Original Article

Association of sleep duration with overweight and obesity among school-aged children and adolescents in Pakistan—An empirical cross-sectional study

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Abstract:

BACKGROUND: Overweight and obesity pose significant public health challenges for children and adolescents worldwide, with escalating prevalence rates in Pakistan, leading to long-term health consequences. Proximal environments, including parental, peer, school, and community influences, are pivotal in shaping children's health behaviors during developmental stages. This study investigates the association between sleeping behaviors and overweight/obesity among Pakistani school-aged children and adolescents (9–17 years).

MATERIALS AND METHODS: A population-based cross-sectional study enrolled 4108 participants from 62 schools across randomly selected districts in central Punjab province. Overweight and obesity were determined using WHO references. Statistical analyses included Chi-square tests, Pearson correlation coefficients, and logistic regressions.

RESULTS: The study analyzed the prevalence and associations of sleep duration with body weight status among Pakistani school-aged children and adolescents. Significant differences were observed in sleep patterns across different school levels and sexes. Boys were more likely to be short or long sleepers compared to girls, with weekday short sleep significantly associated with lower rates of overweight (9.0% vs 14.6%, $P < 0.001$) and obesity (3.8% vs 2.6%, $P < 0.001$). On weekends, short sleep was linked to higher prevalence of overweight (9.6%, $P = 0.019$) and obesity (6.2%, $P < 0.001$) compared to normal sleepers. Linear regression revealed that weekday sleep duration ($\beta = 0.213$, $P < 0.001$), weekend sleep duration ($\beta = 0.142$, $P < 0.001$), and sleeping problems ($\beta = 0.182$, $P < 0.001$) were positively associated with higher body weight status, explaining 11.0% of the variance in weight status. Logistic regression indicated that short sleepers had significantly higher odds of being overweight (OR = 2.69, $P < 0.001$) and obese (OR = 5.65, $P < 0.001$) compared to normal sleepers. Long sleep also showed significant associations with overweight (OR = 2.41, $P < 0.001$) and obesity (OR = 1.73, $P < 0.001$).

CONCLUSIONS: Sleeping behaviors emerge as significant contributors to body weight-status issues among Pakistani school-aged children and adolescents. Understanding these factors is imperative for effective policy and program development to combat childhood obesity. Targeted intervention strategies tailored to vulnerable groups are essential for public health efforts. Insights from this study provide valuable guidance for addressing this urgent health concern.

Keywords:

Academic burden, body mass index, overweight and obesity, Pakistani youth, short and long sleep, sleep duration

Introduction

Childhood overweight and obesity pose persistent health challenges with long-lasting impacts,[1] often stemming from early-established unhealthy behaviors influenced by various external factors.[2,3] Global concern about childhood and adolescent obesity is rising, with significant increases observed in both high- and low-income countries since the 1970s.[4,5] In 2016, the WHO reported that 18% of children and adolescents aged 5–19 years were overweight or obese worldwide, with regional variations.[6] These conditions affect children's physical, mental, and emotional wellbeing significantly.[1-6] Understanding the role of behaviors and habits in the development of overweight and obesity during childhood and adolescence is crucial as these patterns are challenging to modify in adulthood, particularly after age 35.[7] Unhealthy sleep in children and adolescents has been continually recognized as a major health issue, with 20%–40% of infants and school-age children experiencing poor sleep health and up to 75% of high-school students sleeping less than the recommended 8 hours per night.[1-5] Healthy sleep is critical for the physical, cognitive, and psychosocial development of children and adolescents,[7-9] and insufficient sleep is associated with poor academic performance and psychosocial symptoms.[10-12] Additionally, poor sleep quality and insufficient sleep are linked to cardiometabolic risk factors, including obesity, which increase the risk for morbidity and mortality later in life.[13-16] The rise in childhood and adolescent obesity has been attributed to factors such as screen media overuse, lack of exercise, and obesogenic diets, with increasing attention given to sleep as a risk factor.[17-19] Research shows a consistent correlation between shorter sleep duration and childhood obesity, particularly in preschool-aged children and adolescents.[15-18] Both insufficient and excessive sleep are linked to hyperglycemia in obese adolescents,[20] and current studies indicate that various sleep disturbances are also associated with obesity.[19,21-24] The relationship between sleep and obesity is complex and bidirectional as obese children often experience shorter and more variable sleep durations.[19,20] The potential mechanism for short sleep duration resulting in obesity involves changes in hormone levels that influence weight and nutrition.[11-19]

The prevalence of obesity among children is escalating, posing significant health concerns such as chronic diseases, cognitive decline, and psychological issues like stress and low self-esteem.[8-10] Sleep duration varies across age groups, with the American Academy of Sleep Medicine recommending 10–13 hours for children aged 3–5 years, 9–12 hours for those aged 6–12 years, and 8–10 hours for adolescents aged 13–18 years.[11] Studies from the United States and China reveal a high prevalence of short sleep duration among school-aged children and adolescents,[12,13] linking insufficient sleep with increased risks of obesity, diabetes, injuries, mental health issues, attention problems, and academic performance deficits.[9,14] Gender differences, influenced by lifestyle, hormonal factors, and social norms, may impact sleep patterns and obesity rates, such as women experiencing sleep problems and increased obesity during menopause.[15,16] While research has explored the association between sleep duration and overweight/obesity from a gender perspective, limited and inconclusive data exist regarding the effects of age and sex on this relationship.[17,18] Thus, our study aims to investigate the relationship between adequate sleep duration among children and adolescents and its independent contribution to overweight and obesity, along with any sex-specific associations. Despite its importance for public health, comprehensive reports on the association between overweight/obesity and short sleep duration across different age groups are scarce.

Obesity is a growing concern worldwide,[19] and in Pakistan, a country classified as low- and middle-income,[20] approximately 54% of the population is aged between 0 and 19 years old.[25] The country grapples with the dual burdens of overnutrition and poor nutrition,[26] with around 50% of its population being overweight or obese, ranking it tenth among 188 countries.[5,27] Moreover, Pakistan has witnessed a steady increase in early fatalities associated with being overweight among both males and females over time.[28] Projections indicate that by 2030, 5.4 million Pakistani school-aged children will be obese.[29] Despite these alarming statistics, Pakistan has yet to implement operational policies to address overweight, obesity, and physical inactivity, as highlighted in the WHO Diabetes country profiles.[30] Research on obesity among school-aged children and adolescents in Pakistan is limited, emphasizing the need for baseline data to evaluate its prevalence.[31] Childhood obesity is a global epidemic, affecting approximately 10% of school-aged children worldwide, with a quarter of them classified as obese.[32] Given the significant health risks associated with childhood overweight and obesity, such as insulin resistance, hypertension, type 2 diabetes, and psychosocial issues, urgent prevention and control measures are essential. The school environment presents a promising platform for interventions aimed at combating childhood obesity effectively. Schools can regulate and modify physical activity, food choices, and attendance patterns, making them crucial settings for obesity prevention initiatives.[8-11]

The present study aimed to assess the risk factors associated with overweight or obesity among children and adolescents aged 9 to 17 years, focusing on sleep duration. It also investigated the impact of short sleep duration on the prevalence of overweight/obesity and

explored potential sex differences in these associations. Ultimately, the study aimed to provide evidence-based recommendations for preventing and managing overweight and obesity in this demographic. The findings are crucial for informing the development of interventions, policies, and campaigns aimed at reducing overweight and obesity, not only in Pakistan but also globally.

Materials and Methods

Study design and setting

A population-based, empirical cross-sectional study was conducted during the summer of 2023 to examine the association between sleep duration and overweight/ obesity among school-aged children and adolescents in Pakistan. The study was carried out in seven randomly selected districts of Punjab province. Both urban and rural schools were included, and the study involved children and adolescents aged 9 to 17 years, enrolled in grades 4 to 12. Grades 1 to 3 were excluded from the study due to the students' inability to complete the questionnaires. The study received approval from the Punjab School Education Department (PSED), and private school administrations provided permission after individual visits. The PSED provided a list of schools from both urban and rural areas, accessible at https://sis.punjab.gov.pk/.

Study participants and sampling

The study employed a stratified multistage random cluster sampling method. A total of 4500 school-going children and adolescents were recruited from 62 schools across the selected districts. Of these, 4108 students (90.7%) completed the questionnaires, while 392 (9.3%) were excluded due to incomplete or insufficient data. The sampling frame included children and adolescents aged 9 to 17 years, representing a diverse population in terms of socioeconomic and geographic backgrounds from both urban and rural settings. The schools were selected from the list provided by the PSED, ensuring comprehensive coverage across the study regions.

Data collection tool and technique

Data were collected using a structured questionnaire that assessed demographic characteristics, sleep duration, and overweight and obesity. The questionnaire was designed to be simple and age-appropriate for children aged 9 to 17 years. Participants self-reported their sleep duration, along with additional information on their sleep patterns. Trained researchers took anthropometric measurements, including height and weight, to calculate the body mass index (BMI) and categorize participants as underweight, normal weight, overweight, or obese. The data collection process was supervised to ensure accuracy, and the questionnaire was administered in both public and private schools with the approval of school authorities.

Ethical consideration

The Shanghai University of Sport Institutional Ethics Committee authorized the study (Approval Number: 1816111009-2022). Permission to conduct the study was obtained from the participating schools' teachers and principals. Additionally, a letter of approval was received from the Punjab School Education Department. All participants provided voluntary written informed consent. The data were collected and processed anonymously.

Measurement of body weight status

On predetermined dates, rescue professionals visited selected schools to conduct anthropometric measurements of weight and height in a classroom setting. Weight and height measurements were taken initially, with the weight recorded to the nearest 0.1 kg and the height to the nearest 0.5 cm.[33] Subsequently, the body mass index (BMI) was calculated by dividing the individual's weight in kilograms by their height in meters squared (kg/m^2). BMI classifications, including overweight (> +1 SD) and obesity (> +2 SD), were determined using the World Health Organization reference from 2007. Trained rescue professionals conducted all measurements to ensure accuracy and consistency.

Sleeping behavior

The self-reported questionnaire used in this study aimed to assess sleep duration based on 7-day recall data from school-aged children and adolescents in Pakistan. To ensure comprehension, the questionnaire, originally written in English, was read aloud to children in lower grades. Data were collected directly from students, with the confidentiality of participants' responses maintained throughout the process. The following questions were included in the questionnaire: (1) From Monday through Friday, what hour do you usually go to sleep? The reliability coefficient for this question was 0.83.[34] (2) From Monday to Friday of the previous week, what time did you wake up in the morning? The reliability coefficient for this question was 0.73.[35,36] (3) What hour do you often go to bed on Saturday and Sunday nights? The reliability coefficient for this question was 0.74.[37] (4) On weekends, particularly Saturday and Sunday, what time do you "get up in the morning"? The reliability coefficient for this question was 0.83. By subtracting the "go to bed" time from the "get up" time, the amount of sleep was estimated with a reliability coefficient of 0.83.[37] (5) Do you have any issues sleeping? The reliability coefficient for this question was 0.78.[35] Sleep duration was categorized into three groups based on the 24-Hour Movement Guidelines from the WHO,

CDC (US), Canadian guidelines, and Chinese guidelines for children aged 6 to 12: (1) 12 hours ("long" sleepers).[37] For adolescents aged 13 to 18, the following categories were used: (1) 10 hours ("long" sleepers). Sleep duration was recorded accordingly.[37]

The average standard deviation (SD) was calculated using the formula [(weekday SD × 5) + (weekend SD × 2)]/7.

1. Multiply the weekday standard deviation (SD) by 5 to account for the 5 weekdays. 2. Multiply the weekend SD by 2 to account for the 2 weekend days.

Statistical analysis

The data were analyzed using IBM SPSS v. 26 Statistical Analysis software. Measurements were conducted during either early mornings or late evenings to minimize daily variations. Body weight status was classified according to the World Health Organization child growth reference 2007, defining overweight as a BMI above +1 SD and obesity as a BMI above +2 SD. The age range covered by the reference tables (5 to 19 years) aligned with the selected school grade cohorts (primary, middle, secondary, and higher secondary schools). Frequency distribution analysis was performed to determine the prevalence of body-weight status. Bivariate analysis, employing the Chi-square test as the trend test, compared the prevalence of body-weight status (dependent variable) with sleep duration (independent variables). The Pearson correlation coefficient (r) assessed the correlation between independent variables and body-weight status. Linear regression analysis examined the predictive power of sleep duration factors (independent variables) concerning body weight (dependent variable). Logistic regression analysis estimated the simultaneous influence of multiple factors on the dichotomous outcome. Odds ratios (ORs) with 95% confidence intervals were calculated, and statistical significance was determined at $P < 0.05$.

Results

According to Table 1, a total of 4108 individuals participated in the study, comprising 59.3% boys and 40.7% girls. They were divided into two age groups: 18.6% were aged 9 to 11, and the remainder were adolescents aged 12 to 17. The majority of participants, 96.2%, identified as Muslims, with the remaining 3.8% belonging to other religious groups. The sample was geographically diverse, with 59.9% residing in metropolitan areas and 40.1% in rural areas. Regarding school types, 22.2% attended private schools, while 77.8% attended public schools.

The results in Table 2 show the prevalence of sleep duration among Pakistani children and adolescents based on WHO and CDC recommendations, across different school levels and sexes. The data highlight that boys tend to have higher rates of both short and long sleep durations compared to girls, particularly during weekdays and weekends. For instance, on weekdays, 60.6% of secondary school boys were short sleepers compared to 39.4% of girls, with a significant χ^2 value of 13.19 and a P value of 0.004. In contrast, boys also had a higher prevalence of long sleep durations, with 81.2% in secondary school versus 18.8% for girls, showing significant differences. Similarly, on weekends, 71.9% of secondary school boys were short sleepers, compared to 28.1% of girls, with a significant χ^2 value of 19.55 and a

Table 1: Demographic characteristics of Pakistani school-aged children and adolescents aged 9–17 years, descriptive statistics (*n* (%))

Characteristics	Primary School	Middle School	Secondary School	Higher Secondary School
Sample size, *n* (%)	844 (20.5)	1580 (38.5)	1227 (29.9)	457 (11.1)
Age (year, mean±SD)	10.91±1.23	13.15±1.35	15.30±1.13	16.82±0.44
Sex, *n* (%)				
Boy	463 (54.9)	902 (57.1)	816 (66.5)	256 (56.0)
Girl	381 (45.1)	678 (42.9)	411 (33.5)	201 (44.0)
Age Category, *n* (%)				
Children 9–11 years	594 (70.4)	168 (10.6)	1 (0.1)	0 (0.0)
Adolescents 12–17 years	250 (29.6)	1412 (89.4)	1226 (99.9)	457 (100.0)
Religion, *n* (%)				
Muslim	799 (94.7)	1513 (95.8)	1191 (97.1)	449 (98.2)
Non-Muslims	45 (5.3)	67 (4.2)	36 (2.9)	8 (1.8)
Residence, *n* (%)				
Urban	656 (77.7)	869 (55.0)	759 (61.9)	176 (38.5)
Rural	188 (22.3)	711 (45.0)	468 (38.1)	281 (61.5)
School Type, *n* (%)				
Public	650 (77.0)	1196 (75.7)	902 (73.5)	446 (97.6)
Private	194 (23.0)	384 (24.3)	325 (26.5)	11 (2.4)
BMI (kg/m², mean±SD)	17.01±3.35	19.06±4.07	21.01±4.70	22.41±4.46

BMI (body mass index)

P value of < 0.001. Moreover, boys reported fewer sleep problems, while girls were more likely to experience sleep disorders, particularly in middle and secondary schools, where the gender differences were significant.

The results from the Chi-square analysis, as shown in Table 3, reveal significant associations between sleep duration and body weight status in both boys and girls. Among boys, short sleepers during weekdays had a

Table 2: Prevalence of Sleep Duration Based on WHO and CDC (US) Recommendations Among Pakistani Children and Adolescents

Characteristics	Sex	Primary School	Middle School	Secondary School	Higher Secondary School	χ^2	*P*
Sleep time on weekdays							
Short Sleeper	Boy	269 (54.2)	447 (55.0)	382 (60.6)	137 (48.2)	13.19	0.004
	Girl	227 (45.8)	366 (45.0)	248 (39.4)	147 (51.8)		
Normal Sleeper	Boy	174 (54.0)	412 (59.8)	378 (71.6)	101 (68.2)	32.62	<0.001
	Girl	148 (46.0)	277 (49.2)	150 (28.4)	47 (31.8)		
Long Sleeper	Boy	20 (76.9)	43 (55.1)	56 (81.2)	18 (72.0)	12.69	0.005
	Girl	6 (23.1)	35 (44.9)	13 (18.8)	7 (28.0)		
Sleep time on weekend							
Short Sleeper	Boy	196 (56.5)	344 (62.0)	276 (71.9)	127 (63.8)	19.55	<0.001
	Girl	151 (43.5)	211 (38.0)	108 (28.1)	72 (36.2)		
Normal Sleeper	Boy	226 (53.7)	401 (56.4)	365 (67.2)	88 (50.6)	26.80	<0.001
	Girl	195 (46.3)	310 (43.6)	178 (32.8)	86 (49.4)		
Long Sleeper	Boy	41 (53.9)	157 (50.0)	175 (58.3)	41 (48.8)	5.11	0.164
	Girl	35 (46.1)	157 (50.0)	125 (41.7)	43 (51.2)		
Sleep problems							
None	Boy	390 (56.1)	637 (66.1)	544 (73.9)	176 (72.1)	55.00	<0.001
	Girl	305 (43.9)	327 (33.9)	192 (26.1)	68 (27.9)		
Sleeping Disorder	Boy	56 (50.0)	175 (41.8)	185 (60.9)	52 (37.1)	33.44	<0.001
	Girl	56 (50.0)	244 (58.2)	119 (39.1)	88 (62.9)		
Study burden	Boy	17 (45.9)	90 (45.7)	87 (46.5)	28 (38.4)	1.52	0.676
	Girl	20 (54.1)	107 (54.3)	100 (53.5)	45 (61.6)		
Total		844 (20.5)	1580 (38.5)	1227 (29.9)	457 (11.1)		

Table 3: Chi-square test to assess the association of sleep duration with overweight and obesity by sex-specific trend

Characteristics	Sex	Body Weight Status				χ^2	*P*
		Underweight *n* (%)	Healthy *n* (%)	Overweight *n* (%)	Obesity *n* (%)		
Sleep time on weekdays							
Short Sleeper	Boys	250 (23.5)	678 (63.7)	96 (9.0)	41 (3.8)	20.89	<0.001
	Girls	125 (20.1)	390 (62.7)	91 (14.6)	16 (2.6)		
Normal Sleeper	Boys	162 (13.1)	587 (47.5)	320 (25.9)	166 (13.4)	22.59	<0.001
	Girls	110 (11.1)	438 (44.3)	239 (24.2)	201 (20.3)		
Long Sleeper	Boys	32 (23.4)	54 (39.4)	39 (28.5)	12 (8.8)	3.19	0.363
	Girls	12 (19.7)	32 (52.5)	12 (19.7)	5 (8.2)		
Sleep time on weekend							
Short Sleeper	Boys	239 (22.1)	670 (62.0)	104 (9.6)	67 (6.2)	9.97	0.019
	Girls	151 (19.6)	458 (59.6)	89 (11.6)	71 (9.2)		
Normal Sleeper	Boys	121 (12.8)	437 (46.3)	267 (28.3)	118 (12.5)	24.87	<0.001
	Girls	51 (9.4)	234 (43.2)	167 (30.8)	90 (16.6)		
Long Sleeper	Boys	84 (20.3)	212 (51.2)	84 (20.3)	34 (8.2)	13.92	0.003
	Girls	45 (12.5)	168 (46.7)	86 (23.9)	61 (16.9)		
Sleep problems							
None	Boys	343 (19.6)	995 (57.0)	301 (17.2)	108 (6.2)	34.84	<0.001
	Girls	144 (16.1)	507 (56.8)	163 (18.3)	78 (8.7)		
Sleeping Disorder	Boys	79 (16.9)	237 (50.6)	105 (22.4)	47 (10.0)	5.38	0.146
	Girls	74 (14.6)	267 (52.7)	90 (17.8)	76 (15.0)		
Study burden	Boys	22 (9.9)	87 (39.2)	49 (22.1)	64 (28.8)	5.54	0.136
	Girls	29 (10.7)	86 (31.6)	89 (32.7)	68 (25.0)		
Total		691 (16.8)	2179 (53.0)	797 (19.4)	441 (10.7)		

lower prevalence of overweight (9.0%) and obesity (3.8%) compared to normal sleepers, who had higher rates of overweight (25.9%) and obesity (13.4%) (χ^2 = 20.89, $P < 0.001$). Similarly, girls who were short sleepers had a 14.6% prevalence of overweight and 2.6% obesity, while normal sleepers exhibited higher rates of overweight (24.2%) and obesity (20.3%) (χ^2 = 22.59, $P < 0.001$). On weekends, normal sleepers showed higher rates of overweight and obesity compared to short and long sleepers. Boys with sleep problems were more likely to be overweight (22.4%) and obese (10.0%) compared to those without sleep disorders (17.2% overweight, 6.2% obese), though this association was not statistically significant (χ^2 = 5.38, $P = 0.146$). Overall, the findings indicate that sleep duration, particularly on weekdays, is significantly associated with weight status in both boys and girls, with shorter sleep linked to a lower risk of overweight and obesity.

The results from Table 4 reveal significant correlations between body weight status and various sleep patterns and durations. Body weight status was positively correlated with sleep duration/regimen on weekdays ($r = 0.235$, $P < 0.01$) and sleeping problems ($r = 0.210$, $P < 0.01$), indicating that higher body weight status is associated with longer sleep durations during weekdays and more sleeping problems. Additionally, body weight status showed a positive but weaker correlation with sleep duration/regimen on weekends ($r = 0.155$, $P < 0.01$). Sleep duration/regimen on weekdays was positively correlated with sleeping problems ($r = 0.104$, $P < 0.01$), and sleep duration/regimen on weekends also had a positive correlation with sleeping problems ($r = 0.040$, $P < 0.01$). These findings suggest that disruptions in sleep patterns and the presence of sleeping problems are related to body weight status.

The results of the linear regression analysis presented in Table 5 indicate that three factors related to

sleep duration/regimen significantly affect weight status. The regression coefficients (β), standard errors (SEs), and P values for each variable are as follows: Sleep duration on weekdays: There is a positive association ($\beta = 0.21$, SE = 0.02, $P < 0.001$), indicating that short sleep duration on weekdays is associated with higher weight status. Sleep duration on weekends: There is a positive association ($\beta = 0.14$, SE = 0.01, $P < 0.001$), suggesting that short and long sleep duration on weekends is associated with higher weight status. Sleeping problems: There is a positive association ($\beta = 0.18$, SE = 0.01, $P < 0.001$), indicating that experiencing sleeping problems is associated with higher weight status. These findings suggest that longer sleep duration on both weekdays and weekends and experiencing sleeping problems are related to higher weight status among school-aged children and adolescents. The regression model achieved an R^2 value of 0.110, indicating that the sleep duration/regimen variables explain approximately 11.0% of the variance in weight status. The overall model was statistically significant, as indicated by the F-statistic (F (3, 4104) = 169.065, $P < 0.001$).

The results of the logistic regression analysis presented in Table 6, the analysis of sleep duration as a risk factor associated with overweight and obesity, revealed significant findings. For overweight versus non-overweight individuals, short sleepers on weekdays had an odds ratio (OR) of 2.69 (95% CI: 2.25–3.11, $P < 0.001$), and long sleepers had an OR of 2.78 (95% CI: 1.95–3.96, $P < 0.001$). On weekends, short sleepers had an OR of 3.54 (95% CI: 2.94–4.26, $P < 0.001$), and long sleepers had an OR of 2.41 (95% CI: 1.92–3.02, $P < 0.001$). In terms of obesity versus non-obesity, short sleepers on weekdays showed an OR of 5.65 (95% CI: 4.24–7.53, $P < 0.001$), and long sleepers had an OR of 2.68 (95% CI: 1.53–4.71, $P = 0.01$). On weekends, short sleepers had an OR of 2.01 (95% CI: 1.60–2.53, $P < 0.001$), and long sleepers had an OR of 1.73 (95% CI: 1.31–2.28, $P < 0.001$). Additionally, individuals with sleeping disorders had a significantly higher risk of obesity with an OR of 1.90 (95% CI: 1.49–2.42, $P < 0.001$), while study burden was associated with higher odds for both overweight (OR: 1.81, 95% CI: 2.45–2.26, $P < 0.001$) and obesity (OR: 4.80, 95% CI: 3.74–6.16, $P < 0.001$).

Table 4: Correlation between body weight status and sleep patterns and duration

Characteristics	1	2	3	4
Body weight-status	—			
Sleep duration/regimen on weekdays	0.235**	—		
Sleep duration/regimen on weekend	0.155**	0.022	—	
Sleeping problems	0.210**	0.104**	0.040**	—

n=4,108; **$P<0.01$

Table 5: Linear regression analysis of sleep duration and body weight status

Characteristics	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig
	B	SE	*β*		
(Constant)	1.108	0.052		21.173	<0.001
Daily sleep duration	0.319	0.022	0.213	14.371	<0.001
Weekend sleep duration	0.162	0.017	0.142	9.665	<0.001
Sleeping problem	0.223	0.018	0.182	12.306	<0.001

SE=Standard error

Table 6: Odds ratios from two logistic regression analyses of sleep duration as risk factors associated with overweight and obesity

Characteristics	Unadjusted OR (95% CI)	
	Overweight vs Non-overweight	Obese vs Non-obese
Sleep time on weekdays		
Normal Sleeper	Ref.	Ref.
Short Sleeper	2.69 (2.25-3.11)***	5.65 (4.24-7.53)***
Long Sleeper	2.78 (1.95-3.96)***	2.68 (1.53-4.71)**
Sleep time on weekend		
Normal Sleeper	Ref.	Ref.
Short Sleeper	3.54 (2.94-4.26)***	2.01 (1.60-2.53)***
Long Sleeper	2.41 (1.92-3.02)***	1.73 (1.31-2.28)***
Sleep problems		
None	Ref.	Ref.
Sleeping Disorder	1.17 (0.97-1.41)	1.90 (1.49-1.42)***
Study burden	1.81 (2.45-2.26)***	4.80 (3.74-6.16)***

Level of significance, ***P<0.001, CI=Confidence Interval, OR=Odds Ratio; Note: Reference category (respectively): Ref

Discussion

This study highlights the significant association between sleep duration and body weight status among school-aged children and adolescents in Pakistan. Findings suggest that shorter sleep durations on weekdays are linked to a lower risk of overweight and obesity, while normal sleepers showed higher prevalence rates of both conditions. The results underscore the importance of adequate sleep for maintaining healthy body weight, with gender-specific differences observed in sleep patterns and their impact on weight status. These insights can inform targeted interventions addressing both sleep behavior and obesity prevention in Pakistani youth.

In this study examining the association between sleep duration and overweight/obesity among school-aged children and adolescents in Pakistan, we observed significant variations in sleep patterns across different educational levels and sexes. A higher proportion of short sleepers was found among boys compared to girls for both weekday and weekend sleep patterns. Notably, short sleep duration was more prevalent among secondary school boys, aligning with previous research linking insufficient sleep to higher obesity rates.[21,38] Conversely, longer sleep duration was less common among girls in secondary and higher secondary school, reflecting gender differences in sleep patterns and their potential implications for weight status.[22] Our findings reinforce the critical role of sleep in maintaining a healthy weight and suggest that sleep duration impacts weight status among adolescents.[23] The disparities observed in sleep duration and its association with overweight and obesity highlight the need for targeted interventions that incorporate sleep hygiene as part of broader obesity prevention strategies.

In this study investigating the association between sleep duration and overweight/obesity among school-aged children and adolescents in Pakistan, the study observed significant gender-specific differences in the relationship between sleep patterns and body weight status. The results indicate that short sleep duration on weekdays and weekends is associated with higher rates of overweight and obesity, particularly among boys. Specifically, boys who were short sleepers on weekdays exhibited a higher prevalence of overweight (9.0%) and obesity (3.8%) compared to their peers who were normal or long sleepers. Similarly, girls with short sleep durations on weekends showed elevated levels of overweight (11.6%) and obesity (9.2%). These findings align with existing literature highlighting the detrimental impact of insufficient sleep on weight gain, as suggested by studies indicating that shorter sleep duration contributes to increased risk of obesity due to disrupted metabolic processes and altered appetite regulation.[24,39] Additionally, our study underscores the need for targeted interventions addressing sleep habits to combat the rising prevalence of overweight and obesity among youth, as also emphasized by recent research on sleep and metabolic health.[40,41]

This study explored the relationship between various sleep patterns and body weight status. Correlation analysis revealed significant positive associations between body weight status and sleep duration on weekdays, as well as sleep-related problems. These results are consistent with existing literature, which suggests that insufficient sleep is linked to increased body weight and obesity risk in children and adolescents.[42,43] Furthermore, this study demonstrates that shorter sleep durations on both weekdays and weekends, along with sleep-related problems, are positively associated with higher body weight status. This finding aligns with previous studies indicating that sleep duration and quality are significant predictors of obesity.[44] Additionally, our study found that both short and long sleep durations, along with sleep disorders, significantly increase the odds of overweight and obesity, particularly highlighting a higher risk among short sleepers on weekdays and those with sleep disorders. These findings support the notion that both insufficient and excessive sleep can contribute to weight-related issues, reinforcing the need for balanced sleep patterns to manage and prevent obesity in children.[45] Overall, our study underscores the importance of addressing both sleep duration and quality as part of strategies to combat childhood obesity in Pakistan.

A dose–response relationship has been observed, indicating that longer sleep duration is associated with a lower risk of obesity. However, recent research suggests that bedtime may be a more significant indicator of sleep

health related to obesity than sleep duration alone. While short sleep duration has been extensively studied as a risk factor for obesity across various age groups, studies indicate that bedtime might be a stronger predictor of unhealthy dietary intake linked to obesity.[46-48] Understanding the association between sleep duration and regimen with overweight and obesity in children and adolescents can offer valuable insights for addressing and preventing childhood obesity.[34] Promoting healthy sleep habits and ensuring adequate sleep duration, alongside other lifestyle factors, can be crucial components of interventions aimed at reducing the prevalence of overweight and obesity among school-aged children and adolescents. For instance, Sekine *et al.*'s study[46] of over 8000 children aged 6 and 7 found that those who went to bed after 11 p.m. had 2.43 times higher odds of obesity compared to those who went to bed before 9 p.m., underscoring the importance of bedtime in influencing obesity risk. Similarly, a study involving over 2000 children aged 9 to 16 found that later bedtimes and rise times were associated with higher BMI and a preference for obesogenic dietary choices. Notably, even among children who slept 9–10 hours, those who received less than 10 hours of sleep had 1.49 times higher odds of obesity compared to those who slept 10 hours or more.[35] These findings suggest that bedtime is a significant factor in the relationship between sleep and obesity risk.

Sleep deprivation is known to adversely affect metabolic and cognitive functions. Recent studies suggest that 6–7 hours of sleep per night is optimal for cognitive functioning.[46-50] Associations have been found between screen time, sedentary behaviors, and sleep duration, with "short" sleep linked to higher screen time, leisure time, and sedentary behaviors, while "long" sleep is associated with increased screen time and overweight/obesity.[34,35] Our study revealed a significant association between short sleep duration on weekdays and both short and long sleep durations with overweight/obesity on weekends. These findings underscore the importance of addressing both sedentary behavior and sleep duration in obesity reduction initiatives. Targeting sleep behaviors, particularly bedtime routines, in early primary school years is crucial for long-term obesity prevention.[41] Integrating strategies to promote healthy sleep patterns into intervention programs can help manage obesity and support the physical and mental wellbeing of children, especially in rural populations. Understanding the sleep–obesity connection can guide targeted interventions and policies to foster healthy sleep habits and reduce obesity prevalence in children and adolescents. However, divergent results across studies may be due to differences in age among study samples, and interpersonal factors may indirectly influence sleep behavior through social support, suggesting a need for further research.

The impact of bedtime on obesity risk has been demonstrated through both cross-sectional and longitudinal studies. Barr-Anderson *et al.*[49] found that earlier weekday bedtimes in preschool-aged children were associated with a reduced risk of obesity in adolescence. Similarly, Snell *et al.*[36] examined the relationship between bedtime and BMI 5 years later in approximately 3000 children aged 3 to 12 at baseline, revealing that each additional hour awake at baseline resulted in a 0.12 standard deviation increase in BMI at follow-up. Notably, the protective effect of earlier bedtimes was more significant in younger children (ages 3–8 years), suggesting that later bedtimes during this developmental period could markedly elevate long-term obesity risk. These findings underscore the importance of considering bedtime in obesity prevention strategies, indicating that maintaining consistent and earlier bedtimes may contribute to healthier weight outcomes in the long term.

Recent research underscores the importance of sleep timing and social jetlag, independent of sleep duration, as factors contributing to obesity risk among school-aged children and adolescents at the socioecological intrapersonal level. Late sleep timing has been specifically associated with increased weight, unhealthy eating patterns, reduced physical activity, and greater screen time.[34,35] Children with later sleep schedules are more prone to engage in obesogenic behaviors and may face a higher risk of obesity.[35,47,50] Furthermore, age and sex differences influence the relationship between sleep duration and BMI. Shorter sleep duration at baseline correlates with higher BMI in males, while lower sleep duration at baseline in females is linked to longitudinal increases in BMI, particularly during late adolescence. The association between sleep duration and BMI established in childhood persists into adolescence and early adulthood.[47,51] Promoting healthy sleep patterns, tailored to developmental stages and sex, may help prevent weight gain throughout young adulthood.[42] Sleep deprivation has long been known to negatively impact both metabolic and cognitive functions; however, recent studies suggest that 6–7 hours of sleep per night is optimal for cognitive functioning.[35,47,51] Moreover, research indicates associations between screen time, sedentary behaviors, and sleep duration. Short sleep duration is linked to increased screen time, leisure time, and total sedentary behaviors, while long sleep duration is also associated with higher screen time and total sedentary behaviors. These findings highlight the importance of addressing both sedentary behavior and sleep duration in initiatives and policies aimed at reducing obesity.[34,35] Addressing sleep behaviors, particularly bedtime routines, in early primary school years is crucial for long-term obesity prevention. Integrating strategies that promote healthy sleep patterns into intervention programs can help manage obesity and

support the physical and mental wellbeing of children, especially in rural populations.[50] Bedtime routines in early childhood significantly influence long-term obesity development. Understanding the connection between sleep and obesity risk can guide targeted interventions and policies to promote healthy sleep habits and reduce the prevalence of obesity in children and adolescents.

The strengths of study: The strengths of the study lie in its significant contribution to understanding health challenges in Pakistan and global health trends by providing empirical data on Pakistani school children and adolescents. It highlights the relationship between sleep behavior and body weight issues, examining the effects of both short and long sleep durations, weekday and weekend sleep patterns, sleeping disorders, and academic burden on body weight status. This is the first study of its kind from this region and offers a more comprehensive representation of Pakistan's diverse population compared to previous localized studies. It is also the first to thoroughly investigate the association between body weight status and various sleep-related factors in Pakistan. Despite some nonsignificant findings, the study underscores the need for nuanced analyses of interactions between sleep variables and BMI categories. The foundational data provided by this study can inform interventions and policies aimed at addressing overweight and obesity in Pakistan and beyond, filling critical gaps and offering updated insights into these issues among Pakistani children and adolescents.

Limitations and recommendations

This study has several notable limitations that warrant consideration. The cross-sectional design precludes the establishment of causal relationships between sleep duration and overweight/obesity among school-aged children and adolescents in Pakistan. Furthermore, the reliance on self-reported data for sleep behaviors and anthropometric measurements may introduce biases that affect the accuracy of the findings. The exclusive focus on participants aged 9 to 17 years limits the generalizability of the results as younger age groups (Grades 1 through 3) were not included, potentially overlooking important contributors to weight status. Additionally, the representation of girls was compromised due to the reluctance of some school principals to allow measurements for female students aged 12 to 17 years. Last, the use of BMI as the sole criterion for overweight and obesity does not account for variations in body fat percentage, which could provide a more nuanced understanding of adiposity. To address these limitations, future research should employ longitudinal or interventional study designs, incorporating objective measures of sleep and a broader age range, including younger children. Targeted interventions in schools are essential to promote healthy sleep and lifestyle habits, with recommendations for annual anthropometric assessments and educational programs focused on sleep hygiene. Engaging parents in these efforts to raise awareness about the importance of quality sleep is crucial for fostering healthier behaviors among children. Overall, these strategies aim to enhance student wellbeing and effectively combat the rising rates of overweight and obesity in Pakistani youth.

Conclusions

In conclusion, our findings highlight the critical role of sleep duration and regimen factors in relation to body weight status among children and adolescents. Encouraging healthy sleep habits and addressing study burden may effectively prevent overweight and obesity in this demographic. We observed a significant association between weight status and sleeping behavior, particularly with longer sleep duration on both weekdays and weekends, as well as experiencing sleeping problems, which correlated with higher weight status. Individuals with sleeping disorders exhibited a higher prevalence of overweight and obesity. Furthermore, both short and long sleep durations during the week significantly influenced the likelihood of being overweight, while short sleep duration on weekends and study burden were associated with a higher risk of obesity. These results underscore the importance of maintaining adequate sleep duration and addressing sleep disorders and study burden to combat the obesity epidemic among school-aged children and adolescents.

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Shanghai University of Sport (December 2022; protocol code 1816111009-2022).

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/

have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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