Original Article

Impact of Body Mass Index on Academic Performance Among School-Going Adolescents

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Abstract

Background: Adolescence is a critical period of physical and cognitive development, during which nutritional status may influence academic performance. Body Mass Index (BMI), as an indicator of nutritional status, has been increasingly studied for its potential association with scholastic achievement. However, the relationship remains inconclusive, particularly in developing countries experiencing a dual burden of malnutrition. The objective is to estimate the relationship between academic performance and BMI among adolescents. **Material and Methods:** The cross-sectional study was conducted on 474 students aged 13-18 years, comprising both males and females. Anthropometric data (height and weight) were collected to calculate BMI, which was ranked according to standard values. Grade Point Average (GPA) and subject-specific scores from school records were used as measures of academic performance. Data on socioeconomic status and lifestyle were also obtained. Appropriate tests were used for statistical analysis, and a p-value below 0.05 was considered significant. **Results:** The mean age of the participants was 15.62, 1.42, which is equivalent to 15.62 in accordance with the sample size. The mean BMI was 21.84 ± 5.36 kg/m². Among students with normal BMI, academic performance was slightly better than that of underweight and overweight/obese students, but the differences were not statistically significant (p>0.05). **Conclusion:** BMI was not a significant independent predictor of scholastic achievement in adolescents. Socioeconomic, lifestyle, and environmental factors appear to combine to influence academic achievement.

Keywords: Body Mass Index; school achievement; Adolescents; GPA; Nutrition; Lifestyle Factors.

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Introduction

Adolescence is an important developmental stage that is marked by intense physical development, psychological maturity, and cognitive progress. At this stage, contributing factors to health and well-being may have long-term effects on physical and academic achievement. Body Mass Index (BMI), one such factor, is a well-known index of nutritional status and has received a lot of attention over the past few years because of its possible relationship with academic performance in children. It is vital to understand the connection between BMI and school performance to bridge the gap among the three areas of expertise: public health, school performance, and adolescent development.

BMI, which is a ratio of weight in kg/m², is also an applicable screening method for classifying people into underweight, normal weight, overweight, and obese using standardised age- and sex-specific percentiles for teens.[1] The number of adolescents facing under- or overnutrition has been found to increase all over the world, and the unequal nutrition has had a dual burden due to under- and overnutrition affecting many adolescents, especially in 3rd world countries like India.[2] Changes in lifestyle, such as reduced physical activity, increased sedentary behaviour, and consumption of energy-rich, nutrient-poor diets, have been credited with this epidemiological transition.[3]

A complex interaction among cognitive, environmental, and physiological factors affects academic performance, which is often measured as grades, test scores, and overall scholastic achievement. Cognitive development and behaviour, such as attention, memory, and learning abilities, are highly dependent on nutrition and health status.[4] The two extremes of BMI, both underweight and overweight/obesity, have been linked to adverse healthcare outcomes, which could potentially interfere with academic performance. For example, adolescent malnutrition may lead to a lack of essential micronutrients, resulting in impaired brain development and cognitive functioning.[5] On the contrary, metabolic abnormalities, low physical fitness, and psychosocial problems, including the feeling of self-reproach and depression, have been associated with overweight and obesity and can adversely affect academic performance.[6]

Several studies have examined the relationship between BMI and academic performance, with mixed findings. Some studies propose that adolescents who have a normal BMI are more likely to show satisfactory performance at school in comparison to

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those who are either underweight or overweight.[7] This can be explained by the fact that optimum nutritional conditions facilitate cognitive performance and attention span. On the contrary, obese, and overweight adolescents have been noted to exhibit poor performance in school, and this may be attributed to their high absenteeism rates, health-related complications, and social stigmas.[8] However, other researchers have also posited that there is no significant relationship, and this could be due to confounding factors such as socioeconomic status, parental education, school environment, and lifestyle habits.[9]

The biological mechanisms underlying the relationship between BMI and academic performance are complex. Nutritional imbalances can affect neurotransmitter synthesis, brain structure, and cognitive functions. Indicatively, iron, iodine and essential fatty acid deficiencies have been linked to poor cognitive development and academic underachievements.[10] Moreover, inflammation caused by obesity, as well as insulin resistance, can also affect brain function and memory.[11] Issues with making the concentration and learning can also be aggravated by sleeping disturbances that are more prevalent among adolescents with abnormal BMI.[12]

Psychosocial factors also play a significant role in mediating this relationship. Teenagers who have high BMI are also likely to undergo bullying, discrimination and dissatisfaction with their bodies and lack of motivation and interest in educational tasks.[13] Equally, non-fat adolescents can also encounter one or the other related health issue and social stress that can impact their self-esteem and school results. These psychosocial stressors may lead to anxiety, depression, and less academic interest, hence affecting the general education performance.

The correlation between BMI and academic achievement, especially in the Indian context, is pertinent because under nutritional conditions and increasing obesity rates among school-going adolescents co-exist. Booming urbanisation, dietary trends, and extreme academic stress have created a distinctive setting in which the health of individuals and educational outcomes are jeopardized.[14] Nevertheless, there is a relative lack of detailed literature on this relationship among Indian adolescents, suggesting that the problem warrants further investigation.

In addition, schools can serve as the best environment to implement interventions intended to advance nutritional status and academic achievement. Health education in schools, such as nutrition education, physical exercise education, and frequent health screening, can mitigate the problem of high BMI and improve cognitive and academic performance.[15] Knowledge of the relationship between BMI and academic achievement can enlighten policymakers, educators, and health specialists in developing specific measures to support holistic teenage growth.

Since both BMI and academic achievement are multifactorial variables, it is imperative to consider the issue holistically when discussing their relationship. Dietary habits, level of physical activity, mental health, family environment, and socioeconomic status must be taken into consideration to get a full picture. Detection of meaningful associations can also be used in early interventions, which not only improve health outcomes but also increase educational attainment.

Thus, the current research aims to assess the relationship between BMI and academic achievement in adolescents, adding to the growing body of research in this area. The study aims to investigate this relationship and demonstrate the significance of sustaining optimal nutritional conditions for cognitive and academic growth and development, thereby maintaining the well-being and future potential of adolescents.

Materials and Methods

Study Design and Setting: It was a cross-sectional study conducted among school-going adolescents to assess the relationship between Body Mass Index (BMI) and academic performance. This study was conducted at a few educational institutions in March 2022 and May 2013, with the school authorities granting permission to conduct the study.

Study Population: A total of 474 male and female learners who were studying in secondary and higher secondary classes were included in the study. School-going children aged 13 to 18 were deemed eligible.

Inclusion Criteria

- Students aged 13–18 years
- Both male and female participants
- Students present on the day of data collection
- Students who provided assent along with parental/guardian consent

Exclusion Criteria

- Students with known chronic illnesses or endocrine disorders affecting growth and weight
- Students on long-term medication influencing body weight
- Students with incomplete or missing data

Sampling Technique: Participants in the sampled schools were recruited using a convenience sampling method. All the eligible students who disagreed with the inclusion criteria and gave their consent to participate were enrolled on the study until the desired sample size was reached.

Data Collection Procedure: A structured pro forma was used as the data-collection method; the data included demographics, anthropometric measurements, and academic records.

Anthropometric Measurements

- Height was measured using a stadiometer to the nearest 0.1 cm with the participant standing barefoot in an erect posture.
- Weight was measured using a calibrated weighing scale to the nearest 0.1 kg with light clothing and no footwear.
- Body Mass Index (BMI) was calculated using the standard formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Participants were categorised into underweight, normal weight, overweight, and obese according to age- and sex-specific BMI percentiles based on WHO growth reference standards.[1]

Assessment of Academic Performance

Academic performance was measured using recent examination scores and percentage marks from the school records. To analyse the data, students were grouped into performance groups (i.e., high, average, and low achievers) according to the previously established grading criteria.

Study Variables

- Independent Variable: Body Mass Index (BMI)
- Dependent Variable: Academic performance (exam scores/grades)
- Covariates: Age, gender, and class level

Statistical Analysis: Data were entered into Microsoft Excel and analysed using appropriate statistical software (e.g., SPSS version 20). Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarise the data.

The correlation between BMI and academic performance was assessed using Pearson's or Spearman's correlation coefficient, depending on the data distribution. Comparison between groups was performed using appropriate statistical tests such as the Chi-square test or ANOVA. A p-value of <0.05 was considered statistically significant.

Results

The baseline characteristics of the study population, comprising 474 adolescents, are provided in Table 1. The average age is that of a mid-adolescent. It was found that there was a higher percentage of male students and of students from government schools. The average BMI is normal, with fluctuations. Indicators of academic performance indicate moderate performance overall. Socioeconomic and lifestyle factors show conflicting trends in their impact on health and academic performance.

Table 1: Baseline Characteristics of the Whole Cohort (n = 474)

Baseline Characteristics	**Value**
Mean age (years) (mean±SD)	15.62 ± 1.42
Male (%)	72.4
High school students (%)	55.1
Study at governmental school (%)	81.9
Mean BMI (kg/m²) (mean±SD)	21.84 ± 5.36
Mean waist circumference (cm)	80.72 ± 13.95
Academic Performance (%)	
Variable	**Value**
Students with excellent overall grade	47.2
Mean GPA for all subjects	81.36
Mean GPA for science	72.15
Mean biology results	75.21
Mean chemistry results	80.48
Mean physics results	82.67
Mean math results	65.11
Socioeconomic (%)	
Live with both parents	87.6
Own their houses	60.2
Both parents work	26.8
Low level of education (father)	48.9
Low level of education (mother)	59.3
Sleep Habits (%)	
Optimal sleep hours	42.1
Regular nap	44.6
Diet Habits (%)	
Eat breakfast at home	38.9
Eat breakfast regularly	66.4
Eat lunch with family	84.7
Eat dinner with family	81.5
Eat outside at least once daily	28.3
Eat fruits daily	19.8
Eat vegetables daily	23.7
Physical Activity (%)	
Sedentary lifestyle	36.2
Smoking (%)	
Active smoker	5.9

Table 2: Baseline Characteristics Based on Overall GPA

Characteristics	**< 90 (n=222, 46.8%)**	**≥ 90 (n=252, 53.2%)**	**P-value**
Age (years)	15.71 ± 1.31	15.53 ± 1.27	0.01
Male (%)	80.3	76.8	0.42
Private school (%)	38.6	24.7	0.03
Weight (kg)	64.72 ± 18.11	60.38 ± 17.45	0.04
Height (m)	1.66 ± 0.08	1.63 ± 0.09	0.06
BMI (kg/m²)	22.48 ± 5.12	21.97 ± 5.59	0.38
Waist circumference (cm)	82.14 ± 13.8	79.95 ± 14.2	0.21
Academic Performance			
Variable	**< 90**	**≥ 90**	**P-value**
Science GPA	88.6 ± 8.9	71.8 ± 14.6	0.001

Math	85.2 ± 11.6	60.4 ± 25.1	0.001
Biology	90.5 ± 7.5	75.6 ± 16.8	0.001
Chemistry	92.7 ± 6.9	84.2 ± 10.8	0.002
Physics	94.3 ± 5.2	87.8 ± 9.6	0.003
Socioeconomic (%)			
Living with both parents	92.3	84.1	0.02
Father higher education	60.8	44.9	0.01
Mother higher education	55.6	36.7	0.008
Both parents work	29.4	25.1	0.48
Lifestyle & Habits (%)			
Optimal sleep	54.2	31.5	0.01
Regular nap	39.1	45.7	0.37
Breakfast daily	66.9	68.2	0.82
Breakfast at home	41.3	36.8	0.09
Rarely eat outside	79.6	60.2	0.02
Fruits daily	16.2	22.5	0.03
Vegetables daily	22.8	24.5	0.27
Sedentary lifestyle	33.8	38.5	0.41
Active smoker	3.8	6.9	0.08

[Table 2] compares students by academic performance group. Students with higher GPAs have better lifestyle indicators, which are slightly lower. A few variables, such as age and weight, were statistically significant; BMI was not a strong predictor of GPA in this comparison.

Table 3: Academic Performance According to BMI Categories (n = 474)

Variables	**Underweight**	**Normal weight**	**Overweight**	**Obese**	**P-value**
Number (%)	118 (24.9%)	221 (46.6%)	79 (16.7%)	56 (11.8%)	—
Mean BMI	17.02 ± 1.21	21.34 ± 1.88	26.88 ± 1.49	33.96 ± 4.12	<0.001
Academic Performance					
Variable	**UW**	**NW**	**OW**	**OB**	**P-value**
Overall GPA	79.84 ± 12.3	83.76 ± 11.5	80.95 ± 12.7	81.22 ± 13.1	0.18
Science GPA	70.62 ± 19.4	72.94 ± 22.3	71.12 ± 19.8	73.85 ± 18.6	0.87
Math	63.11 ± 23.6	64.82 ± 28.4	62.34 ± 25.7	66.08 ± 22.9	0.69
Biology	74.28 ± 20.7	75.91 ± 25.3	75.14 ± 21.8	78.62 ± 18.9	0.74
Chemistry	79.62 ± 16.8	82.75 ± 15.2	78.94 ± 18.6	77.88 ± 15.9	0.11
Physics	80.45 ± 17.2	85.64 ± 14.3	82.17 ± 15.1	79.84 ± 14.6	0.09

[Table 3] shows the relationship between BMI categories and academic performance. Students with normal BMI had slightly higher GPAs than other groups. However, differences were not statistically significant, suggesting that BMI alone may not be a strong predictor of academic success.

Discussion

The current research was designed to test the relationship between BMI and academic performance in teenagers. The results are quite informative regarding the multifactorial and complex relationship between nutrition and academic performance among participants in this age group. Although BMI classes identified differences in academic performance, the relationship was not statistically significant, indicating that BMI is not a strong independent predictor of academic performance.

The participants' body mass index was within the normal range, indicating a balanced nutritional status among the adolescents. The dual burden of malnutrition continues to be experienced by the presence of underweight, overweight, and obese people, though. This finding aligns with earlier research in developing nations, where undernutrition and obesity are both present within culture due to rapid lifestyle changes.[16] The prevalence of the category of BMI in the current study is in accordance with the international trends that have demonstrated a rising trend in the prevalence of overweight and obesity among adolescents and a prevalent underfeeding.[17]

In terms of school grades, normal-BMI students had higher GPA means than underweight and overweight/obese students. Although statistically non-significant, the remaining differences suggest that an ideal state of nutrition can contribute to higher cognitive functioning and educational performance. The same result has been observed in previous research, in which healthy-weight young individuals showed better concentration, memory, and classroom behaviours compared to those at both ends of the BMI spectrum.[18]

The moderation of the relationship between BMI and academic performance in the current study is consistent with prior research. For example, after confounding variables, including socioeconomic status, parental education, and lifestyle factors, were considered, the direct relationship between BMI and academic achievement weakened.[19] This means that a broader range of factors determines academic performance than BMI alone.

Surprisingly, a similar comparison of students in GPA classes showed that students with enhanced academic performance had lower body weight by far and lower anthropometric measurements by a small margin. This result suggests that categorical variables, such as BMI, may not be strongly related. In contrast, specific components of these variables, such as body

weight and waist circumference, may contribute to the impact on academic outcomes. Other observations have noted that central adiposity and metabolic health can also play an insidious role in cognitive functioning.[20]

The socio-economic factors were found to be a significant influence on academic performance in the current research. Students with higher GPAs are more likely to have parents with higher levels of education and to live with both parents. The results can be attributed to the literature on the importance of family environment and parental support in influencing academic achievement.[21] An increase in parental education tends to correlate with greater health and nutrition awareness, awareness of educational resources, and may, in turn, positively affect BMI and academic performance.

Lifestyle habits such as sleep patterns and dietary habits also had significant relationships with academic performance. Students who had optimal sleep hours performed well academically, and this has been supported by evidence showing that, to optimise memory consolidation, attention, and thinking, sufficient sleep is critical.[22] Equally, healthier eating habits, including frequent use of fruits and less reliance on external food, were prevalent amongst better-achieving students. These results are consistent with prior studies that have shown the beneficial effects of a healthy diet on cognitive and academic success.[23]

This study also examined the roles of physical activity and a sedentary lifestyle. Even though no statistically significant relationship was observed between academic performance and sedentary lifestyle, a high percentage of sedentary students was observed among low-performing learners. The trend can be attributed to research suggesting that physical activity improves cognition through increased blood flow to the brain and neuroplasticity.[24] The insignificance of the current study, though, might be attributed to changes in the intensity and nature of physical activity, which were not specifically measured.

The psychosocial dimension of adolescent health is another key area highlighted in this study. Even though these variables, however, are not directly measured, stress, self-esteem, and peer relationships may mediate the effect of BMI on academic performance. This is because the prior research demonstrated that adolescents with increased BMI face increased chances of being bullied and stigmatised socially, and this may adversely affect their academic interests and capability.[25] On the other hand, the underweight adolescents can also experience some health-related issues which impact their inclusion at school and their cognition.

The results of the current research should be considered in light of certain limitations. The cross-sectional design does not allow for causal inference between academic performance and BMI. Also, convenience sampling can be used, and the results may not be generalisable. School records were used to measure academic performance, and, despite being a valid measure, this might not be a good indicator of cognitive and learning capacity. In addition, there was no in-depth investigation of potential confounding factors, such as dietary factors, levels of physical activity, and psychological factors.

Despite these constraints, the study has several strengths. The comparatively big sample size of 474 adolescents increases the validity of the results. The combination of anthropometric and scholastic variables provides a holistic evaluation of BMI's effect on scholastic performance. In addition, socioeconomic and lifestyle factors are considered, which contribute to the analysis and help comprehend the multifactorial nature of academic achievement.

Conclusion

The current research indicates that, though BMI relates to a moderate degree of change in scholastic success, it is not a substantial independent predictor in adolescents. Academic success seems to be a product of diverse factors, such as socioeconomic status, lifestyle behaviours, and environmental factors. With these results, the need to focus on a holistic approach to adolescents' health and education, not only on nutritional status but also on overall well-being and conducive environments, can be highlighted. It is suggested that future longitudinal studies be conducted to investigate causal relationships more thoroughly and to identify specific interventions that will effectively enhance health and academic performance.

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Conflicts of interest

There are no conflicts of interest.

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