity and Overweight Elementary School Students in Shanghai. J Sch Health. 2018 Feb;88(2):112–21.
24. Sekine M, Yamagami T, Handa K, Saito T, Nanri S, Kawaminami K, et al. A dose-response relationship between short sleeping hours and childhood obesity: Results of the Toyama birth cohort study. Child Care Health Dev. 2002;28(2):163–70.
25. Kong AP, Wing YK, Choi KC, Li AM, Ko GTC, Ma RC, et al. Associations of sleep duration with obesity and serum lipid profile in children and adolescents. Sleep Med. 2011 Aug;12(7):659–65.
26. Wu J, Wu H, Wang J, Guo L, Deng X, Lu C. Associations between sleep duration and overweight/obesity: Results from 66,817 Chinese adolescents. Sci Rep. 2015;5(October):1–10.
27. Jiang F, Zhu S, Yan C, Jin X, Bandla H, Shen X. Sleep and Obesity in Preschool Children. J Pediatr. 2009 Jun;154(6):814–8.
28. Zhang T, Cai L, Ma L, Jing J, Chen Y, Ma J. The prevalence of obesity and influence of early life

and behavioral factors on obesity in Chinese children in Guangzhou. BMC Public Health. 2016 Sep;16(1):2–13.

29. Thasanasuwan W, Srichan W, Kijboonchoo K, Yamborisut U, Wimonpeerapattana W, Rojroongwasinkul N, et al. Low sleeping time, high TV viewing time, and physical inactivity in school are risk factors for obesity in pre-adolescent Thai children. J Med Assoc Thail. 2016;99(3):314–21.
30. Wang H, Hu R, Du H, Fiona B, Zhong J, Yu M. The relationship between sleep duration and obesity risk among school students: A cross-sectional study in Zhejiang, China. Nutr Metab. 2018 Jul;15(1):2–9.
31. Sekine M, Yamagami T, Hamanishi S, Handa K, Saito T, Nanri S, et al. Parental Obesity, Lifestyle Factors and Obesity in Preschool Children: Results of the Toyama Birth Cohort Study. J Epidemiol. 2002;12(1):33–9.
32. Fatima Y, Doi SAR, Mamun AA. Longitudinal impact of sleep on overweight and obesity in children and adolescents: a systematic review and bias-adjusted meta-analysis. Obes Rev [Internet]. 2015 Feb 1 [cited 2022 Dec 1];16(2):137–49. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/obr.12245
33. Li L, Zhang S, Huang Y, Chen K. Sleep duration and obesity in children: A systematic review and meta-analysis of prospective cohort studies. J Paediatr Child Health [Internet]. 2017 Apr 1 [cited 2022 Nov 25];53(4):378–85. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/jpc.13434
34. Eyck A Van, Verhulst S. Sleep-Disordered Breathing and Sleep Duration in Childhood Obesity. In: Freemark MS, editor. Pediatric obesity: Etiology, Pathogenesis and Treatment [Internet]. Second. Switzerland: Humana Press; 2018. p. 497–509. Available from: https://www.academia.edu/41964130/Pediatric_Obesity_Etiology_Pathogenesis_and_Treatment_Second_Edition
35. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Hafer A, Carskadon MA. Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. Sleep. 2005;28(12):1568–77.
36. Gau SSF, Merikangas KR. Similarities and differences in sleep-wake patterns among adults and their children. Sleep. 2004;27(2):299–304.
37. Olds TS, Maher CA, Matricciani L. Sleep duration or bedtime? Exploring the relationship between sleep habits and weight status and activity patterns. Sleep. 2011;34(10):1299–307.