

Association between sleep habits and height in children from low socioeconomic backgrounds: A cross-sectional study

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Abstract. *Background and aim:* Good sleep habits, including adequate sleep duration and appropriate sleep onset, are crucial for supporting optimal growth and development. The literature suggests that insufficient sleep duration is associated with an increased risk of overweight and obesity in children. However, the relationship between sleep duration and sleep onset and height in children from low socioeconomic background has not been explored. This study aims to investigate the association between sleep duration, sleep onset, and height in children from low-income families. *Methods:* A cross-sectional study was conducted from October to November 2023 across five primary schools in Surabaya, involving second- and third- grade students. Participants' weight and height were measured, and they answered structured questionnaires. If children were unsure of their answers, the forms were taken home for parental assistance. Inclusion criteria included students from households earning below the regional minimum wage, while those with incomplete data or chronic illnesses were excluded. *Results:* Among the 264 participants (47.7% boys, 52.3% girls, average age 108.7 ± 7.9 months), significant associations were observed between sleep duration and height ($r=0.205$, $P=0.004$) as well as sleep onset and height ($r=0.397$, $P<0.0001$). No significant links were found between sleep and weight. However, sleep duration and onset were significantly associated with screen time ($P=0.025$ and $P<0.0001$, respectively). *Conclusions:* Insufficient sleep duration and late bedtimes are strongly linked to shorter height in children from low-income families. Beyond duration, sleep timing also emerges as a critical factor in supporting optimal growth. (www.actabiomedica.it)

Key words: body height, children, sleep quality, short stature, stunted

Introduction

Sleep patterns in children refer to the characteristics of sleep duration and consistent sleep habits over a certain period. Understanding children's sleep patterns is essential for improving their overall health, as these patterns not only influence physical well-being but also play a crucial role in cognitive development and emotional health (1). The relationship between sleep duration and sleep onset is a complex interplay influenced by various physiological and environmental

factors. Research indicates that adequate sleep is essential to growth, maturation, and energy balance, primarily due to its role in the secretion of Growth Hormones (GH) (2). GH secretion intensifies during deep, slow-wave sleep, supporting critical processes such as physical growth, muscle development, tissue regeneration and repair. The association between GH levels and brain activity during deep sleep further underscores its role in maintaining tissue stability (3,4). Moreover, GH may serve as a key mediator connecting sleep quality to body composition, suggesting that

adequate sleep could have a positive impact on body structure and function (5). Sleep disturbances can lead to growth retardation, as the production of GH is significantly influenced by sleep quality and duration (6). Specifically, studies suggest that sleep may have a more pronounced effect on height than on weight, highlighting the importance of sufficient sleep for physical growth. Additionally, sleep quality is vital for metabolic processes that regulate growth. Sleep deprivation has been linked to various health issues, including obesity, which can further complicate growth patterns in children (7). Moreover, sleep problems have been associated with behavioral issues that may lead to a sedentary lifestyle, further exacerbating growth concerns (8). Research indicates that GH is released during sleep, with levels peaking earlier in the night, highlighting the significance of sleep quality and timing for optimal GH secretion (9). This hormone plays a key role in growth, affecting bone length and overall height in both children and adolescents. Prolonged sleep deprivation can interfere with GH release, potentially hindering height development by limiting a child's ability to reach their genetic height potential. However, the relationship between sleep duration, sleep onset, and child height remains underexplored. The aim of our study was to investigate the association between sleep duration, sleep onset, and the height of children from low socioeconomic backgrounds.

Methods

Study design

This study was a cross-sectional study conducted among second- and third-grade students from five primary schools in Surabaya, between October and November 2023. All participants had their weight and height measured and were interviewed using a structured questionnaire developed by the research team. If a participant was unsure of an answer, they were allowed to take the questionnaire home for parental assistance. The inclusion criteria consisted of second- and third-grade students whose parents earned below the regional minimum wage. Exclusion criteria

included incomplete data and a history of chronic diseases. In 2023, the minimum wage in Surabaya is Rp. 4,525,480.00. Thus, all the children included in this study had parents with an income below that threshold. The sample size in this study was determined using a total sampling technique. A total of 290 students were initially included, however 26 students had incomplete data, leaving, 264 participants for analysis. Data from questionnaire including demographic information, were analyzed to assess the association between sleep duration, sleep onset, and height. The questionnaire included questions on parents' occupation, monthly income, education level, the child's bedtime, wake-up time, daily screen time (gadget and television use), and frequency of milk consumption. Previous studies have shown that milk and dairy product consumption significantly impacts growth, particularly in children's height (10, 11). In Indonesia, where the stunting rate remains high, milk consumption is relatively low (12). From an economic perspective, milk is an affordable source of animal protein that is easy for children to consume, as it requires no special preparation or cooking by parents. Body weight was measured using a SECA 813 standing scale (Hamburg, Germany) and recorded in kilograms, while body height was measured using a SECA 213 stadiometer (Hamburg, Germany) and recorded in centimeters. At each timepoint, both body weight and height were measured twice. If a discrepancy was observed between the first and second measurements, a third measurement was taken, and the average of the three measurements was recorded. The Weight-for-Age Z-score (WAZ), Height-for-Age Z-score (HAZ), and Weight-for-Height Z-score (WHZ) were calculated using the WHO Child Growth Standards based on the recorded weight and height data. Children were categorized as underweight if their WAZ was less than -2 standard deviations (SD) and severely underweight if it was less than -3 SD from the median. Based on HAZ, children were classified as stunted if their z-score was less than -2 SD and greater than or equal to -3 SD, or as severely stunted if their z-score was less than -3 SD. According to WHZ, children were categorized as wasted if their z-score was between -3SD and -2SD, or as severely wasted if their z-score was less than -3 SD.

Ethical clearance

The ethical approval for this study, 167/EC/KEPK/FKUA/2023 was granted by the Health Research Ethics Committee (KEPK), Universitas Airlangga School of Medicine.

Statistical analysis

Data analysis was conducted using the SPSS ver. 24. To determine the relationship between two independent variables, the Pearson correlation test was performed. If the data were not normally distributed, the Spearman correlation test was used instead. To assess the effect of independent variables on the dependent variable, the Chi-square test was applied, along with Phi or Kramer's V to evaluate the strength of the correlation. If the parametric test assumptions were not met, the Fischer test was performed. A multinomial binary logistic regression analysis was performed to assess the odd ratio for the relationship between sleep duration, sleep onset and screen time with nutritional status (WAZ and HAZ categories). Results were considered statistically significant if the *p*-value was <0.05.

Results

Characteristics of research subjects

A total of 264 children were included in the analysis, with a mean age of 108.77 ± 7.981 months-old. Females were the predominant gender group in this study (52.3%). The average of body weight was 24.489 ± 6.937 kgs, while the average body height was 123.613 ± 6.823 cms.

Among all participants, the majority had a normal height (61%), followed by those classified as stunted (36%) and severely stunted (3%). The average of height-for-age z-score (HAZ) was -1.55 ± 1.14 SD. Regarding sleep patterns, 64.4% of participants had a normal sleep onset, 48.1% had an adequate sleep duration and 45.8% subjects had a normal duration of screen time (Table 1).

Table 1. Basic subject's characteristics

Characteristics	All subjects
Gender n(%)	
• Male	126 (47,7%)
• Female	138 (52,3%)
Age (in months), mean $\pm$ SD	108.77 ± 7.981
Body weight (in kg), mean $\pm$ SD	24.489 ± 6.937
Body height (in cm), mean $\pm$ SD	79.24 ± 30.19
Height-for-age, n(%)	
• Normal	161 (61%)
• Stunted	95 (36%)
• Severely stunted	8 (3%)
Height-for-age Z score (SD)	-1.551 ± 1.14
Sleep onset	
• Normal (max at 09.00 PM)	170 (64.4%)
• Late (> 09.00 PM)	94 (35.6%)
Sleep duration	
• Enough (9-11 hours/day)	127 (48.1%)
• Lack (<9 hours/day)	137 (51.9%)
Screen time	
• Normal (1-1,5 hours/day)	121 (45.8%)
• High (1,5 -2 hours/day)	64 (24.2%)
• Very high (>2 hours/day)	79 (29.9%)

Abbreviations: *n : number; SD: Standard Deviation.

There was a significant difference between sleep duration and HAZ categories as indicated by Kramer's V correlation ($r=0.205$, $P=0.003$) summarized in Table 2. A shorter sleep duration was associated with a lower height. Children with inadequate sleep duration had a 40.1% chance of being stunted, higher than children with normal sleep duration who have a 31.1% chance of being stunted. Children with inadequate sleep duration had a 5.8% chance of being severely stunted, higher than 0.0% chance observed in children with normal sleep duration ($P=0.004$). A significant difference was also observed between sleep onset and height status ($P<0.0001$). Children with a late sleep onset had a 54.3% chance of being stunted, compared to 25.9% in those with normal sleep onset. Children with poor sleep onset had a 8.5% chance of being severely stunted, whereas no cases of severe stunted were observed among those with normal sleep onset.

Table 3 shown that there was no significant difference between sleep duration and sleep onset with

Table 2. Relationship between sleep duration and onset with height for age

Variable		HAZ categories			r	P
		Normal	Stunted	Severely stunted		
Sleep duration	Enough	87 (68.5%)	40 (31.5%)	0	0.205	0.004
	Lack	74 (54%)	55 (40.1%)	8 (5.8%)		
Sleep Onset	Normal	126 (74.1%)	44 (25.9%)	0	0.397	<0.0001
	Late	35 (37.2%)	51 (54.3%)	8 (8.5%)		

Table 3. Relationship between weight for age, BMI for age and sleep duration and onset

Variable	Sleep duration		r	P	Sleep onset		r	P
	Normal	Less			Normal	Late		
Weight-for-age								
Underweight	47 (17.8%)	54 (20.5%)	-0.025	0.687	58 (21.9%)	43 (16.3%)	0.115	0.063
Normal	80 (30.3%)	83 (31.4%)			112 (42.4%)	51 (19.3%)		
Screen time								
Normal	66 (25%)	55 (20.8%)	0.167	0.025	94 (35.6%)	27 (10.2%)	0.321	<0.0001
High	33 (12.5%)	31 (11.7%)			43 (16.3%)	21 (7.9%)		
Very high	28 (10.6%)	51 (19.3%)			33 (12.5%)	46 (17.4%)		

WAZ categories in children. However, a significant difference was observed between sleep duration and sleep onset with screen time in children. Children with inadequate sleep duration had a 12.4% chance of being underweight, compared to 11.0% in children with normal sleep duration ($P=0.022$). Children with a late sleep onset had a 16.0% chance of being underweight, higher than the 9.4% chance observed in children with normal sleep onset. ($P=0.038$). There was also a significant difference between sleep duration and sleep onset with screen time ($P=0.025$, $P<0.001$, respectively).

The multinomial logistic regression evaluating the effect of sleep onset, sleep duration and screen time is summarized in Table 4. The results indicate that normal sleep onset reduced the likelihood of being stunted by 0.232-fold, while normal screen time reduced the likelihood of being stunted by 0.451-fold in children aged 9-10 years old. In other words, normal sleep onset and screen time had a protective effect against stunting. There was a significant relationship between sleep duration, sleep onset and milk consumption frequency ($P<0.001$, and $P<0.001$ respectively), as shown in Table 5.

Table 5 presents the relationship between sleep duration and sleep onset with milk consumption frequency in children. The results indicate that children with shorter sleep duration and later sleep onset consumed milk less frequently compared to those with adequate sleep duration and earlier sleep onset. ($p<0.001$ and $p<0.001$ respectively).

Discussion

Sleep duration refers to the total amount of time a child sleeps in one sleep cycle and is usually measured in hours. Adequate sleep duration is crucial for a child's growth, development, and cognitive functioning (13). Shorter sleep duration has been associated with various negative health impacts, including behavioral problems, cognitive impairment, and increased risk of chronic conditions (14). The recommended sleep duration varies by age. The National Sleep Foundation recommends that school-aged children (6-13 years) get 9-11 hours of sleep per night, while adolescents (14-17 years) should sleep 8-10 hours per night (15).

Table 4. Multinomial logistic regression on effect of sleep onset and duration and screen time

HAZ categories Ref: Normal=0	Variable	B	Exp(β)	Sig	95% CI
Stunted=1	Sleep duration:				
	Normal=0	0.379	1.461	0.207	0.745-2.866
	Less=1				
	Sleep onset				
	Normal=0	-1.462	0.232	<0.000	0.115-0.468
	Late=1				
	Screen time				
	Normal=0	-0.796	0.451	0.017	0.234-0.867
	High=1	-0.476	0.621	0.199	0.300-1.285
	Very high=2	-	-	-	-
Severely stunted=2	Sleep duration:				
	Normal=0	-19.021	5.485×10^{-9}	-	5.485×10^{-9} - 5.485×10^{-9}
	Less=1				
	Sleep onset				
	Normal=0	-21.265	5.821×10^{-10}	-	5.821×10^{-10} - 5.821×10^{-10}
	Late=1				
	Screen time				
	Normal=0	-0.878	0.416	0.330	0.071 - 2.427
	High=1	-1.149	0.317	0.320	0.033 - 3.054
	Very high=2	-	-	-	-
Underweight=1	Sleep duration:				
	Normal=0	0.230	1.259	0.461	0.683-2.323
	Less=1				
	Sleep onset				
	Normal=0	0.333	0.645	0.188	0.336-1.239
	Late=1				
	Screen time				
	Normal=0	-0.622	0.537	0.047	0.059 - 0.991
	High=1	-0.673	0.510	0.059	0.254 - 1.025
	Very high=2	-	-	-	-

Table 5. Relationship between sleep duration and onset and milk consumption frequency

Variable	Sleep duration		r	P	Sleep onset		r	P
	Normal	Less			Normal	Late		
Milk Consumption Frequency:								
Everyday	16 (6.1%)	20 (7.6%)	0.280	<0.001	22 (8.3%)	14 (5.3%)	0.290	<0.001
1-2x/week (@200 ml)	49 (18.6%)	34 (12.9%)			63 (23.9%)	20 (7.6%)		
3-5x/week (@200 ml)	22 (8.3%)	13(4.9%)			23 (8.7%)	12 (4.5%)		
1-2x/month (@200 ml)	32 (12.1%)	37 (14%)			48 (18.2%)	21 (7.9%)		
Never	8 (3%)	33 (12.5%)			14 (5.3%)	27 (10.2%)		

Meanwhile, preschool-aged children are advised to sleep between 11–12 hours per night (2). Sleep onset refers to the time a child falls asleep or begins their sleep period. This component is an important aspect of sleep patterns and can be influenced by various factors, including environmental conditions, bedtime routines, and individual characteristics (16,17). Delayed sleep onset can result in difficulties initiating sleep, leading to inadequate sleep duration and affecting overall sleep quality (18). Our research showed that neither sleep duration nor sleep onset significantly affected body weight, which differs from previous research findings. The relationship between sleep duration and body weight has been extensively studied, particularly in relation to obesity and BMI. Research generally indicates that insufficient sleep is associated with an increased risk of obesity in both adults and children. Shorter sleep duration can affect hormonal regulation, leading to changes in appetite and increased caloric intake, which may contribute to weight gain. For example, reduced sleep alters levels of leptin (a hormone that suppresses appetite) and ghrelin (a hormone that increases appetite), thereby increasing hunger and cravings for high-calorie foods (19). Children with shorter sleep duration generally have higher BMI (20). Kagamimori et al found that anxiety and sleep problems are associated with higher BMI and weight issues in preschool children. Additionally, late bedtimes, such as those during summer vacations, have been linked to more rapid weight gain in children (21). A study in Italy further suggested that weight gain among school children is influenced by sleep duration, regardless of eating habits and physical activity (22). Poor sleep quality, short sleep duration, and sleep disturbances in children have been linked to higher BMI (23). Fragmented sleep has also been associated with higher BMI and an increased risk of obesity (24). Conversely, increasing sleep duration in children has been shown to reduce BMI over time (25). We hypothesize that in our study, although appetite may have increased in children with shorter sleep duration or delayed sleep onset, food availability was limited due to low socioeconomic status, which may have prevented weight gain. Furthermore, children with shorter sleep duration and delayed sleep onset consumed milk less frequently than those with adequate sleep duration and earlier sleep onset

($P < 0.001$). Our research revealed that a significant relationship between sleep duration and sleep onset with screen time in children, which is consistent with previous studies. Technology use has been reported to have a significant impact on children's sleep patterns, particularly in relation to screen exposure before bedtime. Hale & Guan conducted a systematic literature review examining the relationship between screen time and sleep patterns in school-aged children and adolescents. Their findings indicate that screen time, including television, computers, video games, and mobile devices, disrupted sleep patterns in children (26). Philbrook et al demonstrated that bedtime technology use, such as watching television and using tablets, is associated with poorer sleep patterns in children (27). One of the primary mechanisms behind this disruption is the blue light emitted from screens, which inhibits the release of melatonin, a hormone responsible for regulating sleep. Additionally, screen content can induce emotional and cognitive stimulation, further interfering with sleep. Almuaiyel et al identified a significant positive relationship between children's sleep scores and excessive technology use, reinforcing the link between prolonged screen exposure and disrupted sleep patterns (28). Our study revealed that a significant relationship between sleep duration and HAZ ($P = 0.004$). There was also a significant difference between sleep onset and height status in children ($P < 0.0001$). Growth Hormone is a key regulator of growth in children and adolescents. It is produced by the pituitary gland and plays a crucial role in stimulating long bone growth (e.g., in the arms and legs) and increasing height. GH achieves this by stimulating the liver and other tissues to produce Insulin-like Growth Factor 1 (IGF-1), which promotes bone and cartilage growth, leading to an increase in height. The growth plate (epiphyseal plate) in bones is the site where lengthening occurs. GH and IGF-1 stimulate these plates, promoting bone growth until they fuse after puberty (29). During sleep, growth hormone (GH) is released, and disruptions in sleep patterns can lead to poor sleep efficiency, impaired GH secretion, and dysregulation of appetite hormones in children (6,30). GH secretion is particularly influenced by slow-wave sleep (SWS) (31). In the early stages of SWS or shortly after sleep onset, GH plays a crucial role in protein anabolism and tissue growth (32).

GH secretion during sleep is regulated by the production of growth hormone-releasing hormone (GHRH), which acts on the pituitary gland (33). Insufficient sleep can lead to reduced circulating anabolic hormones, including GH (34). Several studies have reported findings consistent with our results. Short stature at age two has been linked to a higher risk of chronic illnesses, as well as lower educational attainment and income in adulthood (35). A longitudinal study in Singapore revealed that lower sleep duration at three months was associated with shorter height at 24 months (36), similar to findings from a North American study of 23 preschoolers followed over 4–17 months. In the latter study, longer nighttime sleep and daytime naps were associated with greater height growth (37). A study conducted by Jiang revealed that in children aged 10–11 years, those who slept <9 hours, those who slept for ≥10 hours grew taller and gained more weight after adjusting for confounding factors (38). When children slept 9–10 hours, they had significantly higher Z score of weight and body mass index. In contrast, a cohort study (39) followed 300 children from ages 1 to 10 every six months from 12 to 24 months and annually after, found no link between sleep duration and growth across any period.

Strength and limitations

Research on sleep in children had yielded varied outcomes, and remains limited in Indonesia. Our study demonstrated that among children from low socioeconomic backgrounds, shorter sleep duration and later sleep onset were significantly associated with shorter height. To our knowledge, this is the first study to investigate the relationship between sleep duration, sleep onset and height in children from low socioeconomic backgrounds. One limitation of this study is the lack of dietary recall assessment, which prevents us from linking nutritional intake with socioeconomic status.

Conclusion

In children from low socioeconomic background, inadequate sleep duration and late sleep onset are

significantly associated with shorter height. Beyond sleep duration, sleep onset also plays a crucial role in supporting optimal growth.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors' Contribution: MHH: Data curation, data analysis, recruitment, drafting, data curation. NW: Supervising. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

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