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Original Article

Sleep disturbance associations with blood pressure and body mass index in school-aged children

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Abstract

Background Sleep disturbances can lead to many health problems in school-aged children, including hypertension and obesity. However, a lack of consensus about the etiology of these conditions is due to conflicting reports on the possible effects of sleep disturbances.

Objective To assess for possible associations between sleep disturbances and blood pressure as well as body mass index in school-aged children.

Methods This cross-sectional study involved primary school children in the 4th-5th grades. Subjects' blood pressure, body weight, and body height were measured and their parents completed the Sleep Disturbances Scale for Children (SDSC) questionnaire.

Results Of the 816 children enrolled, 503 (61.6%) children had sleep disturbances. The most common type of sleep disturbance was initiating and maintaining sleep. Bivariate analysis revealed a significantly increased risk of hypertension among subjects with sleep disturbances (PR 15.06; 95%CI 8.13 to 27.90) and increased risk of obesity (PR 22.65; 95%CI 12.28 to 41.78).

Conclusion The most common type of sleep disturbance is initiating and maintaining sleep. Sleep disturbances are significantly associated with hypertension and obesity in children. **[Paediatr Indones. 2020;60:303-9 ; DOI: 10.14238/pi60.6.2020.303-9**].

Keywords: *sleep disturbances; hypertension; obesity*

Sleep is a state of reduced response and interaction with the environment that is reversible and progresses rapidly.[1] In children, the quantity and duration of sleep vary according to age. Older children tend to need less sleep.[2] Sleep disturbances are disrupted sleep patterns, in terms of quality and quantity, or behavioral disorders and physiological conditions during sleep.[3] According to the *World Health Organization* (WHO) in 2011, the prevalence of sleep disturbances in American children was 5-10%, most commonly in ages 2-15 years.[4] In Indonesia, the prevalence reached 42.2% in elementary school children aged 9-12 years.[5] Complications of sleep disturbances in school-aged children include difficulty concentrating, drowsiness in the morning, and decreased academic achievement.[6]

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Blood pressure in children is partially determined by gender, age, and height.[7] A previous study reported that poor sleep quality was associated with the incidence of pre-hypertension in healthy adolescents, so they concluded that sleep disturbances were a risk factor for hypertension.[8] Complications of hypertension in children and adolescents include increased risk of left ventricular hypertrophy (LVH), hypertensive retinopathy, and proteinuria.[9]

Short sleep duration is a risk factor for weight gain and obesity.[10] A meta-analysis consisting of 17 cross-sectional studies showed an increase in the incidence of obesity (BMI > 30 kg/m2) in children with less than adequate sleep duration (<5 hours per night) compared to those with adequate sleep duration.[11] In addition, the high prevalence of overweight and obesity in adolescents and children (17% in the United States) has forced the issue into a public health priority.[12]

A receiver operating characteristic (ROC) curve, showed the SDSC to be a good diagnostic instrument, with cut-off score of 39 having 89% sensitivity and 74% specificity.[13] The SDSC questionnaire has been used to assess sleep disturbances in children ranging from 3-18 years.[14] A study in China validated the SDSC in a study of 3,525 children aged 5-16 years and obtained a Cronbach's alpha of 0.81, which indicated that SDSC was a reliable diagnostic instrument when used in a population.[15] As such, we aimed to assess sleep disturbances in 4th-5th grade children and analyze for possible associations with blood pressure and BMI.

Methods

This cross-sectional study had a target population of 4th and 5th grade elementary school children in Yogyakarta, Central Java. We used cluster sampling to collect subjects from 4 of 167 elementary schools in Yogyakarta, from May 1 to May 15, 2017. After dividing the city into four sections, one school from each section was randomly chosen. Inclusion criteria were children aged 8-12 years in grades 4-5 of elementary school in Yogyakarta, and whose parents agreed to participate in the study. Exclusion criteria were children who took steroids, had kidney disease, or had special needs. A total of 816 subjects were enrolled from the following elementary schools: Serayu (168 subjects), Sukonandi (377 subjects), Suronatan (157 subjects), and Suryodiningratan (114 subjects).

Data were obtained from *Sleep Disturbances Scale for Children* (SDSC) questionnaires filled by parents as well as direct examination of subjects' body weight, height, and blood pressure. The SDSC questionnaires was filled by parents, which consisted of 26 questions with number scale method (scale 1 to 5): scale 1 means never, scale 2 means seldom (< 2 times/month), scale 3 means sometimes (1-2 times/week), scale 4 means often (3-5 times/week), and scale 5 means always (everyday).

To differentiate the types of sleep disturbances, we look further into particular questions in SDSC questionnaires, in which the total point was higher/predominant. The particular questions were: number 1, 2, 3, 4, 5, 10, and 11 for initiating and maintaining sleep disorder; number 13, 14, and 15 for sleep breathing disorder; number 17, 20, and 21 for arousal disorder; number 6, 7, 8, 12, 18, and 19 for sleep-wake transition disorder; number 22, 23, 24, 25, and 26 for excessive somnolence disorder; and number 9 and 16 for sleep hyperhidrosis.[13,15]

We measured blood pressure using calibrated digital sphygmomanometers. Blood pressure measurements were performed 3 times after the subjects had rested 5-10 minutes, and average systolic and diastolic blood pressures were calculated. Subjects were classified as normotensive for systolic and diastolic blood pressures in the 5th-90th percentile, pre-hypertensive for 90th-95th percentile, or hypertensive for above 95th percentile.[16] Body weights were measured 3 times using calibrated scales, and averages calculated. Body heights were measured 3 times using calibrated microtoise stature meters, and averages calculated. Subjects' BMIs were calculated by dividing body weight (kg)/ body height (m)^2. These measurements were done in the schools by trained health workers. BMI-for-age percentile growth chart by the *Center for Disease Control* (CDC) classified as: underweight (less than the 5th percentile), normal or healthy weight (5th percentile to less than the 85th percentile), overweight (85th to less than the 95th percentile), obese (equal to or greater than the 95th percentile).[17]

Data were analyzed using *SPSS version 22 for Windows*. Statistical tests to compare data included

Chi-square test and T-test (parametric) or Mann Whitney U-test (non-parametric), depending on the normality of data distribution. This study was approved by The Ethics Committee in Department of Child Health, Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada.

Results

The 816 subjects from 4 elementary schools in Yogyakarta consisted of 408 (50%) boys and 408 (50%) girls. Sleep disturbances were found in 503 (61.64%) subjects, with similar numbers of boys (62.7%) and girls (60.5%). Other basic characteristics collected were parental education and occupation, as shown in **Table 1**. Statistical analysis with T-test revealed that mean BMI, systolic blood pressure, and diastolic blood pressure were significantly higher in children with sleep disturbances than in children without sleep disturbances (**Table 2**). The prevalence of sleep disturbances in our subjects was quite high at 61.6%. Univariate analysis of sleep disturbances based on the SDSC questionnaire is presented in **Table 3**.

Bivariate analysis with Chi-square test revealed a significant association between sleep disturbances and overweight/obesity (PR 22.65; 95%CI 12.28 to 41.78; P<0.001). Children with sleep disturbances had 22 times higher risk of overweight/obesity compared to children without sleep disturbances, as shown in **Table 4**. Furthermore, children with a sleep duration of <9 hours had 2 times higher risk of overweight/obesity than children with a sleep duration of ≥ 9 hours (PR 2.53; 95%CI 2.15 to 2.98; P<0.001).

Chi-square test also revealed a significant association between sleep disturbances and hypertension (PR 15.06; 95%CI 8.13 to 27.90; P<0.001). Children with sleep disturbances had a 15 times higher risk of developing hypertension compared to children without sleep disturbances, as shown in **Table 5**. Furthermore, children with a sleep duration of <9 hours had 3 times higher risk of developing hypertension than children with a sleep duration of ≥ 9 hours (PR 3.30; 95%CI 2.60 to 4.17; P<0.001).

Table 1. Characteristics of subjects with and without sleep disturbances

Characteristics	Sleep disturbances	
	Yes (n=503)	No (n=313)
Gender, n(%)		
Male	256 (62.7)	152 (37.3)
Female	247 (60.5)	161 (39.5)
Elementary schools, n(%)		
Serayu	100 (59.5)	68 (40.5)
Muhammadiyah Sukonandi	228 (60.5)	149 (39.5)
Muhammadiyah Suronatan	106 (67.5)	51 (32.5)
Suryodiningratan 3	69 (60.5)	45 (39.5)
Paternal education, n(%)		
Senior high or below	95(63.8)	54(36.2)
College	408 (61.2)	259 (38.8)
Maternal education, n(%)		
Senior high or below	109 (50.5)	107 (49.5)
College	394 (65.7)	206 (34.3)
Paternal occupation, n(%)		
Employee	369 (65.5)	194 (34.5)
Entrepreneur	131 (52.6)	118 (47.4)
Retired	3 (75)	1 (25)
Maternal occupation, n(%)		
Employee	78 (70.4)	75 (29.6)
Entrepreneur	82 (66.1)	42 (33.9)
Housewife	243 (55.4)	196 (44.6)

Discussion

In our study, 503 subjects (61.64%) had sleep disturbances. This prevalence was higher than a previous study that also used the SDSC. Their reported prevalence of sleep disturbances was 42.2% of subjects aged 9-12 years in a Jakarta elementary school.[5] The difference was likely due to different school hours. The Jakarta school study hours were on average 6-7 hours/day for 6 days/week. In contrast,

Table 2. Differences in mean blood pressure and BMI in children with and without sleep disturbances

Sleep disturbances	Outcomes		
	Mean BMI (SD)	Mean systolic blood pressure (SD)	Mean diastolic blood pressure (SD)
Yes	21.58 (4.12)	106.89 (11.26)	71.99 (9.78)
No	16.13 (2.11)	97.88 (8.06)	64.46 (10.0)

Note: P< 0.001 for all

Table 3. Distribution of subjects according to types of sleep disturbances

Variables	(N=816)
Sleep disturbances, n (%)	
No	313 (38.4)
Yes	503 (61.6)
SDSC parameters, n (%)	
Initiating and maintaining sleep disorder	365 (72.6)
Sleep breathing disorder	3 (0.6)
Arousal disorder	6 (1.2)
Sleep-wake transition disorder	107 (21.3)
Excessive somnolence	20 (4.0)
Sleep hyperhidrosis	2 (0.4)

the four Yogyakarta primary schools averaged 7-9 hours/day of teaching and learning activities for 5 days/week. However, sleep can be influenced by other internal and external factors that were not evaluated in either study.

The most common types of sleep disturbances in our subjects were in initiating and maintaining sleep (72.6%), followed by sleep-wake transition disorder (21.3%), excessive somnolence disorder (4.0%), impaired consciousness (1.2 %), sleep breathing disorders (0.6%), and hyperhidrosis disorders during

Table 4. Association between sleep disturbances and overweight/obesity

Variables	BMI status		PR	95% CI	P value
	Overweight/obese (n=374)	Normal/wasted (n=442)			
Sleep disturbances, n (%)					
No	10 (2.7)	303 (68.6)	22.65	12.28 to 41.78	<0.001
Yes	364 (97.3)	139 (31.4)			
Types of sleep disturbances, n (%)					
Initiating and maintaining sleep disorder	283 (75.7)	82 (18.6)	3.84	3.17 to 4.66	<0.001
Sleep breathing disorder	2 (0.5)	1 (0.2)	1.46	0.65 to 3.25	0.596
Arousal disorder	4 (1.1)	2 (0.5)	1.46	0.83 to 2.58	0.421
Sleep-wake transition disorder	62 (16.6)	45 (10.2)	1.32	1.10 to 1.58	0.007
Excessive somnolence	12 (3.2)	8 (1.8)	1.32	0.92 to 1.90	0.198
Sleep hyperhidrosis	1 (0.3)	1 (0.2)	1.09	0.27 to 4.37	1.000
Duration of sleep					
< 9 hours	246 (65.8)	106 (24.0)	2.53	2.15 to2.98	<0.001
≥9 hours	128 (34.2)	336 (76.0)			

PR=prevalence risk

Table 5. Association between sleep disturbances and hypertension

Variables	Blood pressure status		PR	95% CI	P value
	Hypertensive (n=252)	Normal/pre-hypertensive (n=564)			
Sleep disturbances, n (%)					
No	10 (4.0)	303 (53.7)	15.06	8.13 to 27.90	<0.001
Yes	242 (96.0)	261 (46.3)			
Types of sleep disturbances, n (%)					
Initiating and maintaining sleep disorder	188 (74.6)	177 (31.4)	3.63	2.83 to 4.65	<0.001
Sleep breathing disorder	1 (0.4)	2 (0.4)	1.08	0.22 to 5.37	1.000
Arousal disorder	3 (1.2)	3 (0.5)	1.63	0.73 to 3.65	0.380
Sleep-wake transition disorder	40 (15.9)	67 (11.9)	1.25	0.96 to 1.64	0.118
Excessive somnolence	10 (4.0)	10 (1.8)	1.65	1.05 to 2.58	0.061
Sleep hyperhidrosis	0 (0.0)	2 (0.4)			1.000
Duration of sleep					
< 9 hours	180 (71.4)	172 (30.5)	3.30	2.60 to 4.17	<0.001
≥9 hours	72 (28.6)	392 (69.5)			

PR=prevalence risk

sleep (0.4%). Disorders in initiating and maintaining sleep are determined by sleep duration, increased sleep latency, and disturbance at the stage of sleep. Similarly, a study found that the most common sleep disturbance in children was initiating and maintaining sleep.[5]

Our analysis revealed a significant association between duration of sleep and obesity, with a 2.53 times increased risk of obesity in children with duration of sleep < 9 hours. Similarly, a systematic review and meta-analysis of several cohort studies found that children with shorter sleep duration had increased risk of overweight/obesity.[18] In our study, children with sleep disturbances had significantly higher BMI than those without [21.58 (SD 4.12) *vs.* 16.13 (SD 2.11), respectively (P<0.001)]. This finding was consistent with the theory that increased ghrelin hormone is a stimulator of appetite and decreased leptin hormone is an inhibitor of hunger.[19] Both hormones are affected by sleep disturbances.

We also found a significant association between sleep disturbances and hypertension, with a 15 times increased risk of hypertension in those with sleep disturbances. This result was in agreement with a previous study at United States which found an association between poor sleep quality and prehypertension in children and adolescents.[8] In our study, mean blood pressure was significantly different in children with and without sleep disorders, for both systolic and diastolic blood pressures. In children with sleep disorders, the mean systolic blood pressure will increase 7-10 times compared with children without sleep disturbances, while the mean diastolic blood pressure will increase 6-8 times in children with sleep disorders compared with children without sleep disturbances. Higher blood pressure in such children may be due to overactivity of the sympathetic nerves and the renin system of angiotensin and aldosterone, as well as changes in circadian rhythm, and hormone concentration.[17]

We categorized sleep duration into two groups, based on the recommended 9-12 hours for children aged 6-12 years.[20] Significantly more overweight/obese subjects than normal/wasted subjects had sleep duration of <9 hours, with a 2.5 times higher risk of overweight/obesity compared to children with >9 hours sleep duration.[21] This finding was consistent with a previous meta analysis which stated that sleep duration may be inversely and longitudinally associated with the risk of overweight/obesity in children and adolescents.[18] To prevent childhood obesity and, thereafter, chronic diseases, a certain amount of sleep time for children and adolescents should be recommended. We also found that children with a sleep duration of <9 hours experienced 3.3 times greater risk of hypertension compared to children with enough sleep (> 9 hours). This finding is consistent with a previous study.[8]

Use of electronic media by children may affect their sleep. Children who used cell phones, television, video games, or computers before going to bed experienced reduced sleep duration and these gadgets are associated with elevated BMI in children. In this study, the use of electronic media was considered to significantly associated with sleep disturbances (88.9% of children who used electronic media experienced sleep disturbances).[22]

A weakness of our study was the cross-sectional study design, so a direct causal effect could not be determined between sleep disturbances and the incidences of hypertension and obesity. Nor did we analyze other factors known to influence hypertension and obesity in children, such as genetics, diet, and physical activity. In addition, while the SDSC questionnaire has been validated as a screening tool and has high sensitivity and specificity, the SDSC was filled by parents and children who could have biased answers. Nonetheless, the strength of the study was that, to our knowledge, it is the first in Indonesia to use two outcome variables, namely, blood pressure and BMI, simultaneously. Another strength is that this study can provide initial data to be used as a basis for further study. In addition, the cluster sampling method randomly included four primary schools, with a large enough sample size to represent the target population, namely, elementary school students in grades 4-5 in Yogyakarta, Central Java.

This study is expected to increase awareness of health workers and parents about the dangers of sleep disturbances in children. In addition, we recommend screening for elementary school children. Earlier identification of sleep disturbances can lead to proper management, which in turn may reduce the risk of hypertension and obesity. Such conditions are known to increase the risk of metabolic syndrome in adolescence and adulthood.[23] Data from the *Third National Nutrition and Health Examination Survey*

(NHANES III, 1988-96) in the United States revealed that the prevalence of the metabolic syndrome was significantly related to weight status, being found among less than 0.1% of adolescents of normal weight (BMI < 85th percentile), but increasing to 6.8% among overweight adolescents (85th-95th BMI percentile) and being 28.7% among obese adolescents (BMI ≥ 95t^{h} percentile).[23]

Education of children, parents, and schools should take into consideration that children with sleep disturbances, hypertension, and obesity need comprehensive management and require multidisciplinary collaboration between the family, community, and schools. Pediatricians at local health facilities can help educate parents and manage these pediatric problems.

Conflict of Interest

None declared.

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References

1. Tikotzky L, De Marcas G, Har-Toov J, Dollberg S, Bar-Haim Y, Sadeh A. Sleep and physical growth in infants during the first 6 months. J Sleep Res. 2010;19:103-10. DOI: 10.1111/j.1365-2869.2009.00772.x.
2. Javaheri S, Storfer-Isser A, Rosen C, Mitsnefes MM, Exami-N, Preece M, *et al.* Sleeping hours: What is the ideal number and how does age impact this? Pediatrics. 2007;10:421-30. DOI: 10.2147/NSS.S163071.
3. Sekartini R, Adi NP. Gangguan Tidur pada Anak Usia Bawah Tiga Tahun di Lima Kota di Indonesia. Sari Pediatr. 2016;7:188-93. DOI: 10.14238/sp7.4.2006.188-93.
4. Bhargava S. Diagnosis and Management of Common Sleep Problems in Children.Pediatrics in Review. 2011;32:91-9. DOI: 10.1542/pir.32-3-91.
5. Putri H. Studi Deskriptif Gangguan Tidur Pada Anak Usia 9-12 Tahun di SD Negeri Pisangan 1 Ciputat Tahun 2015. 2015; Jakarta : Universitas Islam Negeri Syarif Hidayatullah. DOI: IOS3659.79381.
6. Medic G, Wille M, Hemels MEH. Short- and long-term health consequences of sleep disruption. Nat Sci Sleep. 2017;9:151-61. DOI: 10.2147/NSS.S134864.
7. Ambarita K, Ramayani OR, Lubis M, Ilmiati I, Ramayati R. Rasio tekanan darah terhadap tinggi badan dalam diagnosis hipertensi pada remaja. J Med. Sch. 2017;50:103-6.
8. Javaheri S, Storfer-isser A, Rosen CL, Redline S. Sleep Quality and Elevated Blood Pressure in Adolescents. 2008;1034-40. DOI: 10.1161/CIRCULATIONAHA.108.766410.
9. Weaver DJ. Hypertension in Children and Adolescents. Pediatrics in Review. 2017: 38 (8) 369-382. DOI: 10.1542/pir.2016-0106.
10. Marfuah D, Hadi H. Durasi dan Kualitas Tidur Hubungannya Dengan Obesitas Pada Anak Sekolah Dasar Di Kota Yogyakarta dan Kabupaten Bantul. Gizi dan Diet Indones. 2013;1:93-101. DOI: 10.21927/ijnd.2013.1(2).93-101.
11. Cappuccio FP, Taggart FM, Kandala N-B, Currie A, Peile E, Stranges S, *et al.* Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31:619-26. DOI: 10.1093/sleep/31.5.619.
12. Weiss R, Bremer AA, Lustig RH. What is metabolic syndrome, and why are children getting it? Ann N Y Acad Sci. 2013;1281:123-40. DOI: 10.1111/nyas.12030.
13. Bruni O, Ottaviano S, Guidetti V, Romoli M, Innocenzi M, Cortesi F, *et al.* The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. J Sleep Res. 1996;5:251-61. DOI: 10.1111/j.1365-2869.1996.00251.x.
14. Natalia C, Sekartini R, Poesponegoro H. Skala Gangguan Tidur untuk Anak (SDSC) sebagai Instrumen Skrining Gangguan Tidur pada Anak Sekolah Lanjutan Tingkat Pertama. Sari Pediatr. 2011;12:365-72. DOI: 10.14238/sp12.6.2011.365-72.
15. Huang MM, Qian Z, Wang J, Vaughn MG, Lee YL, Dong GH. Validation of the Sleep Disturbance Scale for Children and prevalence of parent-reported sleep disorder symptoms in Chinese children. Sleep Med. 2014;15:923-8. DOI: 10.1016/j.sleep.2014.03.023.
16. Sekarwana N, Rachmadi D, Hilmanto D. Konsensus Tata laksana hipertensi pada Anak. Jakarta: BP IDai; 2011. p. 3-11.
17. Kuczmarski RJ, Ogden CL, Guo SS, *et al.* 2000 CDC Growth Charts for the United States: methods and development. Vital Heal Stat 11. 2002;246:1-190. PMID: 12043359
18. 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;5:1-14. DOI: 10.1038/srep16160.

19. Horne J. Obesity and short sleep: Unlikely bedfellows? Obes Rev. 2011;12:84-94. DOI: 10.1111/j.1467-789X.2010.00847.x.
20. Iglowstein I, Jenni OG, Molinari L, Largo RH. Sleep Duration From Infancy to Adolescence: Reference Values and Generational Trends. Pediatrics. 2003;111:302-7. DOI: 10.1542/peds.111.2.302.
21. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, *et al*. Recommended Amount of Sleep for Pediatric Populations: A Consensus Statement of the American Academy of Sleep Medicine. J Clin Sleep Med. 2016;12:785-6. DOI: 10.1542/peds.2016-1601.
22. Fuller C, Lehman E, Hicks S, Novick MB. Bedtime Use of Technology and Associated Sleep Problems in Children. Glob Pediatr Heal. 2017;4:2333794X1773697. DOI: 10.1177/2333794X17736972.
23. Liu W, Lin R, Liu A, Du L, Chen Q. Prevalence and association between obesity and metabolic syndrome among Chinese elementary school children: A school-based survey. BMC Public Health. 2010;10:780. DOI: 10.1186/1471-2458-10-780.