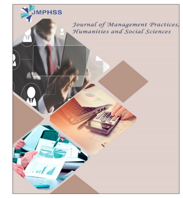
Journal of Management Practices, Humanities and Social Sciences

Vol 7 Issue 6 pp. 39-49

https://doi.org/10.33152/jmphss-7.6.4



ORIGINAL CONTRIBUTION

Assessment of the BMI among 8–12-year-old School Students Stratified by Socioeconomic Status from Multan, Pakistan: A Cross-sectional Study

Syed Ghufran Hadier[1], Medad Ali Sibtain[2], Liu Yinghai[3], Syed Muhammad Zeeshan Haider Hamdani[4*], Syed Danish Hamdani [5]

[1,3] School of Physical Education, Shanxi University, Taiyuan, China

[2] School of Physical Education, North University of China, Taiyuan, China

[4] Department of Sports Sciences, Faculty of Social Science, Bahauddin Zakariya University, Multan, Pakistan

[4] School of Human Kinesiology, Shanghai University of Sport, Shanghai, China

[5] School of Education Department, Multan, Pakistan

Abstract— Addressing a gap in existing research, this study investigates the correlation between socioeconomic status and body mass index among 8-to-12-year-old in Multan, Pakistan. It offers insights into obesity trends in a developing country context, highlighting economic disparities' role in childhood obesity. This cross-sectional study, a component of the PAK-IPPL project focusing on Multan, was conducted during the 2020–2021 academic year across higher secondary schools in Multan division. We employed stratified random sampling for participant selection. Using Cochran's formula, the sample size was calculated to be 1360 across three divisions, with 455 participants specifically from Multan. Anthropometric data were collected to calculate body mass index, and analysis was performed using IBM SPSS 22, encompassing descriptive statistics, Independent samples t-tests, chi-squared tests, ANOVA, and Tukey's HSD test. The study revealed no significant gender differences in age, height, body weight, and body mass index among the children. However, boys showed significantly higher waist circumferences than girls (60.29 ± 9.55 cm vs. 57.38 ± 8.03 cm, $p < 0.05$). SES was found to significantly influence body weight and Body Mass Index, with higher SES linked to increased values. Notably, children from higher SES backgrounds had an average weight of 35.31 kg (± 8.84) and BMI of 18.06 kg/m² (± 3.80). The combined effect of SES, gender, and age accounted for approximately 14% of the variance in childhood obesity. Positive correlations were observed between body mass index and weight, and waist circumference, varying according to SES and weight categories. The study highlights a significant correlation between higher SES and increased body weight and BMI, underscoring the importance of socioeconomic factors in understanding and combating childhood obesity. These findings call for targeted public health initiatives that account for socioeconomic and demographic factors. The insights provided are valuable for future research and interventions aimed at reducing obesity in children.

Index Terms— Anthropometric measurements, BMI, South Punjab, Socioeconomic status, Childhood obesity

Received: 2 September 2023; **Accepted:** 11 October 2023; **Published:** 26 November 2023

*Email: zeeshanhamdani@bzu.edu.pk

Introduction

Childhood obesity is a critical public health issue, increasingly recognized for its complex relationship with socioeconomic factors. Although Body Mass Index (BMI) is a widely accepted measure for assessing obesity in children, its application and relevance across different socioeconomic backgrounds, particularly in developing countries like Pakistan, have not been thoroughly examined. This oversight presents a significant theoretical gap, as understanding the socioeconomic dimensions of health is crucial for effective public health interventions (Broyles et al., 2015). The measurement of BMI in children has become a standard tool for assessing obesity, but its application in diverse socioeconomic contexts, particularly in developing countries like Pakistan, remains understudied (Liu et al., 2023). This research aims to bridge this gap by for the first time assessing the BMI of 8-to-12-year-old school children in Multan, Pakistan, and analyzing how Socioeconomic status (SES) influences these measurements.

The global relevance of BMI assessment in children is well-documented, highlighting its importance as a public health indicator (Williams et al., 2015). BMI is a simple yet effective tool for screening obesity in children and adults, allowing for the classification of individuals into categories such as obese or overweight. These classifications are crucial as they correlate with risks for chronic diseases like hypertension, diabetes, and cardiovascular issues (Williams et al., 2015). However, the application of BMI as an obesity classification tool has its limitations, particularly in failing to identify children and adolescents with elevated cardiometabolic risks due to increased adiposity. This issue becomes even more complex when considering the influence of socioeconomic factors on children's health outcomes (Cameron et al., 2015). Socioeconomic status is known to impact health significantly, with lower SES often correlating with higher risks of obesity and related health issues.

In Pakistan, and specifically in the context of Multan, there is a lack of comprehensive data concerning the relationship between BMI, obesity, and socioeconomic status among school-aged children (Hamdani et al., 2022; Liu et al., 2023; Raza et al., 2022). This gap in research is particularly evident in the stratification of BMI assessments by socioeconomic factors, which is essential for understanding and addressing the multifaceted nature of childhood obesity in the region (Hamdani et al., 2021). Therefore, this study assess BMI among 8-to-12-year-old school students in Multan, stratified by their socioeconomic status. By doing so, it seeks to contribute valuable insights into how socioeconomic factors influence childhood obesity in this demographic and geographic context. This research not only aims to fill the existing gap in literature but also to inform public health policies and educational strategies that are sensitive to the socioeconomic dimensions of childhood obesity.

Methods

Study design and sampling

This research is a part of the Pakistan Initiative to Promote Physical Literacy (PAK-IPPL) study, which employs a cross-sectional approach (Liu et al., 2023). Focusing specifically on Multan, this analysis is part of a broader investigation across three key regions in South Punjab identified for the PAK-IPPL study: Multan, Bahawalpur, and Dera Ghazi Khan (Liu et al., 2023). Multan was selected for its demographic diversity and strategic importance in the province, with a population characterized by a high influx of migrants attracted by its healthcare, educational, and employment opportunities. This demographic profile makes Multan an ideal representative sample of the broader South Punjab region.

The sample size for Multan, integral to the overall PAK-IPPL sample, was determined using Cochran's formula: n=((Z)^2 PQ)/e^2×D, This formula, extensively used in determining sample sizes (Suresh et al., 2012; William, 1977), incorporates the following elements:

Z: Standard normal deviation at a 5% significance level (1.96).
P: Expected proportion (0.234).
Q: 1 - P (0.77).
e: Desired precision level (0.05).
D: Design effect (5).
This calculation resulted in:

$$n = \frac{(1.96)^2(0.234)(0.77)}{(0.05)^2} \times 5 = 1359.8 \approx 1360,$$

with 455 participants from Multan.

A total of 29 higher secondary schools in Multan were selected through Stratified Random Sampling (SRS) for the study by provided list of Punjab education department. The selection of schools was based on diverse criteria to ensure a representative sample of the city's socioeconomic landscape. The analysis in this study primarily involved secondary data derived from the PAK-IPPL study, with a particular focus on the data subset from Multan.

Ethical consideration

Ethical approval was secured from the Shanxi University School of Physical Education, China (SXULL2019012), adhering to the Declaration of Helsinki. Additional permissions were obtained from the South Punjab Education Department (Letter No: 2189/GB), ensuring compliance with local laws and norms. The study strictly followed cultural protocols, including gender-specific guidelines for study assistants and prohibiting visual recordings.

Procedures and measures

This study was conducted during the academic year 2020–2021. This study used questionnaires and other assessment methods to collect information on demographic and anthropometric variables.

Demographics and anthropometrics

The student's age and birth year were obtained from the school record. Height was measured using a Digital Electronic Height-Weight Measurement Scale. Students were instructed to maintain a straight posture while standing barefoot against a level surface with their backs against the wall. Weight was measured in Kilograms (kg) using the same electronic scale, calibrated for accuracy. Participants removed shoes, excess clothing, and accessories. The weight reading, precise to 0.1 kg, was recorded when stable for three seconds. Body Mass Index (BMI) was calculated using the CDC-endorsed standard formula:

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

for BMI calculation and assessment (Hamdani et al., 2023; Prevention, 2023). The CDC percentile classifications were used to classify weight statuses. The waist circumference was measured using a standard tape roughly 1 centimeter above the navel, with measurements recorded in centimeters to one decimal place. Using standard tape, hip circumference was measured at the broadest part over the buttocks (Dalton et al., 2003; Hamdani et al., 2022).

Statistical analysis

The study employed IBM SPSS version 22 for data analysis. Descriptive statistics, including means, standard deviations, and percentages, were calculated to characterize the variables. Outliers, identified using z-scores with a threshold of 5, were adjusted to maintain the integrity of the results while preserving the sample size of 1,360 children. The normality of data was assessed using Q-Q plots and histograms. Differences in various factors by gender were examined using Independent Samples t-tests. Categorical differences among weight groups were analyzed using *Chi*-squared tests. To investigate the influence of SES on childhood obesity, particularly in terms of variations in weight and BMI across different SES categories, ANOVA and Tukey's Honestly Significant Difference (HSD) tests were conducted. Statistical significance was set at a p-value of less than 0.05.

Results

Table 1 provides age and gender-specific descriptive characteristics of the participants, categorized by gender: boys (n = 675) and girls (n = 685). Both groups had similar mean ages, with boys averaging 10.00 ± 1.417 years and girls 9.98 ± 1.417 years, a difference that was not statistically significant (p = 0.896). This age parity is critical as it minimizes potential confounding effects due to age-related growth patterns and body composition differences. Height measurements showed boys with a slightly higher mean height (139.24 ± 13.02 m) than girls (138.79 ± 11.39 m), yet this difference was not statistically significant (p = 0.696). Similarly, body weight comparisons revealed negligible differences between boys (30.80 ± 9.20 kg) and girls (30.75 ± 8.08 kg), as indicated by the insignificant p-value (p = 0.949). In assessing BMI, an essential marker for obesity, boys had a marginally higher mean BMI (15.70 ± 3.20 kg/m^2) compared to girls (14.80 ± 3.05 kg/m^2). However, this variance did not achieve statistical significance (p = 0.729). Contrarily, waist circumference presented a significant difference, with boys exhibiting a higher mean waist circumference (60.29 ± 9.55 cm) than girls (57.38 ± 8.03 cm), supported by a statistically significant p-value ($p < 0.05$). This could indicate a greater central adiposity in boys, which is a known risk factor for metabolic complications. The distribution of BMI classifications based on the Centers for Disease Control and Prevention (CDC) guidelines showed that the majority of both boys (77.3%) and girls (80.9%) were within the 'Normal weight' category. The prevalence of underweight, overweight, and obesity was slightly higher in boys than in girls. In summary, Table 1 reveals no significant gender disparities in age, height, body weight, and BMI among the study participants. However, a marked difference was observed in waist circumference, with boys having a higher measurement. The BMI classification distribution was comparatively similar for both genders.

Table I
Age and gender-specific anthropometric characteristics of study participants

Variable	Boys (n = 675) x̄ ± SD	Girls (n = 685) x̄ ± SD	p-Value
Age (years)	10.00 ± 1.417	9.98 ± 1.417	0.896
Height, (m)	139.24 ± 13.02	138.79 ± 11.39	0.696
Body Weight (kg)	30.80 ± 9.20	30.75 ± 8.08	0.949
BMI (kg/m^2)	15.70 ± 3.20	14.80 ± 3.05	0.729
Wc (cm)	60.29 ± 9.55	57.38 ± 8.03	< 0.05
BMI Classes (CDC)			
UnderWeight (<5th) %	15 (6.7)	19 (8.3)	-
Normal Weight (≥5th - <85th) %	174 (77.3)	186 (80.9)	-
OverWeight (≥85th - <95th) %	22 (9.8)	13 (5.7)	-
Obesity (≥95th) %	14 (6.2)	12 (5.2)	-

Data is presented as x̄: mean; SD: Standard Deviation (or percentages, as indicated);
BMI: Body Mass Index; WC: Waist Circumference; p-value significant at < 0.05.

Table 2 shows the comparison of anthropometric measurements across different socioeconomic status groups. There was no significant difference in height across the Low, Middle, and High SES groups (P = 0.990). The mean heights were 138.98 cm (± 12.64), 139.02 cm (± 10.75), and 139.26 cm (± 11.74) for the Low, Middle, and High SES groups, respectively. This suggests that height is relatively uniform across different SES groups in this sample.

A significant difference was observed in body weight across the SES groups (P = 0.000). The Low SES group had a mean body weight of 29.68 kg (± 8.44), which was lower than the Middle SES group (32.86 kg ± 8.34) and the High SES group (35.31 kg ± 8.84). This indicates that individuals from higher SES backgrounds tend to have higher body weight. Similarly, BMI showed a significant variance across SES groups (P = 0.000).

The average BMI increased with SES: 15.13 kg/m^2 (± 2.76) for Low SES, 17.08 kg/m^2 (± 3.22) for Middle SES, and 18.06 kg/m^2 (± 3.80) for High SES. This trend suggests a potential relationship between higher SES and increased BMI. There was a significant difference in waist circumference among the groups (P = 0.014). The Low SES group had a mean WC of 58.07 cm (± 8.80), which was slightly lower than the Middle (60.80 cm ± 9.36) and High SES groups (60.84 cm ± 8.35). This finding aligns with the trend seen in body weight and BMI, where individuals in higher SES groups exhibit higher measurements.

Table II
Comparison of anthropometric measurements across low, middle, and high Socioeconomic Status (SES) groups

Variable	Low SES	Middle SES	High SES	p-Value
Height, (m)	138.98 ± 12.64	139.02 ± 10.75	139.26 ± 11.74	0.990
Body Weight (kg)	29.68 ± 8.44	32.86 ± 8.34	35.31 ± 8.84	0.000
BMI (kg/m^2)	15.13 ± 2.76	17.08 ± 3.22	18.06 ± 3.80	0.000
WC (cm)	58.07 ± 8.80	60.80 ± 9.36	60.84 ± 8.35	0.014

The regression model summary revealed a moderate correlation (R = 0.374) between the predictors (SES, gender, age) and obesity indicators (weight and BMI). The R Square value of 0.140 indicates that approximately 14% of the variance in childhood obesity was accounted for by these variables, with the Adjusted R Square (0.134) providing a slightly more conservative estimate. The standard error of the estimate was found to be 2.91047, suggesting a moderate degree of variability around the predicted values. Further, the Tukey HSD analysis for multiple comparisons revealed statistically significant differences in weight and BMI across the SES groups. Children in the lowest SES bracket (less than 20,000) were observed to have significantly lower weight and BMI compared to those in the higher SES brackets (20,000 to 60,000 and more than 60,000). Specifically, the mean weight difference between the lowest and the middle SES group was -3.17057 kg (p = 0.007), and -5.62468 kg (p < 0.001) when compared to the highest SES group. Similarly, for BMI, there was a mean difference of -1.94749 kg/m^2 (p < 0.001) and -2.92941 kg/m^2 (p < 0.001) when the lowest SES group was compared to the middle and highest groups, respectively.

These findings suggest a clear association between lower SES and lower indices of obesity (weight and BMI), indicating that socioeconomic factors play a significant role in childhood obesity. The significant differences in obesity indicators across SES groups underscore the importance of considering socioeconomic context in public health strategies aimed at addressing childhood obesity.

Table III
Comparative analysis of weight and BMI across different Socioeconomic Status (SES) groups

Analysis Type	Variable	Comparison Groups	Mean Difference	Standard Error	*p*-Value 95% Confidence Interval
Multiple Comparisons (Tukey HSD)	Weight (kg)	Low SES vs Middle to High SES	-3.17057	1.03852	.007 (-5.6126, -.7285)
		Low SES vs High SES	-5.62468	1.38556	.000 (-8.8828, -2.3666)
		Low to Middle SES vs High SES	-2.45410	1.60150	.277 (-6.2200, 1.3118)
	BMI (kg/m^2)	Low SES vs Middle to High SES	-1.94749	.36278	.000 (-2.8006, -1.0944)
		Low SES vs High SES	-2.92941	.48401	.000 (-4.0675, -1.7913)
		Low to Middle SES vs High SES	-.98192	.55944	.186 (-2.2974, .3336)
Homogeneous Subsets (Tukey HSD)	Weight (kg)	Subset 1 (Low SES)	-	-	0.053
		Subset 2 (Low to Middle SES, High SES)	-	-	.170
		Subset 1 (Low SES)	-	-	1.000
	BMI (kg/m^2)	Subset 2 (Low to Middle SES, High SES)	-	-	.099
Model Summary					
R			0.374		
R Square			0.140		
Adjusted R Square			0.134		
Std. Error of the Estimate			2.91047		

The figure 1 bar graph presents the mean Body Mass Index for boys and girls, categorized into four weight classifications: lean, normal, overweight, and obese. For boys, the mean BMI ranges from 10.82 kg for the lean category to 21.63 kg for the obese category. Girls exhibit a similar trend with the lean category having a mean BMI of 10.22 kg, and the obese category having a mean BMI of 20.39 kg. The progressive increase in mean BMI from lean to obese categories is consistent for both genders, suggesting a clear differentiation in BMI according to weight classification. For boys, the increase in mean BMI between consecutive categories is notable, with the largest increase observed between the overweight (*M* = 20.19, 95% CI [19.52, 20.86]) and obese categories (*M* = 21.63, 95% CI [20.96, 22.30]). Similarly, girls show a significant rise between the normal (*M* = 15.77, 95% CI [15.10, 16.44]) and overweight categories (*M* = 20.34, 95% CI [19.67, 21.01]), with the obese category (*M* = 20.39, 95% CI [19.72, 21.06]) slightly higher than the overweight.

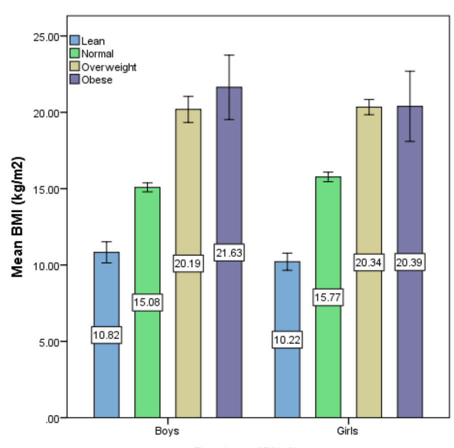


Fig. 1 *Comparison of mean BMI by weight classification among Boys and Girls*

The error bars, representing a 95% confidence interval, indicate variability within each classification. While there is some overlap between the error bars of the overweight and obese categories for girls, suggesting a less pronounced difference, the separation between the normal and obese categories for both genders is more distinct, implying statistical significance. These findings illustrate a robust relationship between the weight classification and mean BMI, with both boys and girls demonstrating higher mean BMI values in the higher weight classifications. The trend is indicative of the gradational nature of BMI across the spectrum from lean to obese. The consistent pattern observed between the two genders emphasizes the potential for weight classification to serve as a predictor of BMI in children. Given the implications of BMI on children's health, understanding these patterns is critical for public health interventions aimed at preventing obesity. Strategies focusing on maintaining a healthy weight from an early age could potentially benefit from these insights, by addressing the specific needs of children in different weight categories.

Figure 2 shows a scatter plot examining the relationship between Body Mass Index and weight among children, stratified by low, middle, and high socioeconomic statuses. The data points are color-coded, indicating the SES of the participants. A linear regression line has been fitted to the data, with an R^2 value of 0.595, suggesting that approximately 59.5% of the variability in weight can be explained by BMI for the combined SES groups. A quadratic fit is also provided, with an R^2 value of 0.598, indicating a slightly better fit to the data than the linear model. The scatter of points indicates a positive correlation between BMI and weight across all SES groups. However, the closeness of the R^2 values for both the linear and quadratic models suggests that the relationship between BMI and weight does not dramatically deviate from linearity across the SES spectrum. It is noteworthy that the spread of weight increases with higher BMIs, particularly for the middle and high SES groups, indicating a potential variance in weight distribution within these categories.

Figure 3 presents a scatter plot that correlates BMI with Waist Circumference (WC) in children, categorized by weight status: lean, normal, overweight, and obese. Each category is distinguished by a unique color. The plot includes both a linear and a quadratic regression line, with R^2 values of 0.095 and 0.097 respectively. These values suggest a weak correlation between waist circumference and BMI within the weight classifications, implying that only about 9.5% to 9.7% of the variability in BMI is accounted for by changes in waist circumference.

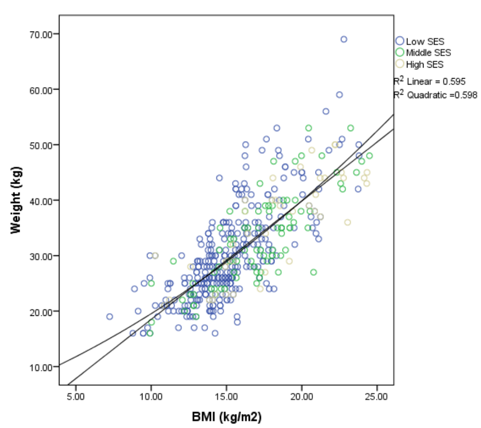


Fig. 2 *Correlation between BMI and weight across different SES*

The distribution of data points indicates a general trend where an increase in waist circumference corresponds with an increase in BMI. Nevertheless, the weak R^2 values imply substantial scatter and a high degree of individual variability that is not captured by these two measures alone. Interestingly, the quadratic fit does not offer a substantially improved explanation of the variance compared to the linear fit, as indicated by the similar R^2 values. This suggests that the relationship between WC and BMI does not notably deviate from a straight-line relationship across the weight categories observed. The concentration of data points around the lower end of the waist circumference and BMI values for the lean and normal categories suggests a clustering of measurements in these healthier weight classifications. In contrast, the overweight and obese categories display a broader dispersion of data points, reflecting greater variability in the BMI and WC measurements for these groups. This could indicate a more complex relationship between BMI and WC as children's weight increases, potentially affected by factors such as body composition and fat distribution which are not directly measured by these two indices.

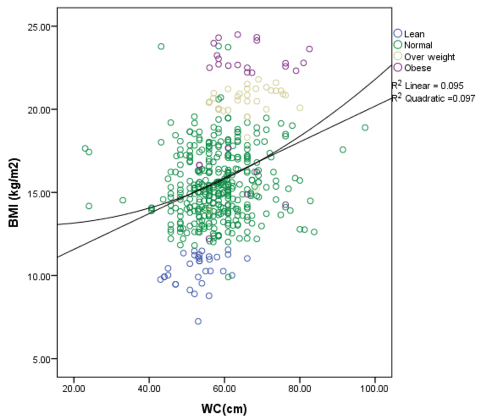


Fig. 3 *Correlation between BMI and waist circumference categorized by weight status*

Discussion

This study, examining BMI in 8–12-year-old school students from Multan, Pakistan, stratified by Socioeconomic Status (SES), enhances the existing knowledge on childhood obesity. It investigates the relationship between SES and anthropometric measures such as height, weight, BMI, and waist circumference, providing essential insights for public health interventions.

The study found no significant gender differences in age, height, body weight, and BMI, but a notable difference in waist circumference, higher in boys. This aligns with research suggesting that gender differences in body composition and fat distribution emerge during childhood. Boys tend to accumulate more visceral fat, which is reflected in waist circumference measurements (Hamdani et al., 2022; Hamdani. S et al., 2022; Zhou et al., 2022). This is significant as central adiposity is a known risk factor for metabolic complications. These observations are echoed in broader research. For instance, Topal et al. (2021) and Gajević et al. (2022) also reported gender differences in physical development among primary school children, supporting the notion that boys and girls differ in various physical parameters (Gajević et al., 2022; Topal et al., 2022).

These findings suggest that socioeconomic status may be a determinant in anthropometric characteristics, particularly in body weight, BMI, and waist circumference. The absence of significant variation in height across SES groups may indicate that genetic or other non-socioeconomic factors play a more dominant role in determining height (Khanolkar, 2013). Conversely, the significant differences in weight, BMI, and waist circumference across SES groups could be attributed to lifestyle differences, dietary habits, or access to resources, which often vary with socioeconomic status (Baum et al., 2009; Beauchamp et al., 2014; Ntandou et al., 2008). These results underscore the importance of considering SES in studies related to nutritional status and health outcomes (Baum et al., 2009).

The study revealed a significant difference in body weight and BMI across SES groups, with higher values in children from higher SES backgrounds. This finding is consistent with global trends where the relationship between SES and obesity varies by economic development (Pampel et al., 2012). In high-income countries, higher SES is often associated with lower obesity rates, possibly due to better access to healthy foods and recreational facilities (Dinsa et al., 2012). However, in lower-income countries, the opposite trend is observed, where higher SES correlates with increased obesity, potentially due to greater access to energy-dense foods and sedentary lifestyles (Dinsa, 2015; Vazquez et al., 2020). The significant variances in body weight and BMI across different SES groups in our study are consistent with broader trends noted in literature. For example, Kobylińska et al. (2022) explored the impact of age and gender on body composition in children, highlighting the importance of socioeconomic context in these differences (Kobylińska et al., 2022).

The study's findings on the progressive increase in mean BMI from lean to obese categories in both boys and girls are consistent with the established understanding that BMI is a reliable indicator of adiposity in children (Boeke et al., 2013; Vanderwall et al., 2017). The clear differentiation in BMI according to weight classification underscores the utility of BMI as a screening tool for identifying children at risk of obesity-related health issues (Boeke et al., 2013; Staiano et al., 2012; Vanderwall et al., 2017). The analysis of BMI in relation to weight and waist circumference revealed positive correlations. However, the modest R^2 values in the BMI-waist circumference relationship highlight significant individual variability, suggesting that BMI alone may not fully capture body fat distribution. This underscores the need for incorporating additional measures like waist circumference in comprehensive obesity assessments.

It is important to note, however, that while the study reveals significant associations, it does not imply causation. Moreover, given that the model accounted for only 13.4% of the variance in childhood obesity, there are evidently other contributing factors, which were not included in this model. Future research should therefore consider incorporating a wider range of variables, potentially including dietary habits, physical activity levels, genetic factors, and environmental influences, to gain a more comprehensive understanding of the determinants of childhood obesity (Bigornia et al., 2013). The significant differences observed in weight and BMI across SES groups underscore the need for nuanced public health interventions that consider the socioeconomic realities of different communities. By tailoring obesity prevention and intervention programs to address these socioeconomic disparities, more effective strategies can be developed to combat the growing epidemic of childhood obesity.

Moreover, these results call for a broader perspective on childhood obesity, one that goes beyond individual behavior and genetics to include social and economic factors. This approach aligns with the social determinants of health framework, which emphasizes the impact of social, economic, and environmental factors on health outcomes.

Implications

The study indicates that socioeconomic status significantly influences children's weight and BMI, with lower SES associated with reduced weight and BMI. This correlation may stem from disparities in diet quality, access to nutritious food, opportunities for physical exercise, and the overall lifestyle tied to various SES levels. However, it is critical to recognize that this association does not establish causality; other unaccounted factors might also play a role.

These findings are pivotal for public health policy and intervention design targeting childhood obesity. They underscore the necessity of implementing strategies that are sensitive to the socioeconomic backgrounds of children and their families. Tailoring public health approaches to meet the unique needs and challenges faced by different SES groups is crucial. In lower-income countries, for instance, interventions for higher SES groups might focus on promoting healthy eating habits and physical activity, while those for lower SES groups could prioritize ensuring access to nutritious food and safe environments for physical exercise (Hart et al., 2003).

Limitations

This study sheds light on the relationship between socioeconomic status, gender, and childhood obesity, but it accounts for only 14% of the variability, suggesting that other factors are at play, future study should investigate additional factors influences. The cross-sectional design of our study limits the ability to establish causality. To unravel the dynamics of SES, gender, and obesity over time, longitudinal research is essential. Delving deeper into aspects like dietary patterns, physical activity, and genetic predispositions will offer a more comprehensive understanding of childhood obesity.

Conclusion

In conclusion, this study contributes valuable data to the existing body of knowledge regarding the influence of socioeconomic status on the physical development of school-aged children. The significant differences in obesity indicators across SES groups underscore the importance of contextualizing public health strategies to effectively address childhood obesity. The findings also highlight the necessity for targeted interventions that are sensitive to the socioeconomic disparities within populations. Moreover, the study reinforces the need for ongoing research to further understand the multifaceted factors contributing to childhood obesity, particularly in developing countries like Pakistan.

Future research

Future research should investigate additional factors influences, such as dietary habits, physical activity, genetics, and broader environmental and social factors. Future studies should replicate and expand these findings in diverse settings, examining how socioeconomic factors influence childhood obesity. Longitudinal studies are pivotal for elucidating causal relationships and observing temporal changes. Additionally, qualitative research would provide valuable insights into the lived experiences of children from diverse socioeconomic backgrounds, aiding in the creation of more targeted and effective interventions.

Conclusively, while our research contributes to the understanding of the complex relationship between SES, gender, and childhood obesity, it underscores the need for context-specific public health strategies, particularly in developing countries like Pakistan. Policymakers and health practitioners should incorporate SES considerations in developing interventions against childhood obesity. Addressing socioeconomic disparities could significantly mitigate the prevalence and impact of childhood obesity, thereby enhancing the well-being of children across various socio-economic strata.

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.

Funding

This study did not receive any financial support from any institute or agency.

Acknowledgment

We would like to thank the school administration and students who participated in this study and the team who assisted with data collection.

REFERENCES

Baum, C. L., & Ruhm, C. J. (2009). Age, socioeconomic status and obesity growth. *Journal of Health Economics, 28*(3), 635-648. doi:https://doi.org/10.1016/j.jhealeco.2009.01.004

Beauchamp, A., Backholer, K., Magliano, D., & Peeters, A. (2014). The effect of obesity prevention interventions according to socioeconomic position: A systematic review. *Obesity Review, 15*(7), 541-554. doi:https://doi.org/10.1111/obr.12161

Bigornia, S. J., LaValley, M. P., Benfield, L. L., Ness, A. R., & Newby, P. K. (2013). Relationships between direct and indirect measures of central and total adiposity in children: What are we measuring? *Obesity, 21*(10), 2055-2062. doi:https://doi.org/10.1002/oby.20400

Boeke, C. E., Oken, E., Kleinman, K. P., Rifas-Shiman, S. L., Taveras, E. M., & Gillman, M. W. (2013). Correlations among adiposity measures in school-aged children. *BMC Pediatrics, 13*(1), 99. doi:10.1186/1471-2431-13-99

Broyles, S. T., Denstel, K. D., Church, T. S., Chaput, J. P., Fogelholm, M., Hu, G., . . . for the, I. R. G. (2015). The epidemiological transition and the global childhood obesity epidemic. *International Journal of Obesity Supplements, 5*(2), S3-S8. doi:10.1038/ijosup.2015.12

Cameron, A. J., Spence, A. C., Laws, R., Hesketh, K. D., Lioret, S., & Campbell, K. J. (2015). A review of the relationship between socioeconomic position and the early-life predictors of obesity. *Current Obesity Reports, 4*(3), 350-362. doi:10.1007/s13679-015-0168-5

Dalton, M., Cameron, A. J., Zimmet, P. Z., Shaw, J. E., Jolley, D., Dunstan, D. W., & Welborn, T. A. (2003). Waist circumference, waist–hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. *Journal of Internal Medicine, 254*(6), 555-563. doi:https://doi.org/10.1111/j.1365-2796.2003.01229.x

Dinsa, G. (2015). *The socioeconomic inequalities in and determinants of obesity in developing countries*. Norwich, England: University of East Anglia.

Dinsa, G. D., Goryakin, Y., Fumagalli, E., & Suhrcke, M. (2012). Obesity and socioeconomic status in developing countries: A systematic review. *Obesity Reviews, 13*(11), 1067-1079. doi:https://doi.org/10.1111/j.1467-789X.2012.01017.x

Gajević, A., Ivanović, J., & Pržulj, R. (2022). Differences in the physical development of primary school children by gender. *Open Journal System, 17*, 1, 125-133. doi:https://doi.org/10.7251/SIZ2201125G

Hamdani, M. Z. H., Zhuang, J., Hadier, G., Tian, W., Hamdani, D. H., Shireen, S., & Fatima, U. (2022). Normative reference standard for core muscular endurance of adolescence 12-16 years from south Punjab Pakistan: A cross-sectional study. *Pakistan Journal of Physiology, 18*(1), 3-8.

Hamdani, S. M. D. H., Zhou, Y., Shireen, S., & Hamdani, S. M. Z. H. (2022). Systemic review of swim bench training during last five years. J*ournal of Business Social Review in Emerging Economies, 8*(2), 265-276. doi:https://doi.org/10.26710/jbsee.v8i1.2222

Hamdani, S. M. Z. H., Jie, Z., Hadier, S. G., Tian, W., Hamdani, S. D. H., Danish, S. S., & Fatima, S. U. (2022). Relationship between moderate-to-vigorous physical activity with health-related physical fitness indicators among Pakistani school adolescents: Yaali-Pak study. *The Scientific World Journal*, 1-10. doi:https://doi.org/10.1155/2022/6402028

Hamdani, S. M. Z. H., Zhuang, J., Hadier, S. G., Khurram, H., Hamdani, S. D. H., Danish, S. S., . . . Tian, W. (2023). Establishment of health related physical fitness evaluation system for school adolescents aged 12–16 in Pakistan: a cross-sectional study. *Frontiers in Public Health, 11*, 1-15. doi:10.3389/fpubh.2023.1212396

Hamdani, S. M. Z. H., Zhuang, J., Tian, W., & Hadier, S. G. (2021). Normative reference standard for handgrip strength among adolescent students in South Punjab Pakistan: A cross-sectional study. *Journal of Business Social Review in Emerging Economies, 7*(4), 997-1009. doi:https://doi.org/10.26710/jbsee.v7i4.2064

Hart, K. H., Herriot, A., Bishop, J. A., & Truby, H. (2003). Promoting healthy diet and exercise patterns amongst primary school children: A qualitative investigation of parental perspectives. *Journal of Human Nutrition and Dietetics, 16*(2), 89-96. doi:https://doi.org/10.1046/j.1365-277X.2003.00429.x

Khanolkar, A. (2013). *Inequalities in health: social, biological, ethnic and life-course perspectives*.Stockholm, Sweden: Karolinska Institute.

Kobylińska, M., Antosik, K., Decyk, A., Kurowska, K., Skiba, D. & Health, P. (2022). Body composition and anthropometric indicators in children and adolescents 6–15 years old. *International Journal of Environmental Research and Public Health, 19*(18), 11591.

Liu, Y., Hadier, S. G., Liu, L., Hamdani, S. M. Z. H., Hamdani, S. D., Danish, S. S., . . . Guo, Y. (2023). Assessment of the relationship between body weight status and physical literacy in 8 to 12 year old Pakistani school children: The PAK-IPPL cross-sectional study. *Children, 10*(2), 363.

Ntandou, G., Delisle, H., Agueh, V., & Fayomi, B. (2008). Physical activity and socioeconomic status explain rural-urban differences in obesity: A cross-sectional study in Benin (West Africa). *Ecology of Food and Nutrition, 47*(4), 313-337. doi:10.1080/03670240802003835

C., Denney, J. T., & Krueger, P. M. (2012). Obesity, SES, and economic development: A test of the reversal hypothesis. *Social Science & Medicine, 74*(7), 1073-1081. doi:https://doi.org/10.1016/j.socscimed.2011.12.028

Prevention, C. (2023). Defining child BMI categories. Retrieved from https://www.cdc.gov/obesity/basics/childhood-defining.

Raza, M., Ling, H. Y., Hamdani, S. M. Z. H., & Haider, S. G. (2022). Socio-cultural interest and motivational barriers for female sports participation in Pakistan: A comparative study of universities and colleges. *Sustainable Business Society in Emerging Economies, 4*(2), 547-560. doi:https://doi.org/10.26710/sbsee.v4i2.2393

Staiano, A. E., & Katzmarzyk, P. T. (2012). Ethnic and sex differences in body fat and visceral and subcutaneous adiposity in children and adolescents. *International Journal of Obesity, 36*(10), 1261-1269. doi:10.1038/ijo.2012.95

Suresh, K., & Chandrashekara, S. (2012). Sample size estimation and power analysis for clinical research studies. *Journal of Human Reproductive Sciences, 5*(1), 7-13. doi:10.4103/0974-1208.97779

Topal, Z., Bahşi, I., Karadag, M., Sarp, A. S., Akkaya, C., & Gokcen, C. (2022). Anthropometric analysis of the orbital region in children with autism spectrum disorder and healthy controls. *Journal of Craniofacial Surgery, 33*(1), 322-324. doi:10.1097/scs.0000000000007834

Randall Clark, R., Eickhoff, J., & Carrel, A. L. (2017). BMI is a poor predictor of adiposity in young overweight and obese children. *BMC Pediatrics, 17*(1), 135. doi:10.1186/s12887-017-0891-z

Vazquez, C. E., & Cubbin, C. (2020). Socioeconomic status and childhood obesity: A Review of literature from the past decade to inform intervention research. *Current Obesity Reports, 9*(4), 562-570. doi:10.1007/s13679-020-00400-2

William, G. C. (1977). *Sampling techniques*. New Jersey, United States: John Willey & Sons Inc.

Williams, E. P., Mesidor, M., Winters, K., Dubbert, P. M., & Wyatt, S. B. (2015). Overweight and obesity: Prevalence, consequences, and causes of a growing public health problem. *Current Obesity Reports, 4*(3), 363-370. doi:10.1007/s13679-015-0169-4

Zhou, Y., Shireen, S., & Li, Q. (2022). Infant swimming increase the risk of atopy and respiratory tract infections: A systematic review and meta-analysis. *Journal of Business Social Review in Emerging Economies, 8*(1), 209-216.