

Sleep Duration, Sleep Problems, and Socioeconomic Inequalities Associated with Overweight and Obesity Among School-Aged Children and Adolescents: A Population-Based Cross-Sectional Study

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Abstract

BACKGROUND

Overweight and obesity among school-aged children and adolescents are major public health concerns globally, including in Pakistan.

OBJECTIVES

To assess the association of socioeconomic factors and Short Sleep Duration, Sleep Problems with people with overweight and obesity among Pakistani school-aged children and adolescents.

METHODS

A cross-sectional study was conducted among 4,108 children and adolescents from 62 schools in Punjab, Pakistan. Body weight status was classified using the WHO growth reference (2007), with people with overweight defined as BMI $> +1$ SD and people with obesity as BMI $> +2$ SD. Socioeconomic status (SES) was assessed through parental education and occupation, while sleep duration was categorized as short, normal, or long. Bivariate and logistic regression analyses were used to examine associations between weight status and socioeconomic and sleep factors, calculating odds ratios (OR) and 95% confidence intervals (CI).

RESULTS

A significant proportion of children and adolescents exhibited insufficient sleep. Those with short sleep duration on weekdays and weekends had higher rates of overweight (25.1% and 29.2%, respectively) and obesity (16.5% and 14.0%, respectively). Logistic regression analysis revealed that children with low SES had higher odds of obesity (OR = 1.12, 95% CI: 1.03–1.23), particularly those with lower parental education (OR = 1.22, 95% CI: 1.05–1.41). Additionally, boys from urban areas had significantly higher odds of long sleep duration on weekdays (OR = 1.59, 95% CI: 1.37–1.83). Sleep problems and academic burden were also significantly associated with increased odds of obesity, especially among girls (OR = 1.19, 95% CI: 1.01–1.41). Children from high SES backgrounds were more likely to have normal sleep duration (OR = 0.95, 95% CI: 0.81–1.12).

CONCLUSION

Socioeconomic status and sleep duration significantly influence the risk of overweight and obesity among Pakistani school-aged children and adolescents. Those from lower-income households and experiencing sleep deprivation are at higher risk. Targeted interventions are needed.

1. Introduction

Overweight and obesity in children continue to be major worldwide health issues with long-lasting effects, frequently stemming from unhealthy habits influenced by outside factors early in life [1, 2]. Childhood and

adolescent obesity has significantly increased worldwide since the 1970s [3], in both high- and low-income nations [4, 5]. About 18% of people between the ages of 5 and 19 were considered to have overweight or obesity in 2016, according to the World Health Organization (WHO), with significant regional variations [6, 7]. The physical, emotional, and psychological development of children and adolescents with obesity is negatively impacted by these conditions [8]. Given how difficult it is to change early-life behavioral habits in adulthood, especially after the age of 35, it is imperative to comprehend how these behaviors lead to obesity [9–11]. Sleep has been identified as one of these behavioral elements that significantly influences health. Between 20% and 40% of children report not getting enough sleep, while up to 75% of high school students don't get the necessary eight hours a night [12]. Getting enough sleep is essential for healthy physical development, mental clarity, and emotional control [13], and lack of sleep is repeatedly associated with poorer academic outcomes and more psychological problems [14, 15]. Furthermore, getting too little or poor-quality sleep increases the risk of long-term morbidity and death by contributing to cardiometabolic risks, such as obesity [16–19]. Obesity is known to be caused by sedentary behavior, decreased physical activity, and poor eating habits, but sleep is also becoming recognized as a controllable risk factor [20–24]. Obesity and short sleep duration have been strongly linked in studies [25, 26], especially in preschool-aged children and adolescents with obesity [27, 28]. Both too little and too much sleep have been connected to hyperglycemia in teenagers with obesity [29], and a variety of sleep disorders are becoming more and more linked to an increased risk of obesity [30–32]. Sleep and obesity are linked in both directions; children with obesity frequently have inconsistent and shorter sleep periods [33–35]. Mechanistically, sleep deprivation may influence weight through hormonal disruptions that impact appetite regulation and energy balance [25].

Children are becoming more and more affected by obesity, which is causing serious health problems such as chronic illnesses, cognitive decline, and psychological problems like stress and low self-esteem [7–9]. According to the American Academy of Sleep Medicine, toddlers aged 3 to 5 should sleep 10 to 13 hours, children aged 6 to 12 should sleep 9 to 12 hours, and teenagers aged 13 to 18 should sleep 8 to 10 hours [36]. Insufficient sleep is very common among school-aged children and adolescents [37], according to research from China and the United States. Short sleep duration is linked to a higher risk of obesity, diabetes, injuries, mental health issues, attention issues, and poor academic performance [37–40]. Sleep patterns and rates of obesity may also be impacted by gender variations, which are influenced by lifestyle choices, hormones, and societal conventions. For example, after menopause, women with obesity are more likely to experience greater sleep difficulties [41, 42]. Although some research has examined the association between sleep duration and obesity among different genders, there is conflicting and limited data on how age and sex relate to this relationship [43, 44]. Thus, the purpose of this study is to investigate the association between sleep length and obesity in Pakistani school-aged children and adolescents, with a particular emphasis on sleep duration's independent role in overweight and obesity, as well as any sex-specific effects [45, 46]. Comprehensive research on the relationship between inadequate sleep and obesity across different age groups is lacking, despite its significance for public health.

The prevalence of obesity is rising worldwide [2–5, 19], and in Pakistan, a low- and middle-income nation [20], about 54% of the population is under the age of 19 [21]. The nation ranks tenth out of 188 nations [5, 23], with around 50% of its people living with overweight or obesity, and it suffers the twin problems of overnutrition and inadequate nutrition [22]. Additionally, throughout time, Pakistan has shown an increase in overweight-related early deaths among both boys and girls [24]. It is predicted that 5.4 million school-age children in Pakistan will be children with obesity by 2030 [25]. According to the WHO Diabetes country profiles, Pakistan does not have operational plans to address overweight, obesity, and physical inactivity, despite these alarming statistics [26].

Due to the paucity of research on obesity in Pakistani school-age children and adolescents, baseline data is necessary to determine its prevalence [27]. About 10% of school-aged children worldwide are affected by childhood obesity, with 25% of them being children with obesity [46, 48]. Prompt intervention and preventive strategies are essential since pediatric obesity poses serious health hazards, including insulin resistance, hypertension, type 2 diabetes, and psychological issues. Schools provide an important context for addressing childhood obesity because they may control physical activity, dietary choices, and attendance patterns, which makes them ideal settings for obesity prevention initiatives [8–11].

The purpose of the current research was to examine risk factors of overweight and obesity in children and adolescents aged between 9 and 17 years with the special emphasis given to sleep duration. It investigated the association between short sleep duration and the proportion of overweight and obesity among children and adolescents with question of whether there were sex differences in such associations. The research was also aimed at determining the role of socioeconomic differences on compliance of sleep duration and how it affects body weight status. The results can inform the formulation of specific interventions, policies and social health campaigns to prevent and control obesity and overweight in the youth not only in Pakistan but also in other parts of the world. These understandings are important to enhance the health outcomes among this group of people and decrease the incidence of health challenges within the obesity context.

2. Materials and Methods

2.1 Study design, and participants

In the summer of 2023, a population-based cross-sectional survey was conducted in seven randomly selected districts of Punjab, Pakistan, in children and adolescents (ages 9 to 17). They selected 4,200 pupils in 62 schools to include in the final sample, using a stratified multistage random cluster selection strategy with 92 students being filtered out because of the poor data. Moreover, 737 parents failed to respond to the questionnaire, or provided inadequate information, and 3371 parents (82.05) responded to the questionnaire. The data of each child was linked with the responses of their parent with a unique serial number, which resulted in 3,371 complete parent-child pairs. The sample was comprised of children in grades four through twelve; children in grade one through three were excluded.

The Punjab School Education Department gave the approval to do the study and gave a formal permission to the involvement of the public schools. Inspections were also done physically by the administration of the private schools which gave approval. The Punjab School Education Department (<https://sis.punjab.gov.pk>) offered a list of both urban and rural schools. In the case of a nominal fee, the schools which were publicly operated were 20 PKR, whereas the schools which were privately operated were 10,000 PKR, due to the socioeconomic differences [7, 26]. Alternative institutions were selected where the schools were not participating to ensure the representative sampling. The researchers worked together with the Rescue-1122 and education departments as well.

The sample size was calculated with the Epi Info 6.04d software; it guaranteed a 95 percent confidence level (1 – 0), a 5 percent estimated prevalence, and a 1 percent margin of error, which was based on the data of the US Centers of Disease Control and Prevention (2004). The study sample of 3,371 participants was more than the minimum number of 3,246 participants and could give strong statistical power to the study [7, 26].

This study was approved by Shanghai University of Sport's Institutional Ethics Committee on December 23, 2022, in accordance with the Declaration of Helsinki's tenets (Ethical Code: 1816111009-2022. Additionally, the principals and teachers of the participating schools, as well as the Punjab School Education Department (Approval Code: PU180220-633357), granted permission to conduct the study. All participants gave their written informed consent. Consent was obtained from parents or legal guardians of participants under the age of sixteen. During the data collection and processing process, all participants received assurances regarding the confidentiality and anonymity of their answers.

2.2 Measurement of Weight-status

Trained experts conducted anthropometric measurements in a classroom environment at a few chosen schools on prearranged days. Height and weight were reported to the closest 0.5 cm and 0.1 kg, respectively. The weight in kilograms was then divided by the height in meters squared (kg/m^2) to determine the body mass index (BMI). The BMI categories for people with overweight ($> +1$ SD) and people with obesity ($> +2$ SD) were derived from the 2007 World Health Organization reference. To guarantee accuracy and consistency, all measurements were performed by qualified experts [2, 7, 26].

2.3 Weekday and Weekend Sleep Duration, Academic Sleep Problems

In this study, school-aged children and adolescents in Pakistan completed a self-reported questionnaire to gauge how much sleep they had based on a seven-day recollection. Students in lower grades were read the questionnaire, which was initially written in English, to make sure they understood it. Participants provided the data directly, and their answers were kept completely secret at all times [7, 26].

The questionnaire included the following questions: (1) "From Monday through Friday, what time do you usually go to sleep?" (reliability coefficient: 0.83) [30]; (2) "From Monday to Friday of the previous week, what time did you wake up in the morning?" (reliability coefficient: 0.73) [7, 31, 32]; (3) "What time do you usually go to bed on Saturday and Sunday nights?" (reliability coefficient: 0.74) [7, 33]; (4) "On weekends, particularly Saturday and Sunday, what time do you wake up in the morning?" (reliability coefficient: 0.83); and (5) "Do you have any issues sleeping?" (reliability coefficient: 0.78) [7, 26].

Sleep duration was calculated by subtracting the "go to bed" time from the "get up" time, with an overall reliability coefficient of 0.83 [7, 33]. The sleep duration was then 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, the categories were as follows: (1) 12 hours (classified as "long" sleepers) [33]. For adolescents aged 13 to 18, the categorization used was: (1) 10 hours (classified as "long" sleepers) [7, 33].

To calculate the average sleep duration, the standard deviation (SD) was computed using the formula: $[(\text{weekday SD} \times 5) + (\text{weekend SD} \times 2)] / 7$. This accounts for the 5 weekdays and 2 weekend days, ensuring an accurate representation of sleep patterns *throughout the week* [7, 26].

2.4 Socioeconomic Disparities

The parental questionnaire used to assess sociodemographic factors among Pakistani school-aged children and adolescents included the following key items:

1. **Number of Siblings** (Reliability Coefficient = 0.72): This item assessed whether the child had only one sibling or multiple siblings [1, 10, 26].
2. **Parental Education Level** (Reliability Coefficient = 0.78): Respondents indicated their highest level of education, categorized as low education (less than college or university) and high education (college, university, or higher) [1, 36].
3. **Parental Occupation** (Reliability Coefficient = 0.78): This item identified the respondent's profession, with options including: (1) Own company or job, (2) Day laborer [10, 26, 36].
4. **Household Income** (Reliability Coefficient = 0.87): Respondents reported their household income in Pakistani rupees, classified into three categories: low socioeconomic status (SES), middle SES, and high SES, based on predefined income ranges [8, 26, 36].
5. **Family Structure** (Reliability Coefficient = 0.81): This question identified whether the child was raised in a **single-family** or **joint-family** household [26, 36].

The reliability coefficients demonstrate the internal consistency of each item. The questions were adapted from previous studies by Cai et al. [1], Mushtaq et al. [10], Chen et al. [36], and Kiyani et al. [38]. Additionally, the questionnaire collected broader socioeconomic data, including the number of children in the family, detailed education levels (illiterate, primary, middle school, secondary, intermediate, graduate, postgraduate), occupation (civil servant, private-sector employee, business owner, daily laborer), and family living arrangements. Household income was classified as low-income ($\leq 90,000$ PKR), middle-income ($90,000-300,000$ PKR), and high-income ($> 300,000$ PKR) [26–28].

2.5 Statistical Analysis

IBM SPSS v.26 software was used to analyze the data. To reduce daily changes, measurements were taken either in the early morning or late at night. The World Health Organization's 2007 Child Growth Reference was used to classify body weight status; a BMI above + 1 SD was considered as people with overweight, while a BMI above + 2 SD was considered as people with obesity [7]. The reference tables' age range of 5 to 19 years matched the chosen school grade cohorts, which included primary, middle, secondary, and upper secondary schools [26]. To determine the prevalence of body weight status, a frequency distribution analysis was conducted. Socioeconomic inequalities and sleep duration (independent variables) were compared to the prevalence of body weight status (dependent variable) using a bivariate analysis using the chi-square test. Logistic regression analysis was conducted to estimate the simultaneous influence of these multiple factors on the dichotomous outcomes. Odds ratios (OR) with 95% confidence intervals were calculated to examine the relationship between socioeconomic disparities, sleep duration, and overweight/obesity. Statistical significance was set at $p < 0.05$.

3. Results

Table 1. Demographic Characteristics of School-Aged Children and Adolescents in Pakistan (Aged 9–17) and Their Parents, Categorized by Educational Level (n = 4,108 for Students; n = 3,371 for Parents).

(Body Mass Index)

Table 1 shows demographic status of school-going children and adolescents (aged 9–17) in Pakistan and their parents based on the educational level. The student sample (n = 4,108) demonstrates a progressive growth in

the BMI with higher education level, $17.01 \pm 3.35 \text{ kg/m}^2$ at primary schools to $22.41 \pm 4.46 \text{ kg/m}^2$ at higher secondary schools, with an anticipated trend in the aging of the population. Boys were predominant in all the categories especially secondary school (66.5), with majority of the students being Muslim (94.7%-98.2). The lower level of education had more urban residents and higher secondary school had more rural representation. Students in the public institutions were also in the majority of higher secondary with the number of students attending the school being almost 97.6 percent. In the case with parents ($n = 3,371$), the greatest number of parents had two or more children, where a higher proportion was in the lower education category of joint families. The most typical occupational phase of parents was business or jobs (68.1%74.4%), and lower socioeconomic status (SES), especially in primary (66.5%) and middle school (65.9%). The level of higher education was increasing in progressive levels among the parents with the highest percentage of higher education level parents at 45.9 being of the higher secondary school.

Fig 1. Assessment of the Prevalence and Association Between Socioeconomic Status and Sleep Duration Guidelines with Overweight and Obesity.

The data on **Fig 1** shows the prevalence and correlation of socioeconomic status, sleep duration guidelines and overweight/obesity in school aged children and adolescents. The overweight (18.7%) and obesity (9.0) prevalence among boys was higher than the prevalence among girls (20.5% and 13.3%, respectively). The length of sleep also contributed a lot with short sleepers (25.1% overweight, 16.5% with obesity) on weekdays and short sleepers (29.2% overweight, 14.0% with obesity) on weekends having more weight problems than normal and long sleepers. Body weight was also affected by sleep problems with children with study burden showing the highest level of overweight (27.9%) and obesity (26.7%). Weight status was linked with parental education and occupation: children whose parents had high educational levels (25.0) were more prone to overweight compared to children whose parent had low education (11.6). Another important factor was the socioeconomic status (SES) of children of high SES origin were more obese children (14.1) compared to middle (11.2) and low SES origin children (9.4%). Moreover, the form of family living also affected the weight status, as the children of joint families were a bit more obese (11.0%) compared to children of single-family households (9.8%). The results indicate the intricate interaction between socioeconomic and sleep-related factors in obesity and overweight in childhood..

Fig 2. Significance assessment of the prevalence and association between socioeconomic factors and sleep duration guidelines with people with overweight and people with obesity.

Fig 2 presents the significance assessment of the prevalence and association between various socioeconomic factors and sleep duration guidelines with overweight and obesity. The analysis highlights significant associations for several variables. Gender differences were evident, with boys ($\chi^2 = 26.99, p < 0.001$) showing a stronger association than girls. Sleep duration on weekdays and weekends also showed significant correlations, with normal sleepers exhibiting the most prominent association (weekdays: $\chi^2 = 374.67, p < 0.001$; weekends: $\chi^2 = 273.96, p < 0.001$). Sleep problems were linked with obesity, as no sleep problems were associated with lower obesity rates ($\chi^2 = 232.81, p < 0.001$). Socioeconomic factors also played a role, with children from single-child families ($\chi^2 = 18.03, p < 0.001$) and those with lower parental education ($\chi^2 = 104.93, p < 0.001$) showing higher rates of obesity. Conversely, parental occupation ($\chi^2 = 4.20, p = 0.240$) and family living arrangements ($\chi^2 = 4.24, p = 0.237$) did not show significant associations. Furthermore, a low socioeconomic status (SES) was linked to obesity ($\chi^2 = 16.51, p = 0.011$), emphasizing the influence of socioeconomic disparities on childhood obesity.

Table 2. Regression analysis of sex differences in people with varying sleep duration guidelines and socioeconomic status.

Table 2 regression analysis examines sex differences in the correlation between reports on sleep duration guidelines, socioeconomic status (SES), and other variables. There are only slight differences between the odds of being short or long sleepers and normal sleepers among boys and slight changes in the odds of long sleepers (OR = 0.853) among boys than girls (OR = 1.173). Urban boys stand a considerably better chance of getting long sleep duration during weekdays (OR = 1.591) than girls (OR = 0.629). About sleep problem, boys with sleep problems are less likely to report short sleep duration (OR = 0.837), whereas girls with sleep problems are more likely to report long sleep duration (OR = 1.195). Socioeconomic conditions also affect the duration of sleep; boys whose parent education level is high tend to have normal sleep (OR = 1.221), whereas girls whose parent education level is high do not have long sleep duration (OR = 0.819). Finally, living in a single-family is related to better sleep quality among boys (OR = 1.045) but not with girls (OR = 1.013). The results in this case suggest that there are no-table gender differences in the sleep patterns based on family structure, sleep problems and socioeconomic status.

Table 3. Regression analysis of grade differences with sleep duration guidelines and socioeconomic status in people with overweight/obesity.

Table 3 The regression test investigated the difference in grades based on the duration of sleep and the socioeconomic status among different school levels. In primary school students (4-5 grades), boys were much less likely to have sleep problems than girls (OR 0.684, 95% CI: 0.574-0.815). Contrary to this, the odds of students with Muslim background experiencing sleep problems were higher than those of students with non Muslim background (OR 3.361, 95% CI: 2.747-4.114). The duration of sleep was also a factor with short sleepers having slightly elevated odds of sleep problems and long sleepers having less odds (OR 0.677, 95% CI: 0.424-1.079). The socioeconomic status (SES) showed that students with high socioeconomic backgrounds were less likely to have sleeping problems than students with low socioeconomic backgrounds (OR 0.329, 95% CI: 0.212-0.510). There was also an influence on the sleep duration patterns by other factors including family structure and parental education level, but the associations were different in various grade levels.

Table 4. Stagewise/Stepwise Multivariate Logistic Regression Adjusted Odds Ratios (95% CI) for sleep duration guidelines and Socioeconomic Status as Risk Factors for People with Overweight and People with Obesity.

Note: Reference category (respectively): Ref.; * $p \leq 0.05$, ** $p < 0.01$, *** $p < 0.001$; Abbreviations: CI = confidence interval, OR = Odds Ratio;

Table 3, the stepwise multivariate logistic regression analysis revealed several significant associations between sleep duration, socioeconomic status (SES), and weight status among Pakistani school-aged children and adolescents. Boys had significantly lower odds of being overweight or having obesity compared to girls, especially in Model 2 (OR=0.79 and OR=0.66, respectively). Urban residence was associated with higher obesity risk (OR=1.35, 95% CI: 1.06–1.72). Notably, short sleep duration on weekdays and weekends was strongly associated with overweight and obesity in Model 1. For instance, short weekday sleepers had more than five times higher odds of obesity (OR=5.14, 95% CI: 3.83–6.90), while short weekend sleepers had significantly increased odds of both overweight (OR=3.28) and obesity (OR=1.77). Long sleep duration also showed elevated obesity risk in Model 1. Additionally, students reporting study-related sleep problems had higher odds of

overweight and obesity. In Model 2, being a single child and having parents with higher education levels were associated with greater odds of being overweight, while high SES was significantly linked to increased obesity risk (OR=1.57, 95% CI: 1.08–2.28). These findings underscore the multifaceted influence of sleep behaviors and SES on childhood overweight and obesity, highlighting the need for holistic prevention strategies.

4. Discussion

Results of this research show that socioeconomic inequalities as well as the duration of sleep play a major role in contributing towards overweight and those with obesity in school going children and adolescents in Pakistan. The findings indicate that children in the lower socioeconomic status (SES) were more likely to have overweight and obesity rates and children in the high SES backgrounds had relatively higher rates of obesity. This highlights the multidimensional interaction of socioeconomic and weight condition among children and adolescents [2–5]. Moreover, the compliance of sleep duration, especially short sleepers, is strongly associated with the high rate of obesity and overweight, which is consistent with available literature on the significance of a healthy sleep to ensure good body weight [7]. The findings also indicate a large gender variation in sleep patterns and weight condition, whereby, boys tend to have a higher tendency towards obesity although their sleep behavior is different to that of girls. The results form the basis of the necessity of the customized interventions that concentrate on sleep hygiene and socioeconomic elements to reduce the increasing obesity rates among children in Pakistan [26].

The results of the present research highlight the complexity of the relationships between socioeconomic factors, the length of sleep and childhood obesity in Pakistan. An interesting fact was that the gains in BMI were reported to be more than the gains in education and levels of education were associated with increased levels of BMI [34, 35]. Boys had a higher occurrence of overweight and obesity particularly those who have sleeping disorders. Sleep patterns were also found to play a crucial role in childhood weight control since short sleep duration especially on weekends had a significant relationship with high levels of overweight and obesity [7]. In addition, socioeconomic status (SES) became a significant predictor [26]; children with higher SES were found to have a bigger tendency to obesity compared to the desired trend [36]. The regression analysis also showed gender differences in the duration of sleep and its relationship with obesity where boys had stronger relationships with sleep problems and girls had more pronounced relationships with long sleep duration. These findings underscore the complexity of obesity in children, in which a combination of sleep issues, as well as socioeconomic inequalities intersect to determine weight status [37]. These dynamics are essential to understand so as to develop specific interventions that respond to both behavioral and environmental factors that determine obesity among school-going children.

Such findings are in line with previous studies which have associated sleep deprivation with weight gain. Research indicates that sleep deprivation increases the risk of obesity through poor appetite control and metabolism. We find that to mitigate obesity among the youth, it is important to aim at altering sleep pattern. We looked at the relationship between various sleeping patterns and body weight. Correlation analysis demonstrated that there is a significant positive relationship between weight status and the duration of the sleep on weekdays and problems related to sleep. The findings are consistent with the prior research regarding weight of children in relation to the poor sleep. Additionally, we also discovered that the more one weighs, the less one sleeps throughout the weekdays and on weekends, and the fewer the problems with sleep. Sleep disorders, short and long sleep are all risk factors that contribute toward chances of overweight and obesity with the

highest risk being those who have both disorders and short sleep. Therefore, proper sleeping habits play a crucial role in preventing and managing obesity in children since insufficient sleep, as well as excessive sleep, leads to obesity. In our study, the quality and quantity of sleep are important issues that should be considered to counter childhood obesity in Pakistan.

Obesity risk was found to be reduced according to length of sleep: the longer the sleep, the less the risk. Recent publications indicate that bedtime could become a stronger indicator of sleep health related to obesity, rather than sleep duration. Although short sleep is a famous risk factor of obesity across the age groups, bedtime can be a more accurate indicator of unhealthy food intake. Learning the relationship between sleep duration and timing and childhood and teen obesity can be used to enhance prevention and treatment. Sleep habits and proper sleep time among other lifestyle modification interventions could be critical in the prevention of overweight and obesity among school going children. Sekine et al. studied more than 8 – 000 children between the age of 6–7. They discovered that children who fell into bed after 11 3.p.m. had odds of obesity of 2.43 times more than those who fell into bed before 9 3.p.m., which meant that bedtime was a risk factor. Another study of over 2,000 children aged between 9 and 16 years found a link between later bedtime and later wake times and increased BMI and increased preference to obesogenic foods. Even with sleep duration of 9–10 hours, children who slept less than 10 hours were found to be at the highest risk of being obese with the risk of being obese being 1.49 times compared to children who slept 10 hours or above.

Such results indicate that bedtime is considered one of the important aspects of the sleep-obesity relationship. Sleep deprivation inhibits brain and body activity. According to recent studies, 6 to 7 hours of sleep daily are the most optimal sleep hours in terms of cognition. Sleep length is related to screen time, leisure activities and sedentary behavior. Short sleep is associated with increased screen time, leisure and sedentary habit whereas long sleep is related to increased screen time and obesity. Our research has revealed that short weekday sleep and short and long weekend sleep had a significant positive correlation with overweight and obesity. Thus, interventions to decrease obesity should focus on the duration of sleep and sedentary behavior. To prevent it in the long term, it is necessary to pay attention to sleep habits, in particular, night routine in primary school. The promotion of proper sleeping patterns in intervention programs would facilitate their physical and mental wellbeing especially in rural regions and assist them to cope with obesity.

Longitudinal and cross-sectional research have shown how bedtime affects the risk of obesity in children and adolescents [7]. Early bedtimes on weekdays were linked to a lower incidence of obesity in adolescence, according to research by Anderson et al. [49]. Snell et al. also looked at the association between bedtime and BMI five years later in over 3,000 children who were between the ages of 3 and 12 at baseline. They found that for every hour more that the children were awake at baseline, their BMI increased by 0.12 standard deviations at follow-up. Early bedtimes were found to have a greater protective impact on younger children (ages 3–8), indicating that later bedtimes at this developmental stage may significantly increase the risk of long-term obesity [32]. These results highlight the need of taking bedtime into account when developing obesity prevention measures, suggesting that consistent and earlier bedtimes may eventually lead to better weight outcomes. At the socio-ecological intrapersonal level, recent studies highlight the importance of social jet-lag and sleep scheduling, which are factors that influence the risk of obesity in school-aged children and adolescents regardless of sleep length [26]. Particularly, late sleep scheduling has been linked to higher screen time, poor eating habits, decreased physical activity, and weight gain [30, 31]. Children who sleep later are at a higher risk of obesity because they are more likely to participate in obesogenic activities [31, 47, 50]. Additionally, the

association between sleep duration and BMI is influenced by changes in age and sex. Males who had shorter baseline sleep duration had higher BMIs, but females who had shorter baseline sleep duration had higher BMIs over time, especially in late adolescence. Childhood-established relationships between sleep duration and BMI continue into adolescence and the early years of adulthood [47, 51]. Encouraging sleep habits that are appropriate for a person's sex and developmental stage may help keep them from gaining weight as they become older [42]. While it has long been recognized that sleep deprivation impairs both metabolic and cognitive processes, new research indicates that 6–7 hours of sleep each night are ideal for cognitive performance [31, 47, 51]. Furthermore, studies show links between screen use, sedentary habits, and sleep length. Increased screen time, leisure time, and overall sedentary behaviors are connected to short sleep length, whereas greater screen time and overall sedentary activities are linked to long sleep duration. These results emphasize the need of targeting sleep duration and sedentary behavior in programs and policies targeted at lowering obesity [30, 31]. Long-term obesity prevention requires addressing sleep habits, especially nighttime routines, in the early elementary school years. Particularly in remote areas, incorporating techniques that encourage sound sleep habits into intervention programs can aid in the management of childhood obesity and enhance children's physical and emotional health [50]. Early childhood bedtime practices have a big impact on the development of obesity over the long run. Knowing how sleep affects the risk of obesity might help direct focused treatments and policies that encourage sound sleeping practices and lower the incidence of childhood and adolescent obesity [52].

Strengths of the Study:

This research would be a useful addition to the concept of the problem of public health in Pakistan and the development of global health trends. It provides new empirical data of Pakistani school-age children and adolescents with references to the relationship between body weight status and sleep duration. A total of more than 600 participants are analyzed (overweight and obese) assessing short versus long sleep, patterns of sleep on weekdays and on weekends, sleep disturbances and academic stress. Having a great sample size and being more diverse than prior local research, the work sets new standards in the field by experimenting with the connection between the variables of sleep and body weight among Pakistani youth in a more thorough manner. Although there were no significant findings in some of them, the study calls on close studies of the interactions between sleep behaviors and BMI groups. The provided background data can be used to inform the future interventions and policies, which would help to address the gaps in the research and provide new perspectives on these problems in children and adolescents in Pakistan and beyond.

Limitations of the Study:

This research has a number of significant limitations. To begin with, its cross-sectional nature does not allow us to draw a causal conclusion to the observed relationships. Second, the use of self-reported sleep patterns and anthropometric measurements creates a possibility of reporting bias. Third, the researchers used only children and adolescents aged 9–17 that limited the generalizability of the study, especially to lower reaches of grades (1–3) that might have different sleep and weight patterns. Fourth, we could not record many female students between the ages of 12 to 17 in the schools that refused to be measured thus it was inadequately represented. Lastly, the application of BMI in determining overweight and obesity overlooks the percentage of body-fat that may be a better measure of adiposity. These limitations imply that the results may be viewed with skepticism and that future studies should be conducted to address these limitations.

5. Conclusions

In this cross-sectional research, there was an obvious correlation between overweight and obesity among Pakistani children and adolescents, the duration of sleep, and socioeconomic disparities. Boys more often than girls were obese and residing in an urban area predisposed one to obesity. Reduced hours of sleep, on weekdays and weekends, was highly linked to increased likelihood of overweight or obesity, which demonstrates the significance of sleep patterns in weight. The research also established that children in higher socioeconomic status families were more obese compared to children in middle and low status families. The family structure, parental education and occupation also had an effect: children had more likely to be overweight with highly educated parents but there was no correlation between the job of parents and obesity problem.

These findings suggest that childhood obesity is caused by a combination of sleep habits and socioeconomic factors and therefore the two have to be addressed simultaneously in order to be effectively prevented. Academic stress on children caused the highest rates of overweight and obesity in children, and with stress management and an increase in sleep quality probably being major components of any intervention, it is important to note that their sleep was disrupted. Longitudinal or intervention designs should be used in future studies to better establish the way in which sleep duration, socioeconomic gaps and obesity relate to each other as time progresses. Priority should be given to interventions that aid children in obtaining adequate sleep, particularly children with sleep disorders or those that study stress. Interventions that lessen socioeconomic inequalities, such as the provision of improved access to healthy food and physical activity, education, etc., can also play a critical role in combating obesity in children. Further studies are necessary to consider the influence of gender and urban-rural disparities on sleep patterns and obesity to make the strategies of the public health more specific and efficient.

Declarations

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethics Statement: This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the Institutional Review Board of Shanghai University of Sport (23 December 2022; protocol code 1816111009-2022).

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Clinical Trial: Not applicable.

Author Contributions:

Moazzam Tanveer and Cai Yujun conceptualized the study project, supervised the implementation process, and edited the manuscript. Moazzam Tanveer, Alexios Batrakoulis, Cai Yujun, Nadeem Roy, Umar Tanveer and Shemaila Saleem participated in study development. Moazzam Tanveer, Umar Tanveer, and Nadeem Roy collected the data. Ejaz Asghar analyzed the data and contributed to the manuscript. Luca Paolo Ardigo advised on the study and edited the manuscript. Moazzam Tanveer, Cai Yujun, Georgian Badicu, Nadeem Roy, and Luca Paolo Ardigo assisted in data analysis and edited the manuscript. All authors have read and approved the final manuscript.

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Tables

Table 1. Demographic Characteristics of School-Aged Children and Adolescents in Pakistan (Aged 9–17) and Their Parents, Categorized by Educational Level (n = 4,108 for Students; n = 3,371 for Parents).

Characteristics	4th-5th Graders n (%)	6th-8th Graders n (%)	9th-10th Graders n (%)	11th-12th Graders n (%)
Sample size, n (%) 4108	844 (20.5)	1580 (38.5)	1227 (29.9)	457 (11.1)
BMI (kg/m2, mean $\pm$ SD)	17.01 $\pm$ 3.35	19.06 $\pm$ 4.07	21.01 $\pm$ 4.70	22.41 $\pm$ 4.46
Age (year, mean $\pm$ SD)	10.91 $\pm$ 1.23	13.15 $\pm$ 1.35	15.30 $\pm$ 1.13	16.82 $\pm$ 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)
Religion				
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				
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				
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)
Parental sample, n (%) 3371	719 (21.3)	1208 (35.8)	1080 (32.0)	364 (10.8)
Siblings				
Single child	56 (7.8)	69 (5.7)	36 (3.3)	29 (8.0)
Two or more children	663 (92.2)	1139 (94.3)	1044 (96.7)	335 (92.0)
Parental education				
Low education level	462 (64.3)	753 (62.3)	653 (60.5)	197 (54.1)
High education level	257 (35.7)	455 (37.7)	427 (39.5)	167 (45.9)
Parental occupation				
Own business or job	535 (74.4)	849 (70.3)	735 (68.1)	248 (68.1)
Daily laborer	184 (25.6)	359 (29.7)	345 (31.9)	116 (31.9)
Socioeconomic status (SES)				
Low SES	478 (66.5)	796 (65.9)	681 (63.1)	238 (65.4)
Middle SES	217 (30.2)	316 (26.2)	275 (25.5)	93 (25.5)

High SES	24 (3.3)	96 (7.9)	124 (11.5)	33 (9.1)
Family living				
Single family	410 (57.0)	718 (59.4)	708 (65.6)	199 (54.7)
Joint family	309 (43.0)	490 (40.6)	372 (34.4)	165 (45.3)

(Body Mass Index)

Table 2. Regression analysis of sex differences in people with varying sleep duration guidelines and socioeconomic status.

	Boy			Girl		
Characteristics	OR	Adjusted OR (95%CI)		OR	Adjusted OR (95%CI)	
Religion						
Muslim vs Non- Muslim	0.92	0.64	1.33	1.07	0.75	1.55
Residence						
Urban vs Rural	1.59	1.37	1.83	0.62	0.54	0.72
Sleep duration weekdays.						
Normal Sleeper	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Short Sleeper vs Normal Sleeper	1.07	0.92	1.24	0.93	0.80	1.08
Long Sleeper vs Normal Sleeper	0.85	0.61	1.18	1.17	0.84	1.63
Sleep duration weekend.						
Normal Sleeper	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Short Sleeper vs Normal Sleeper	1.00	0.85	1.17	0.99	0.85	1.17
Long Sleeper vs Normal Sleeper	0.72	0.59	0.87	1.38	1.14	1.67
Sleep problems.						
None	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Sleeping Disorder vs None	0.83	0.70	0.98	1.19	1.01	1.41
Study burden vs None	0.82	0.66	1.01	1.21	0.98	1.51
Siblings						
Single child vs Two or more	2.74	1.92	3.92	0.36	0.25	0.52
Parental education						
Low education level v s high level	1.22	1.05	1.41	0.81	0.70	0.94
Parental occupation						
Business or job vs	1.05	0.90	1.23	0.94	0.81	1.10
Socioeconomic status (SES),						
Low SES	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Middle SES vs Low SES	1.04	0.88	1.23	0.95	0.81	1.12
High SES vs Low SES	1.12	0.87	1.46	.885	0.68	1.15
Family living						
Single family vs Joint family	0.98	0.85	1.13	1.01	0.87	1.16

Table 3. Regression analysis of grade differences with sleep duration guidelines and socioeconomic status in people with overweight/obesity.

	Primary School 4th-5th graders			Middle School 6th-8th graders			Secondary School 9th-10th graders			Higher Secondary School 9th-10th graders		
Characteristics	OR	Adjusted OR (95%CI)		OR	Adjusted OR (95%CI)		OR	Adjusted OR (95%CI)		OR	Adjusted OR (95%CI)	
Sex												
Boy vs Girl	0.68	0.57	0.81	0.78	0.67	0.90	1.77	1.52	2.07	0.96	0.76	1.21
Religion												
Muslim vs Non- Muslim	3.36	2.74	4.11	0.83	0.58	1.20	1.55	1.02	2.36	2.36	1.08	5.16
Residence												
Urban vs Rural	3.36	2.74	4.11	0.71	0.62	0.83	1.01	0.86	1.18	0.33	0.26	0.41
Sleep duration weekdays.												
Normal Sleeper	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Short Sleeper	1.07	0.89	1.29	1.11	0.95	1.30	0.92	0.78	1.08	0.81	0.64	1.02
Long Sleeper	0.67	0.42	1.07	1.09	0.77	1.53	1.18	0.83	1.66	0.99	0.59	1.65
Sleep duration weekend.												
Normal Sleeper	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Short Sleeper	0.87	0.72	1.05	1.18	1.00	1.38	1.01	0.86	1.20	0.79	0.61	1.03
Long Sleeper	0.68	0.54	0.87	1.30	1.07	1.58	0.91	0.74	1.12	1.18	0.87	1.58
Sleep problems.												
None	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Sleeping Disorder	0.82	0.67	1.01	1.39	1.18	1.65	0.91	0.76	1.09	0.70	0.52	0.94
Study burden	0.91	0.70	1.18	0.95	0.76	1.20	0.95	0.75	1.20	1.44	1.05	1.99
Siblings												
Single child vs Two or more	1.97	1.39	2.78	1.04	0.76	1.41	0.43	0.30	0.64	1.34	0.87	2.06
Parental education												

Low education level v s high level	0.78	0.65	0.94	0.96	0.82	1.11	1.04	0.89	1.22	1.46	1.16	1.84
Parental occupation												
Business or job vs	0.80	0.66	0.98	0.95	0.81	1.11	1.17	1.00	1.38	1.09	0.85	1.39
Socioeconomic status (SES)												
Low SES	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Middle SES vs Low SES	1.00	0.83	1.21	0.99	0.84	1.17	0.99	0.83	1.18	0.99	0.76	1.29
High SES vs Low SES	0.32	0.21	0.51	0.95	0.73	1.24	1.81	1.40	2.35	1.07	0.72	1.60
Family living												
Single family vs Joint family	0.83	0.70	0.99	0.93	0.80	1.08	1.38	1.18	1.61	0.78	0.62	0.98

Table 4. Stagewise/Stepwise Multivariate Logistic Regression Adjusted Odds Ratios (95% CI) for sleep duration guidelines and Socioeconomic Status as Risk Factors for People with Overweight and People with Obesity.

	Model 1: (n = 4,108)		Model 2: (n = 3,371)	
	Overweight vs. Non-Overweight	People with obesity vs. People without obesity	Overweight vs. Non-Overweight	People with obesity vs. People without obesity
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Characteristics				
Sex				
Boys	0.92 [0.78-1.09]	0.81 [0.66-1.01]	0.79 [0.65-0.96]**	0.66 [0.53-0.83]**
Girls	Ref.	Ref.	Ref.	Ref.
Religion				
Muslim	1.04 [0.67-1.60]	0.67 [0.40-1.12]	0.68 [0.43-1.05]	0.71 [0.42-1.20]
Non-Muslims	Ref.	Ref.	Ref.	Ref.
Residence				
Urban	1.04 [0.88-1.23]	1.37 [1.10-1.71]**	0.96 [0.79-1.17]	1.35 [1.06-1.72]*
Rural	Ref.	Ref.	Ref.	Ref.
Sleep duration weekdays.				
Normal Sleeper	Ref.	Ref.	Ref.	Ref.
Short Sleeper	2.38 [1.98-2.87]***	5.14 [3.83-6.90]***	0.92 [0.76-1.12]	1.26 [0.99-1.62]
Long Sleeper	2.83 [1.97-4.08]***	2.36 [1.33-4.21]**	0.90 [0.65-1.61]	1.27 [0.76-2.15]
Sleep duration weekend.				
Normal Sleeper	Ref.	Ref.	Ref.	Ref.
Short Sleeper	3.28 [2.71-3.97]***	1.77 [1.39-2.25]***	1.23 [1.00-1.52]*	1.25 [0.96-1.61]
Long Sleeper	2.53 [2.01-3.20]***	1.96 [1.46-2.63]***	0.92 [0.70-1.19]	1.34 [0.99-1.82]
Sleep problems.				
None	Ref.	Ref.	Ref.	Ref.
Sleeping Disorder	1.08 [0.88-1.31]	1.71 [1.33-2.20]***	1.08 [0.86-1.34]	0.98 [0.75-1.29]

Study burden	1.61 [1.27-2.03] ^{***}	4.23 [3.63-5.49] ^{***}	1.25 [0.95-1.64]	1.16 [0.84-1.62]
Siblings				
Single child			1.77 [1.26-2.50] ^{**}	1.06 [0.64-1.75]
Two or more			Ref.	Ref.
Parental education				
Low education level			Ref.	Ref.
High education level			2.51 [2.07-3.03] ^{***}	0.97 [0.76-1.23]
Parental occupation				
Business or job			1.10 [0.89-1.35]	1.08 [0.84-1.39]
Daily laborer			Ref.	Ref.
Socioeconomic status (SES)				
Low SES			Ref.	Ref.
Middle SES			1.17 [0.95-1.45]	1.17 [0.90-1.51]
High SES			1.16 [0.83-1.60]	1.57 [1.08-2.28] [*]
Family living				
Single family			0.93 [0.77-1.12]	0.89 [0.71-1.12]
Joint family			Ref.	Ref.

Note: Reference category (respectively): Ref.; * $p \leq 0.05$, ** $p < 0.01$, *** $p < 0.001$; Abbreviations: CI = confidence interval, OR = Odds Ratio;

Figures

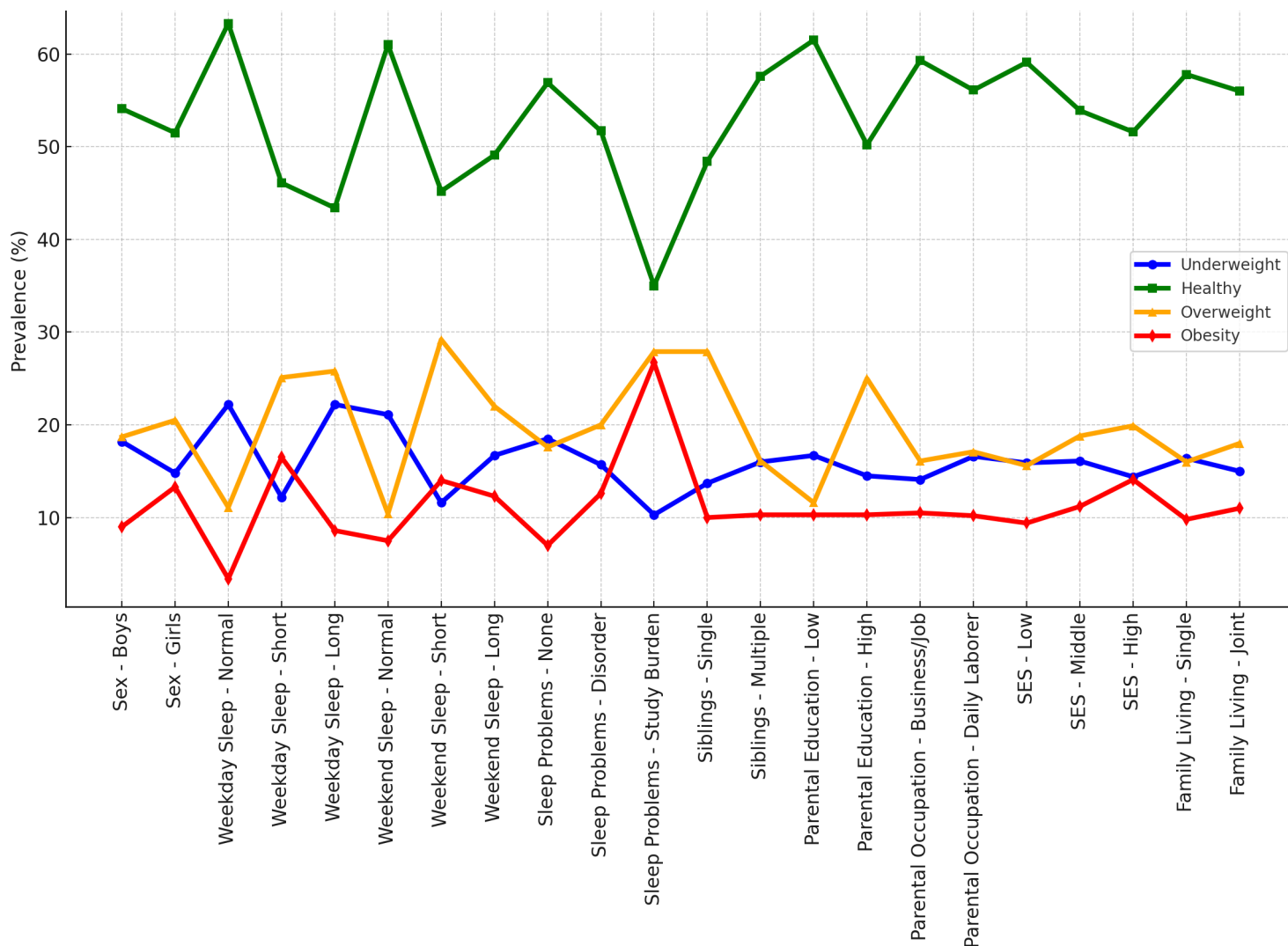


Figure 1

Assessment of the Prevalence and Association Between Socioeconomic Status and Sleep Duration Guidelines with Overweight and Obesity.

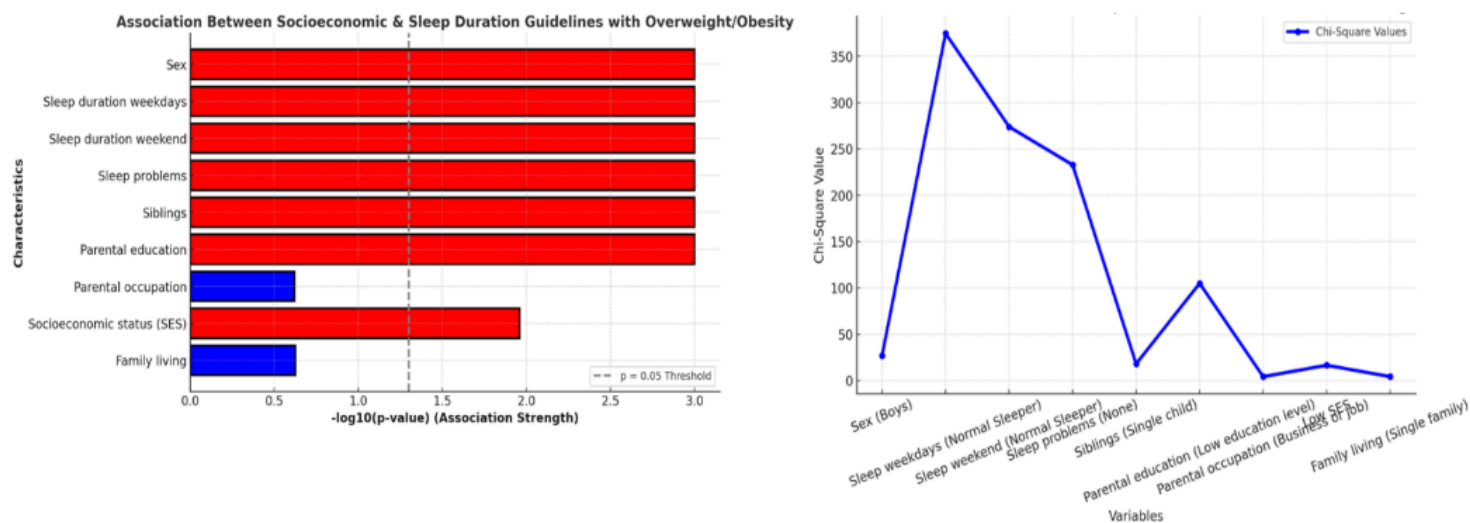


Figure 2

Significance assessment of the prevalence and association between socioeconomic factors and sleep duration guidelines with people with overweight and people with obesity.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterials.docx](#)