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Short sleep duration is linked with short stature and delayed age of menarche in Indonesian boarding school girls

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Age of Menarche, Boarding School, Girl, Growth, Regular School

Abstract

Background Several factors directly and indirectly influence child growth. Menarche is the initial menstrual period that is regulated by the hypothalamic-pituitary-gonadal axis. Both growth and menarche are affected by biological, genetic, epigenetic, nutritional, and psychosocial factors. Boarding schools are assumed to encourage responsibility and maturity in children, but boarding schools are also reported to have less sleeping duration.

Objectives The current study aims to assess whether there are differences and associations in sleeping duration, physical activity, weight, height, body mass index (BMI), and age of menarche among students in boarding school and regular school.

Sample and Methods 123 girls from boarding school and 90 from regular school were selected. Students completed a questionnaire, and data on weight, height, and BMI were collected. Weight, height, and BMI were transformed into standard deviation score (SDS) according to the WHO growth chart. The data were processed using an independent t-test, multiple regression analysis, and St. Nicolas house analysis.

Results Independent t-test results showed that there are differences in the median sleep duration (5.36 hours vs. 7.14 hours), weight SDS (-0.09 vs. 0.41), height SDS (-0.65 vs. 0.05), and age of menarche (11.6 vs. 11 years old), respectively, for boarding school and regular school, while there are no differences in physical activity and BMI SDS. Multiple regression analysis and St. Nicolas house analysis showed that sleep duration has a correlation with weight SDS, height SDS, and age of menarche ($p < 0.05$).

Conclusions There is an association between sleep duration, growth, and menarche. Girls with less sleep duration have lower height and weight and are delayed in the age of menarche.

Take-home message for students Sleep length of girls from an Indonesian boarding school was shorter than sleep duration of girls who lived at home. The slimness, short stature, and considerable delay of menarche in the sleep-deprived boarding school girls were recognized. This underscores the need for proper sleep to support optimal growth and puberty in children.

Abbreviations

BMI : Body Mass Index

PAQ-A : Physical Activity Questionnaire for Adolescents

SDS : Standard Deviation Score

SNHA : St. Nicolas House Analysis

WHO : World Health Organization

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Introduction

Linear growth is regarded as the "best universal indicator[s] of child wellness" in general health (Scheffler et al. 2020; Thompson 2021). Menarche is the first menstrual period that is easily memorized in the development of a woman's sexual maturity (Krzyżanowska et al. 2016; Yermachenko and Dvornyk 2014). Several factors directly and indirectly influence child growth and puberty (Hermanussen et al. 2022; Rogol et al. 2000; Waterlow 1996) among which adequate sleep is essential. Children aged 13–18 years old are recommended to get 8–10 hours of sleep per day to achieve good health. Sufficient duration, suitable timing, high quality, regularity, and absence of sleep disruptors are necessary for a healthy sleep. One of the sleep parameters that is regularly studied in relation to health is the duration of sleep (Hirshkowitz et al. 2015; Paruthi et al. 2016). Over the last 103 years, the duration of sleep has rapidly declined among children and adolescents. The duration of sleep has been reduced by 10–12 minutes per year and is linked to later bedtime coupled with consistent or earlier getting up (Campbell et al. 2023; Matricciani et al. 2012).

Sleep duration differs among students from different countries. Sleep duration in Finland, France, Hungary, Italy, the Netherlands, South Africa, South Korea, Spain, and the UK range from 7:21 hours (South Korea) to 8:46 hours (South Africa, UK) on schooldays (Garcia-Roman et al. 2024). Few studies have investigated the determinant factors of sleep quality and quantity in children. Social, demographic, economic, environmental, culture, screen time, and medical conditions can influence sleep duration in children (Fadzil 2021; Hense et al. 2011; Yip et al. 2020; Yoo 2020) as well as the educational environment (Alfonsi et al. 2020; Chan et al. 2018; Yeo et al. 2019). A study in South Korea explained that extracurricular activities, school assignments, examination preparation, and early class start time can cause lack of sleep among students (Yang et al. 2005). Hong Kong's boarding students report significantly lower sleep durations (6–7 hours) than recommended (Chan et al. 2018).

The boarding school concept, which originated in British public schools, is a regular form of school that combines the academic and personal lives of students and also provides them with board and lodging (Zhong et al. 2024). Evidence states that boarding school students achieve greater academic sucess than non-boarding school students (Curto and Fryer 2014; Foliano et al. 2019). However, since students are separated from their parents and familiar surroundings, boarding school may also be stressful for them, which can be vital during crucial growth phases (Chang et al. 2023).

To the best of our knowledge, until now, there is no specific government policy regarding the regulation of boarding schools

in Indonesia. In a discussion by the Indonesia Ministry of Education and Culture, it was stated that boarding schools are a viable educational model to improve access to high-quality education and instill a positive character into students as boarding schools require students to share dormitories and to closely interact with teachers and peers (Research Center for Education and Culture Policy – Indonesia Ministry of Education and Culture 2018). We aimed to assess whether there are differences and associations between sleep duration, physical activity, weight, height, BMI, and age of menarche among girls of boarding school and regular school. We hypothesized that sleep duration differs between boarding school and non-boarding school girls and that the sleep duration influences students' weight, height, BMI, and age of menarche.

Sample and Methods

This observational study was conducted among 123 girls aged 12–18 from boarding high school and 90 girls from regular high school in East Java, Indonesia. The study was approved by the Ethics Committee of the Faculty of Medicine, Universitas Airlangga with the protocol number 17/EC/KEPK/FKUA/2024. All subjects provided written informed permission in compliance with the institutional Human Investigation Committee rules and the Declaration of Helsinki. The study was conducted in March–May 2024.

A qualified examiner assessed each anthropometric characteristic. Weight measurements were performed using a digital scale (Onemed®), offering precision to within 100 grams. Height measurements were obtained using a microtoise (GEA Medical®) or stadiometer, assuring accuracy to the closest 1.0 millimeter. Weight, height, and body mass index (BMI) were transformed into standard deviation score (SDS) according to the WHO growth chart. The age of menarche was obtained from students' self-remembering of the month and year or their age at the onset of first menstruation. Sleep duration was derived fromstudents' self-reports. Physical activity was assessed by PAQ-A (Physical Activity Questionnaire for Adolescents). PAQ-A consisted of 8 questions. After assigning a score from 1 to 5 for each of the 8 items (items 1 to 8) included in the physical activity composite score, the mean of these 8 items is calculated to obtain the final PAQ-A activity summary score. A score of 1 signifies minimal physical activity, whereas a score of 5 denotes maximal physical activity (Rahayu et al. 2022; Kowalski et al. 2004).

An independent t-test was used to analyze the difference of each variable between regular school and boarding school. Subsequently, a Spearman correlation matrix and a multivariate regression model were used with height SDS, weight SDS, BMI SDS, and age of menarche as the dependent variables, then sleep duration, PAQ score, school type, and parental education as the independent variables, with a significance level set at 0.05. St. Nicolas House Analysis (SNHA) (Hermanussen et al. 2021) was used to translate correlation matrices into network graphs by tracing "association chains". SNHA serves to identify and illustrate extensive interactions among variables. Data analysis was conducted using RStudio, an open-source software (RCoreTeam 2023).

Results

The characteristic data of the students are shown in Table 1. The mean sleep duration is 5.36 hours in the boarding school

versus 7.14 hours in regular school. The average age of menarche was 11.6 years old in boarding school and 11 years old in regular school. Parents who have recently attended college are more common among boarding school students.

When comparing sleep duration in boarding school, the median is lower than in regular school (5.36 hours vs. 7.14 hours, $p<0.05$), which is clinically relevant. There is no difference in physical activity (Figure 1). The difference in age of menarche (11.58 years (boarding school) vs. 11.04 years (regular school)) is significant ($p<0.05$). Height SDS and weight SDS also differed between boarding school students and those of regular school ($p<0.05$), whereas there was no remarkable difference in BMI SDS (Figure 2).

A Spearman correlation test was performed to analyze the correlation among the variables (Figure 3a). The correlation between weight SDS and BMI SDS was strongest ($r=0.89$), followed by the correlation between school type and sleep time ($r=0.76$). The most pronounced negative correlation was seen between maternal education and school type ($r=-0.49$), followed by the association between age of menarche and BMI SDS ($r=0.35$). To clarify the link between the variables, we illustrated the findings using SNHA (Figure 3b).

A multiple regression analysis was conducted to study whether sleep duration, physical activity, school type, and parental education can predict height SDS and age of menarche. Multiple regression analysis showed that sleep duration was a significant predictor of height SDS, weight SDS, BMI SDS, and age of menarche (Table 2)

Discussion

This study shows that students from both schools sleep less than recommended. Boarding school students sleep almost 2 hours less than students in regular school. Sleep-deprived girls in boarding school are slimmer, shorter, and have a significant delay in the age of menarche compared to girls in regular school who sleep more. There is no difference between physical activity and BMI in both boarding school and

Table 1 Characteristics of Indonesian girls from boarding school and regular school.

Characteristics		Boarding school (n= 123)	Regular school (n= 90)
Age (y), mean (SD)		14.25 (1.26)	12.38 (1.29)
Mother's education (freq)	Junior high school	2	2
	Senior high school	18	57
	College	103	31
Father education (freq)	Junior high school	1	1
	Senior high school	6	21
	College	116	68
Weight SDS, mean (SD)		-0.092 (1.15)	0.42 (1.20)
Height SDS, mean (SD)		-0.66 (0.76)	0.05 (1.09)
BMI SDS, mean (SD)		0.304 (1.02)	0.394 (1.28)
Age of menarche (y), mean (SD)		11.6 (1.07)	11.0 (0.86)
Sleep duration (hours), mean (SD)		5.36 (0.78)	7.14 (0.77)
Physical activity (PAQ-A score), mean (SD)		2.19 (0.54)	2.14 (0.53)

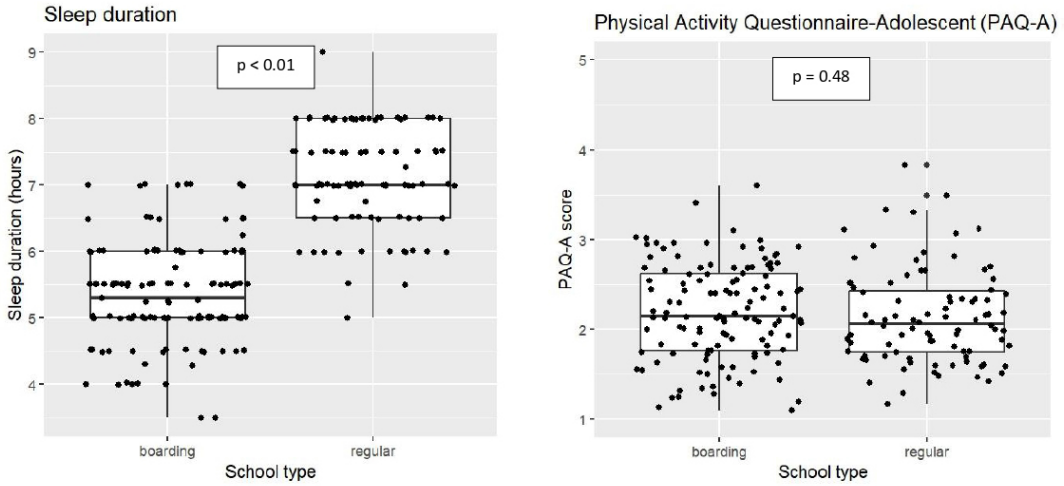

Figure 1 Comparison between sleep duration and physical activity of 12–18-year-old Indonesian girls of a boarding school and a regular school.

regular school. A moderate-to-strong age effect exists regarding adolescent school-night bedtimes and total sleep duration. Older adolescents go to bed later and sleep less. This effect is stronger in Asian teenagers who retire later than their North American peers, sleep less than European adolescents, and have higher levels of daytime drowsiness compared to adolescents from other countries (Gradisar et al. 2011). To ensure optimal health, adolescents aged 14–18 years should consistently have 8–10 hours of sleep in each 24-hour period (Loo et al. 2022).

Research on sleep duration in secondary boarding school students provided different results. Nashwan et al. 2023) showed that the mean sleep duration in an Islamic boarding school in Malaysia was 5 hours 21 minutes, with a standard deviation (SD) of 1 hour 5 minutes Owens et al. 2010) study in an independent coeducational college preparatory boarding and day school serving grades 9 to 12 showed that boarding

Table 2 Multiple regression analysis between physical activity, sleep duration, parents' education and growth, and age of menarche of 213 Indonesian girls

Independent variables	Dependent variables			
	Height SDS	Weight SDS	BMI SDS	Age of menarche
Physical activity (PAQ-A score)	-0.03 (ns)	-0.1 (ns)	-0.14 (ns)	0.01 (ns)
Sleep duration	0.27 (p<0.01)	0.24 (p=0.01)	0.06 (ns)	-0.16 (p<0.01)
Father's education	-0.32 (ns)	0.24 (ns)	1.9 (ns)	-0.34 (ns)
Mother's education	0.13 (ns)	0.08 (ns)	0.01 (ns)	0.22 (ns)
Adjusted R-squared	0.11	0.03	0.01	0.04
p-value	<0.01	0.01	ns	0.01
F-statistic	7.44	3.05	1.46	3.22

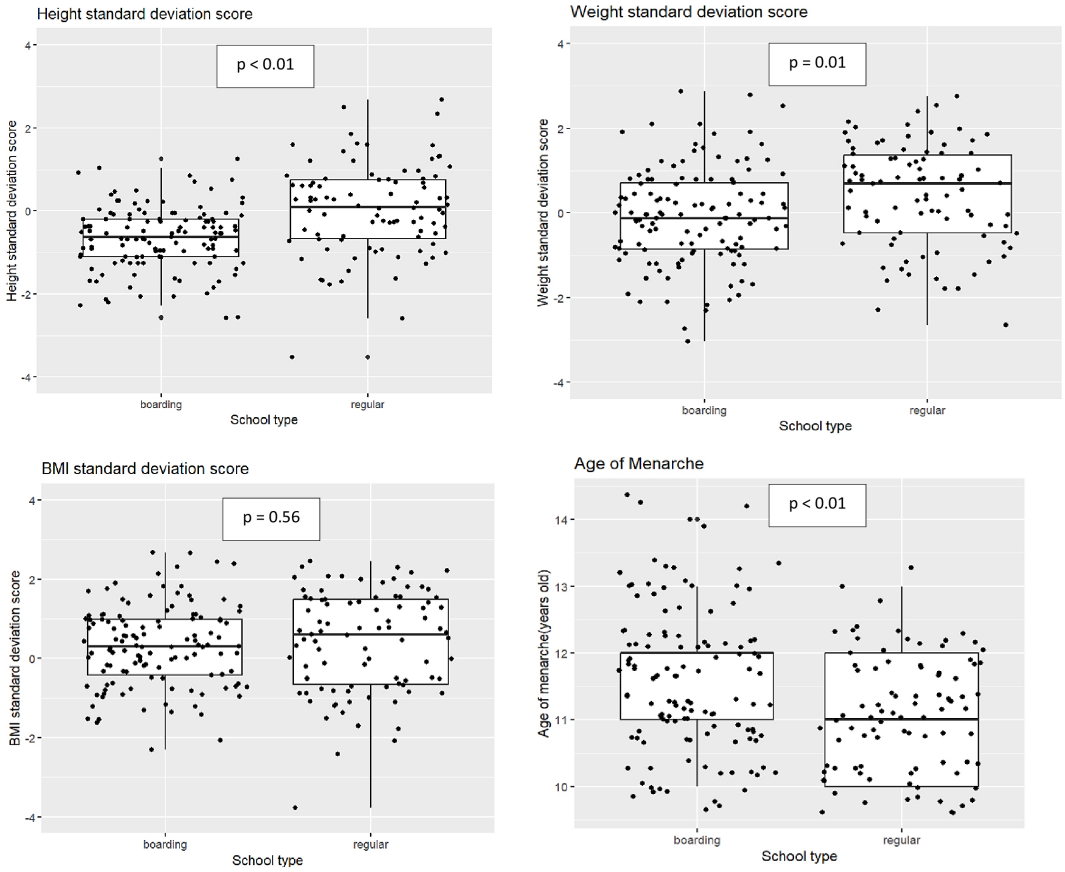

Figure 2 Differences in height SDS, weight SDS, BMI SDS, and age of menarche of 12–18-year-old Indonesian girls of a boarding school and a regular school.

students sleep shorter only on non-school nights but not on school nights, compared to day-students. Conversely, Kalak et al. 2019) observed that boarding students had a longer sleep duration. Paradoxically, they also indicated that boarding students had more sleep problems than day students, even though they slept more. Reardon et al. 2023) documented those boarding students, in contrast to day-students, reported additional 40 minutes of sleep every weekday ($p<0.001$), an earlier sleep start ($p=0.026$), and a later wake-up time ($p=0.008$).

The longer sleep duration of boarding students can be partially ascribed to a consistent nighttime routine and the restriction of technology usage after bedtime. A consistent schedule that allows for sufficient sleep is recognized as essential for children's sleep. Boarding entails a highly organized atmosphere, with designated hours for athletics, dining, academic pursuits, and social interaction, alongside stringent lights-out and wake-up schedules. Although acclimatization to boarding may need time, the established daily pattern might enhance sleep hygiene and facilitate sleep. Establishing a bedtime that allows for a minimum of 9–10 hours of sleep will further guarantee that sleep requirements are fulfilled (Hall and Nethery 2019; Mander and Lester 2021).

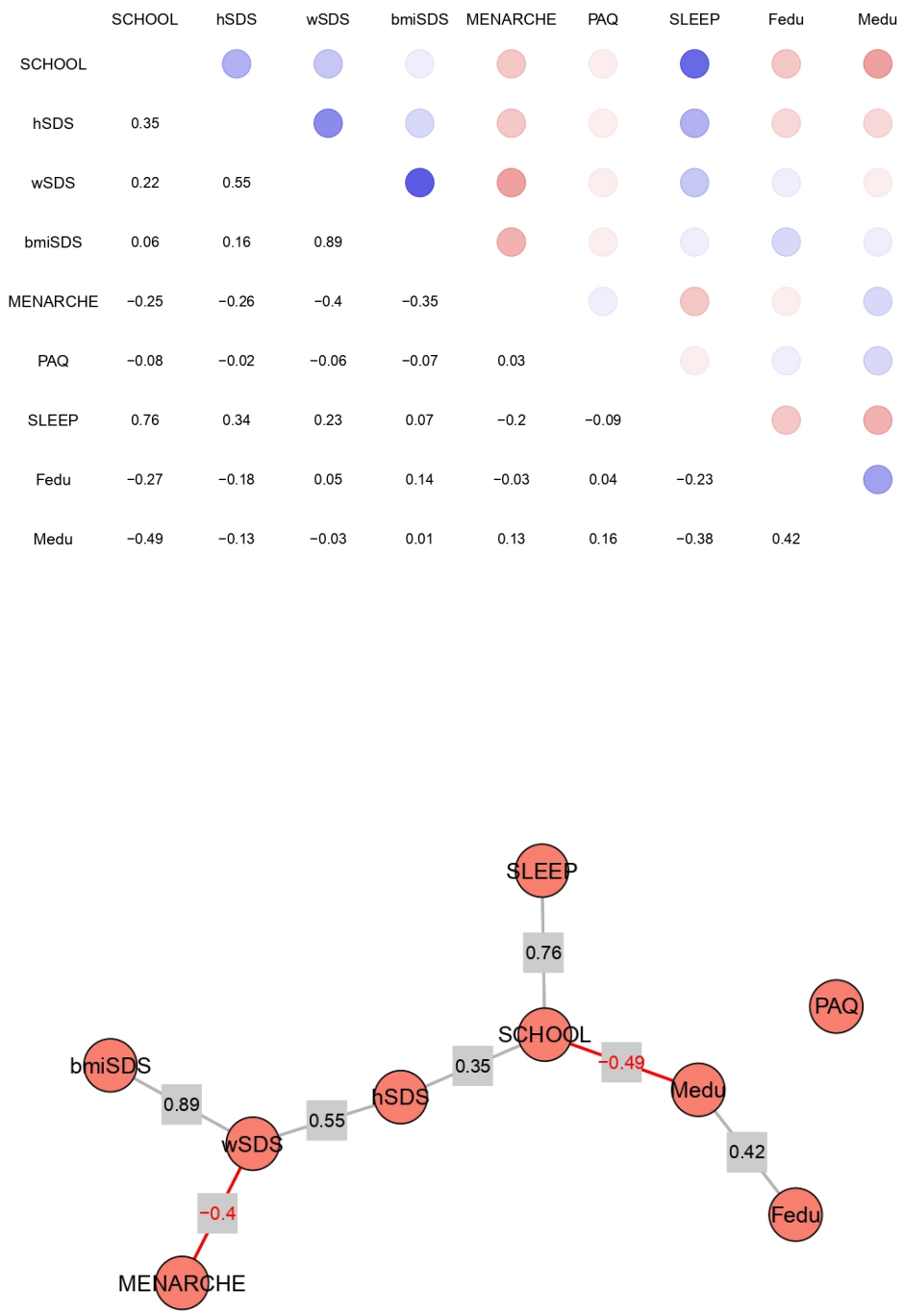

Figure 3 (a) Spearman correlation matrix for pairwise correlations between anthropometric variables, parents' education, physical activity, and sleep duration of 12–18-year-old Indonesian girls of a boarding school and a regular school. Blue circles indicate positive correlations; red circles indicate negative correlations. (b) St. Nicolas House Analysis (SNHA) for all the variables. Red lines indicate negative associations; gray lines indicate positive associations. SCHOOL=school type, Fedu=father's education, Medu=mother's education

There is evidence that lack of sleep among students has a negative correlation with height SDS. Sleep-depleted students are shorter than students with longer duration of sleep. Shorter sleep was associated with shorter body length in the first two years of life. Previous studies in older children suggest that sleep duration might influence body weight and length from infancy onwards (Zhou et al. 2015). Nocturnal Growth Hormone (GH) secretion depends on sleep and is released early after sleep starts, or in temporal correlation with the initial phase of slow-wave sleep (stages 3 and 4).

This study revealed that children with less sleep duration in boarding school have lower weight SDS than children in regular school. This data is similar to an earlier investigation that discovered that lean children who sleep for 10 hours or more increase more in weight and BMI than children who sleep less than 9 hours. This indicates that lean children may require additional sleep to increase weight (Jiang et al. 2014). This finding contradicts many prior studies that concluded that insufficient sleep predisposes to weight increase and obesity (Al-Hazzaa et al. 2012; Chaput et al. 2023; Han et al. 2022; Hitze et al. 2009). Our data suggest U-shaped or more complex non-linear links between sleep and anthropometric variables (Hassan et al. 2011; Knutson and Lauderdale 2007; Lowry et al. 2012).

Our results concerning the role of sleep duration and age of menarche correspond with the study of Zhu et al. 2023) who showed that children aged 9 to <11years who sleep less than recommended have later menarche. This was different in children age >11years who sleep less than recommended. Late menarche in the sleep-deprived children of our study contradicts previous research that suggests an association between poor sleep duration and earlier onset of the first menstrual period (Diao et al. 2020; Tang et al. 2023)

The retardation of growth and age of menarche in sleep-deprived children may be linked to stress. Decreased sleep duration and daytime drowsiness correlate with worse academic, behavioral, and psychological outcomes. These adolescents show less school satisfaction, higher absenteeism and tardiness, and inferior academic performance. Prolonged bedtime and reduced sleep duration correlate with higher anxiety and sadness, suicidal ideation, an augmented propensity for hazardous behavior, and a greater vehicular accident risk (Campbell et al. 2023). Two primary pathways are activated: 1) the hypothalamic-pituitary-adrenal (HPA) axis, and 2) the sympathetic-adrenomedullary (SAM) system, which generates catecholamines including epinephrine (adrenaline), norepinephrine (noradrenaline), and dopamine (Fernald and Grantham-McGregor 2002). Persistent activation of the stress system and hypercortisolism adversely affect the development, thyroid function, reproduction, and puberty, as well as metabolism. Elevated cortisol inhibits the growth hormone-insulin-like growth factor 1 axis, the hypothalamic-pituitary-gonadal axis, and the thyroid axis (Mousikou et al. 2023).

Given the significance of sleep for children's well-being, there is an increasing need for further research and for sleep recommendations for children in Indonesia. Lo and colleagues emphasized that adolescent male boarding students (aged 15–19 years) should not compromise sleep quality for academic performance and that staff should recognize the cumulative adverse effects of inadequate sleep on mood, attention, working memory, and processing speed. Moreover, this effect did not revert to baseline following two nights of recovery sleep and was not entirely mitigated by weekend catch-up sleep (Lo et al. 2016; Lo et al. 2017). Adjusting the school start times

may improve the child's sleep. Research at an international boarding school in Hong Kong indicated that students increased sleep duration by 35 minutes following the postponement of school start from 7:30 AM in 2016–2017 to 8:30 AM in 2017–2018 (Chan et al. 2018).

Overall, these findings support our hypothesis that there is a disparity in sleep length between boarding and non-boarding school children and that the duration of sleep has an impact on weight, height, BMI, and age of menarche.

This study has several limitations. First, the sleep duration information was obtained by self-reporting, which may introduce data bias. Second, our study largely concentrated on nocturnal sleep duration and did not analyze sleep scheduling or day sleep duration. Third, our study did not evaluate additional factors associated with growth and menarche, such as diet, depression, or other parental data. Thus, more detailed data and a larger population are required. Future research may utilize actigraphy to accurately assess sleep measurement.

Conclusion

Both boarding school girls and girls from regular schools did not meet the recommendations for total sleep duration. There is an association between sleep duration, growth, and menarche. Girls who sleep less have shorter height, lower weight, and are delayed in menarche. The findings contribute to the literature on the impact of sleep on children's growth and puberty and highlight the need for further research in this area. This study highlights the necessity of developing appropriate sleep recommendations to normalize children's growth and pubertal development.

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