



ORIGINAL CONTRIBUTION

Exploring the Relationship Between Sleep Patterns, BMI, and Academic Performance: A Comparative Study of Adolescent Students in Rural and Urban Areas of Multan

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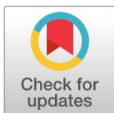
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Abstract— This study aimed to explore the interrelations among sleep duration, body mass index, and academic performance in adolescents from rural and urban areas of Multan, Pakistan. The current study, utilizing a quantitative approach, the study focused on two primary research questions: The impact of nightly sleep duration on academic achievement and the role of BMI in this relationship. Conducted in the 2019 academic year, the study employed a cross-sectional design and included 250 high school students aged 12 to 14 from South Punjab, Pakistan. The participants, comprising 49.7% boys and 50.3% girls, were selected through a suitable sampling technique. Data analysis was performed using SPSS software, with a significance level set at $p < 0.05$. Contrary to expectations, longer sleep duration was found to significantly improve academic performance in adolescents. A positive correlation emerged between reduced sleep and improved academic outcomes. BMI was identified as a mediator in this relationship, elucidating how sleep patterns influence academic success. Notable disparities were observed in sleep patterns and BMI between rural and urban adolescents, with high rates of insufficient sleep linked to overweight and obesity risks. Urban students generally slept less than rural ones, while rural students showed a higher tendency toward being underweight. The study highlights the counterproductive nature of sacrificing sleep for academic gains, revealing that insufficient sleep negatively impacts both health and academic achievement. It calls for a re-evaluation of educational priorities towards a more holistic approach to student wellbeing. The findings suggest the need for policies focusing on enhancing sleep duration, reducing academic stress, and improving nutrition and health in rural areas. Future studies should delve deeper into this relationship, exploring interventions that optimize sleep, health, and learning in diverse socio-ecological settings.

Index Terms— Academic performance, Body mass index, Sleep duration, Obesity, Overweight

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Introduction

In the contemporary academic landscape, the pursuit of educational success often comes at the expense of adequate sleep, a trend increasingly observed among adolescents worldwide. This paper explores the intricate relationship between sleep patterns, Body Mass Index (BMI), and academic performance among adolescent students in the diverse urban and rural areas of Multan, Pakistan. The significance of sleep as a fundamental physiological need, particularly during the critical developmental phase of adolescence, cannot be overstated. Adolescence is a period characterized by significant physical, cognitive, and emotional growth, making sleep an essential component for overall health and wellbeing. The relationship between sleep and academic performance in adolescents is a topic of considerable interest and debate in the field of educational and health sciences.

The role of sleep in influencing academic performance has been a topic of considerable interest and debate in recent years. Research has established a complex relationship between sleep duration, quality, and academic outcomes. Chada et al. (2023) found that sleep duration is inversely related to daytime somnolence, which in turn negatively affects academic performance in adolescents (Chada et al., 2023). This suggests that inadequate sleep can lead to increased sleepiness during the day, impairing students' ability to concentrate and perform academically. Similarly, Jalilolghadr et al. (2021) reported that factors such as sleep duration, sleep onset delay, and sleep insufficiency significantly influence academic performance, highlighting the multifaceted nature of sleep's impact on educational outcomes (Jalilolghadr et al., 2021).

However, the relationship between sleep and academic performance is not simple. Short et al. (2013) observed that while sleep duration showed no direct effect on adolescent functioning, sleep quality, and circadian chronotype significantly impacted alertness, mood, and academic performance (Short et al., 2013). This indicates that the quality of sleep, rather than just its duration, plays a crucial role in determining academic success. In contrast, Musshafen et al. (2021) found that sleep duration and sleep quality in adolescents have negligible correlations with academic performance, suggesting that other factors might also play a significant role in this relationship (Musshafen et al., 2021).

Further complicating this relationship is the finding by Hysing et al. (2016) that short sleep duration and sleep deficit are associated with the highest odds of poor academic performance in adolescents aged 16-19 years (Hysing et al., 2016). This aligns with the research by Wang et al. (2016), who noted that increased sleep time is associated with improvements in classroom concentration and increased educational attainment (Sabia et al., 2017). Raley et al. (2016) also found that a longer duration of sleep is associated with better academic performance in university students, as demonstrated by a higher GPA (Raley et al., 2016).

Our inquiry is rooted in the necessity to decipher the multifaceted relationship between sleep, BMI, and academic performance in adolescents. We aim to unravel whether sleep deprivation, a common occurrence due to academic demands, is a practical approach to academic achievement. Multan, a region in South Punjab, Pakistan, presents a unique backdrop with its urban and rural divisions to study this complex interaction (Liu et al., 2023). Urban and rural settings may offer varied lifestyles, dietary habits, and sleep patterns, potentially influencing BMI and academic performance differently. Furthermore, there are prevalent cultural beliefs that less sleep might be conducive to better academic outcomes, urging students to sleep less and study more. This study is crucial in debunking or confirming such notions and providing evidence-based recommendations for students' wellbeing and academic success.

Theoretical and practical significance

This study enriches the academic discourse by examining the intersection of sleep patterns, BMI, and academic performance among adolescents in Multan, Pakistan. It contributes to developmental psychology, educational sciences, and health studies, especially in understanding how physiological and health factors influence cognitive outcomes in adolescents.

Practically, this research offers insights for educators, health practitioners, and policymakers. It helps in developing strategies that promote adolescent wellbeing and academic success, considering the unique urban and rural contexts of Multan. The findings could reshape educational policies and health interventions and address cultural misconceptions about sleep and study habits.

Research gap

This study addresses the gap in the existing literature by focusing on the interplay between sleep, BMI, and academic performance, specifically in adolescents from both urban and rural areas of Multan, Pakistan. It explores BMI's role as a mediator in sleep and academic performance and compares sleep and BMI patterns in different environmental settings. This investigation provides a deeper understanding of the multifaceted influences on adolescent development in a culturally specific context.

The primary objective of this study was to determine the relationships among sleep duration, BMI, and academic performance in adolescent students aged 12 to 14 from both rural and urban divisions of Multan, Pakistan. Moreover, the study aimed to establish the effect of sleep duration on academic achievements. Understand the role of BMI as a mediator in the relationship between sleep and academic performance. Identify the differences in sleep patterns and BMI among adolescents from rural and urban settings. By uncovering these

links, the study strives to offer insights that can guide educational institutions, policymakers, and caregivers in creating an environment that fosters both physical health and academic excellence for adolescents.

Methods

Study design & setting

This cross-sectional study was conducted during the 2019 academic year to explore the relationship between sleep patterns, BMI, and academic performance among adolescents. The study was conducted in Multan city, South Punjab, Pakistan, encompassing five high schools selected from both urban and rural divisions. This geographical diversity allowed for a comparative analysis between these two distinct settings.

Participant selection method

In the study, the sample size was determined to be 250 high school students. The selection of participants for this study was conducted using a purposive sampling technique. This method was chosen due to its effectiveness in ensuring a representative sample that meets the specific criteria and objectives of the research. In this case, the criteria included:

Age range

The study focused on adolescents aged 12 to 14 years. This age group was specifically targeted as it represents a crucial stage in physical, emotional, and cognitive development, where factors like sleep patterns and BMI can significantly impact academic performance.

Geographical distribution

The sample needed to represent students from both urban and rural areas of Multan city. This criterion was essential to facilitate a comparative analysis between these two distinct environments, which may have differing influences on the variables of interest. Gender balance: An almost equal distribution of boys (49.7%) and girls (50.3%) was aimed to ensure gender parity in the study. This balance was crucial to avoid gender bias in the results and to understand any gender-specific patterns in the relationship between sleep, BMI, and academic performance.

School selection

Five high schools were selected from urban and rural areas of Multan. The schools were chosen based on their willingness to participate and the feasibility of conducting the study within their premises. This selection was also influenced by the need to have a diverse sample that could adequately represent the adolescent student population in these areas.

By employing purposive sampling, the study aimed to gather data from a sample that was not only representative of the broader population of high school students in Multan but also met the specific requirements of the research. This method allowed for a focused approach to participant selection, ensuring that the sample was well-suited to address the research questions regarding the interplay of sleep patterns, BMI, and academic performance in adolescents. Measurements & variables

Academic achievement

For measuring academic achievement, the study utilized midterm exam scores in Urdu, Math, and English. This approach is consistent with the understanding that standardized academic tests are a reliable measure of academic performance in adolescents. Additionally, the use of multiple subjects provides a more comprehensive assessment of overall academic achievement.

Body Mass Index (BMI)

BMI was calculated based on self-reported weight and height measurements. Body mass index: BMI was calculated using the formula

$$BMI = \frac{W(\text{ kg})}{Hm^{(2)}}$$

(Hamdani et al., 2023). Students were then categorized into four groups: underweight, normal weight, overweight, and obese.

Sleep duration

To measure sleep patterns, the study utilizes subjective measures. They provide detailed information on sleep duration and quality by reporting daily sleep time in hours and minutes.

Control variables

The study also considers several control variables, such as parents' educational and occupational background, students' academic goals, family economic status, and residential status (living on campus). These factors are essential in providing a more nuanced understanding of the primary relationships being studied.

Statistical analysis

In this study, a comprehensive statistical analysis was conducted to investigate the relationships between sleep patterns, BMI, and academic performance among adolescents. Descriptive statistics provided foundational insights into the data distribution. Ordinary Least Squares (OLS) regression was employed to examine linear relationships between variables, while subsample regression analysis differentiated these relationships in urban and rural contexts. The Sobel-Goodman mediation test explored potential indirect effects, and Structural Equation Modeling (SEM) was utilized for a holistic view of the interrelationships among variables. A significance level of $P < 0.05$ was maintained throughout, and analyses were performed using SPSS software, ensuring robust and reliable findings.

Results

The results from table 1 revealed a marginal gender difference, with females showing slightly higher mean values (2.49) compared to males (2.47). Self-expectation scores reveal a notable rise, especially among females (mean = 8.24), surpassing those of males (mean = 7.77). Future work expectations increased marginally, with boys marginally outscoring girls.

Observations in parental work status reflected higher scores for mothers' work among boys and higher scores for fathers' work among girls. Family economic status experienced a slight rise, with girls perceiving a marginally better economic status than boys. Residential status, in terms of living on campus, also increased, with girls reporting higher scores.

Parental education levels saw a significant increase, particularly in the perception of girls, who rated their mothers' and fathers' education higher than boys. Sleep duration figures increased slightly, with boys reporting a slightly longer duration. Finally, the BMI values increased, with girls showing a marginally higher average BMI than boys. These findings offer insights into gender-based differences and perceptions among the studied demographic.

Table I
Gender-wise socio-demographic and lifestyle variables

Variables	Total		Boys		Girls	
	mean	SD	mean	SD	mean	SD
Gender	2.48	1.50	2.47	1.50	2.49	1.50
Self-Expectation	8.00	2.72	7.77	2.81	8.24	2.56
Future Work	6.09	4.18	6.17	4.20	6.00	4.15
Family SES Status	3.98	1.59	3.85	1.59	4.12	1.56
On Campus or Off Campus Living	2.69	1.46	2.53	1.50	2.87	1.34
Mother's Education	4.94	2.99	4.36	2.63	5.59	3.14
Father's Education	5.30	3.00	4.70	2.66	5.98	3.14
Sleep Duration (Minutes)	491.08	7.07	491.93	7.06	481.17	6.96
BMI	19.83	4.64	19.60	4.57	20.06	4.61

Table 2 shows a comprehensive analysis of various socio-demographic and lifestyle factors among students from different backgrounds; notable distinctions were observed between rural and urban students. The study focused on variables such as sleep duration, BMI, gender, self-expectation, future work, family SES status, living on or off campus, and parental education. Sleep duration exhibited a negative correlation across all groups, more pronounced among rural students (-0.075**) compared to urban students (-0.057*). BMI also showed a negative association, with the effect being significantly stronger in the urban cohort (-0.224***) than the rural one (-0.156**). Gender presented a varied pattern, with a negligible correlation in the total sample (-0.132) and rural subset (0.045) but a substantial negative correlation among urban students (-0.406).

Self-expectation emerged as a strong positive factor, particularly striking among urban students (0.846***) compared to rural students (0.455***). The future work variable demonstrated a negative correlation, more pronounced in the rural group (-0.219***) than in the urban group (-0.131+). Family SES status showed a significant negative correlation overall (-0.568*), with a dramatically stronger effect observed in the urban population (-1.675***). The influence of living on or off campus and parental education varied, with no significant correlation in the overall and rural groups but a negative tendency in the urban group, particularly for mothers' education (-0.250).

The R-squared values indicated a moderate explanatory power of the models, with slightly higher values for urban students (0.259) than for rural students (0.249). The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) scores, available only for the total and urban cohorts, suggested the model's adequacy in explaining the observed variations, particularly in the urban student group (AIC = 13748.91, BIC = 13770.84). These findings underscore the complex relationship of socio-demographic factors and their differential impacts on rural and urban student populations, highlighting the need for tailored approaches in addressing their unique challenges and needs.

Table II
The results of the ordinary least squares regression

Variables	Total	Rural Students	Urban Students
Sleep Duration	-0.063**	-0.075**	-0.057*
BMI	-0.127**	-0.156**	-0.224***
Gender	-0.132	0.045	-0.406
Self-Expectation	0.563***	0.455***	0.846***
Future Work	-0.188***	-0.219***	-0.131+
Family SES Status	-0.568*	-0.155	-1.675***
On Campus or Off Campus Living	-0.101	-0.021	-0.396
Mother's Education	-0.135	-0.054	-0.250
Father's Education	0.106	0.126	0.125
R-Squared	0.248	0.249	0.259
Akaike Crit. (AIC)	-	25591.78	13748.91
Bayesian Crit. (BIC)	-	25616.43	13770.84

Figure 1 presents the results of Sobel-Goodman mediation tests, elucidating the intricate relationships between sleep duration, BMI, and academic performance among students. The analysis delineates three distinct pathways. Path A uncovers a significant influence of sleep duration on BMI, with a regression coefficient (β) of -0.041, indicating that longer sleep duration is associated with a lower BMI ($p=0.01$). This inverse relationship suggests that increased sleep may contribute to a decrease in BMI among students. Path B further reveals that BMI has a consequential impact on academic achievement, as denoted by a β of -0.071 ($p=0.01$). This signifies that a higher BMI is correlated with lower academic performance, underscoring the importance of healthy body weight management for educational success. Path C illustrates the direct effect of sleep duration on academic performance, with a substantial β of -0.112 ($p<0.001$). This indicates a markedly negative association, where for each 10-minute increment in sleep duration, there is a 5.10% decrease in academic performance. This finding is particularly striking, as it suggests that there may be an optimal amount of sleep necessary for peak academic function, beyond which the benefits diminish.

Collectively, these paths corroborate that BMI serves as a mediating factor in the relationship between sleep duration and academic performance. The mediated model posits that not only does sleep duration directly affect academic outcomes, but it also exerts an indirect influence through its effect on BMI. The implications of these findings suggest that interventions aimed at improving academic performance should consider the multifaceted roles of both sleep and BMI in student health and learning.

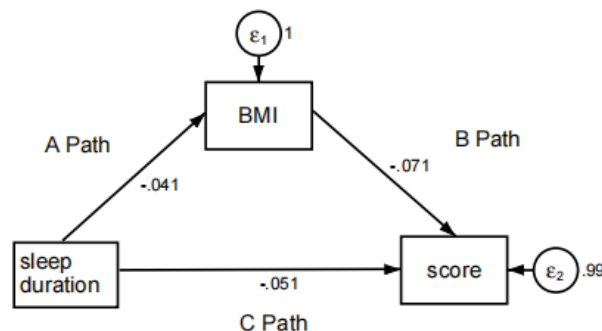


Fig. 1 The medication role of BMI between the relationship of sleep duration and academic scores

Discussion

The study explores the relationship between sleep patterns, BMI, and academic performance of adolescent students in rural and urban areas of Multan, as well as provides a comprehensive analysis of the relationship between various socio-demographic factors, sleep patterns, BMI, and academic performance among adolescents. The findings reveal intricate relationships and differences based on gender, residential status, and urban-rural backgrounds, offering valuable insights for educational and health policy interventions.

Gender differences in perceptions and outcomes

The marginal gender differences observed in self-expectation scores, with females scoring higher, align with research suggesting that gender can influence academic self-concept and expectations. For instance, Bleidorn et al. (2016) noted that gender differences in self-esteem and expectations are contextually influenced and can impact academic outcomes (Bleidorn et al., 2016). The higher scores in future work expectations among boys may reflect societal norms and expectations, which often place a greater emphasis on career success for males (Croft et al., 2015; Stout et al., 2016).

Socio-demographic factors and their impact

The study's findings on the impact of parental work status, family economic status, and parental education levels on students' perceptions and outcomes are consistent with existing literature. The role of socio-economic status in educational outcomes has been well-documented, with higher SES often correlating with better academic performance (Hamdani et al., 2023; Sirin, 2005). The negative correlation of family SES status with academic performance, especially pronounced in urban areas, underscores the complex dynamics of socio-economic factors in educational attainment.

Sleep duration, BMI, and academic performance

The negative correlation between sleep duration and academic performance, particularly among rural students, is a significant finding. This aligns with research by Dewald et al. (2010), who found that inadequate sleep can negatively impact academic performance (Dewald et al., 2010). However, the study's indication of a negative impact of longer sleep duration on academic performance suggests a nuanced relationship, possibly pointing towards an optimal sleep duration for academic efficacy, as suggested by (Lo et al., 2016).

The relationship between BMI and academic performance, with higher BMI correlating with lower academic achievement, resonates with the findings of Taras and Potts-Datema (2005), who reported that health-related factors, including obesity, can adversely affect educational outcomes (Hamdani et al., 2022; Taras & Datema, 2005). The mediated model showing BMI as a factor in the relationship between sleep duration and academic performance adds a new dimension to this discourse, suggesting that interventions targeting BMI and sleep patterns could be beneficial for academic success.

Urban vs. rural differences

The study's comparative approach between urban and rural students highlights significant disparities. The stronger negative association of BMI with academic performance in urban students could be reflective of different lifestyle factors prevalent in urban settings, such as dietary habits and physical activity levels (Biehl et al., 2013; Hamdani et al., 2022; Hamdani et al., 2017). The stronger positive correlation of self-expectation in urban students further suggests that urban environments might foster higher academic aspirations, potentially due to greater exposure to diverse educational opportunities (Aikens & Barbarin, 2008).

Implications for policy and practice

These findings have important implications for educational and health policies. Tailored interventions that consider the unique challenges and needs of different student demographics, including gender and urban-rural backgrounds, are crucial. Strategies focusing on optimizing sleep patterns, promoting healthy BMI, and addressing socio-economic disparities could significantly enhance academic outcomes.

In conclusion, this study provides valuable insights into the complex interplay of sleep patterns, BMI, and academic performance among adolescents, highlighting the influence of socio-demographic factors. The findings underscore the need for holistic approaches in educational and health interventions, considering the multifaceted roles of sleep, BMI, and socio-economic factors in shaping academic success.

Conclusion

The study conducted in Multan, Pakistan, uncovers a counterintuitive yet significant relationship: less sleep duration is positively associated with better academic performance among adolescents, with BMI serving as a key mediator. These findings bring to light a worrying trend of inadequate sleep among students from both urban and rural backgrounds, which is intricately tied to issues of weight management. These outcomes underscore the need for a more holistic approach to education, one that incorporates the critical aspects of sleep and physical health within the larger context of adolescent development and educational practices. Such results necessitate a re-evaluation of current educational and health strategies, considering the complex dynamics between sleep, physical wellbeing, and learning. They prompt a shift in focus from a narrow emphasis on academic achievement to a broader consideration of overall student health and wellbeing.

Future recommendations

It's high time for both government and educational bodies to pivot their focus from solely academic metrics to a more comprehensive view of student wellbeing. Implementing strategies to ensure adequate sleep, reducing academic pressures, and improving nutrition, especially in rural areas, are essential steps in this direction. There is a critical need for educational programs that emphasize the importance of sleep. Schools should incorporate sleep education into their curricula to help students understand and manage their sleep better. Schools and educational bodies must reevaluate the intensity of academic demands placed on students. Reducing unnecessary stressors can contribute to more balanced sleep patterns and, consequently, better health and academic outcomes.

Special attention should be given to nutrition, particularly in rural areas where access to healthy food options might be limited. Implementing school-based nutrition programs could be a significant step in improving students' overall health and BMI. The government should play a pivotal role in this transformation by providing resources and frameworks for schools to implement these changes. Policies that support healthier lifestyles for students are crucial for long-term educational and health benefits. Further research is needed to explore the complex relationships between sleep, BMI, academic performance, and other potential factors. Future studies could focus on different age groups and regions and the long-term effects of these dynamics.

Declaration

Ethics approval and consent to participate: In accordance with the principles outlined in the Declaration of Helsinki, the study was approved by the Shanxi University School of Physical Education in 2020 (Letter No: SXULL201912). Informed consent was obtained from the education department, school principals, and parents of participants, either in writing or verbally.

Consent for publication

All authors agree to publish this paper.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Data can be requested by contacting the corresponding author on a reasonable request.

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