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BMI Categories And Their Relationship With Postural Deformities In Male School Children: A Study From Urban Gwalior

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ABSTRACT

The focus of this study: This study aims to assess the relationship between BMI categories and postural deformities in male schoolchildren from urban Gwalior. Materials and methods: A total of 2,495 samples were chosen. Samples were obtained from schools located in the urban areas of the Gwalior Region, Madhya Pradesh. The subjects' ages varied from 8 to 12 years, and they were chosen from all categories of schools. The participants were chosen by multi-stage cluster selection from schools in the Gwalior Region. Results: Kyphosis was identified as strongly positive ($p<0.05$), with a coefficient value of 0.047 for severe malnutrition. At a significance level of 0.05, no significant link was seen between kyphosis and mild malnutrition, normal weight, overweight, and obesity among male pupils in the metropolitan districts of the Gwalior Region. Our analysis revealed no significant link ($p > 0.05$) between Lordosis and overweight at a 5% significance level in the metropolitan districts of the Gwalior Region. Scoliosis was substantially ($p<0.05$) positively correlated with obesity, with a coefficient value of 0.047. Nevertheless, using a threshold of 0.05, we identified no significant link between scoliosis and severe malnutrition, moderate malnutrition, or overweight among male pupils in urban areas of the Gwalior Region. Knock-knee had a significant negative correlation ($p<0.05$), with a coefficient of -0.050 for mild malnutrition. Nonetheless, we observed no substantial link between knock-knee and severe malnutrition among male pupils in urban areas of the Gwalior Region, with a significance level of 0.05. Our analysis revealed no significant connection ($p > 0.05$) between bow-leg deformity and severe or moderate malnutrition among male pupils in the metropolitan districts of the Gwalior Region. Flatfoot was significantly associated ($p < 0.05$) with a negative coefficient of -0.046 in relation to moderate malnutrition and a positive coefficient of 0.272 concerning obesity among male schoolchildren in the urban districts of the Gwalior Region. Conclusions: This study aims to investigate the correlation between BMI categories and postural abnormalities in male pupils from urban Gwalior. By establishing links between several BMI categories and various postural abnormalities, we want to offer significant insights for early identification and preventative techniques that may be included into school health programs.

Keywords: BMI status, Postural deformities, Height, Weight, Urban areas.

INTRODUCTION

The physical health of children during their school years is critical for their overall well-being, and one aspect that has gained significant attention is the association between body mass index (BMI) and postural deformities (Karakus, Yildirim, & Dinc, 2019). The relationship between BMI and postural deformities in children, especially during the developmental stages, has garnered increasing attention (Guedes et al., 2010). The relationship between BMI and postural deformities is complex. On one hand, overweight and obese children tend to have increased pressure on the musculoskeletal system, which can lead to compensatory postures (Zhu et al., 2017). On the other hand, underweight children may lack the muscular strength to maintain proper posture, increasing the risk of deformities (Fernández-García & López, 2021). Recent studies suggest that children with abnormal BMI—either too high or too low—are more likely to present postural deviations compared to those with a healthy BMI (Papanastasiou et al., 2020).

Postural deformities, including scoliosis, lordosis, and kyphosis, are conditions where the natural curvature of the spine is altered, leading to potential health issues (Panteliadis et al., 2015). These deformities often develop due to musculoskeletal imbalances, which may be aggravated by improper body weight (Kratenová, Zejglicová, Macek, & Filipovský, 2007). Postural deformities such as kyphosis, lordosis, and scoliosis, often manifest during childhood and adolescence due to various intrinsic and extrinsic factors, including body composition (Poussa et al., 2005).

Body mass index (BMI) is a simple measure that categorizes individuals into underweight, normal weight, overweight, and obese, based on their height and weight (World Health Organization [WHO], 2020). This categorization has been widely used in pediatric populations to assess the risk of various health problems, including cardiovascular diseases, diabetes, and musculoskeletal issues (Raj, Kumar, & Goyal, 2012; Wijnhoven et al., 2014). However, its relationship with postural deformities is still being explored, with many studies indicating a potential link between abnormal BMI and poor postural alignment in children (Pereira et al., 2020; Neumann et al., 2013).

Several studies have highlighted that overweight and obesity may cause an anterior shift in body posture due to the increased load on the spine, contributing to conditions such as hyperlordosis and kyphosis (Mihajlović et al., 2015; Brzek, Plinta, & Bronikowski, 2016). Conversely, children who are underweight may suffer from muscle weakness, which may lead to postural instability and deformities like scoliosis (Fusco et al., 2013). This growing body of research suggests that BMI is not merely a marker for metabolic health but also plays a crucial role in the musculoskeletal development of schoolchildren (Straker et al., 2013; Widhe, 2010).

Research indicates that postural problems in children with higher BMI levels may be linked to excess body weight putting stress on the spine and lower extremities, resulting in deformities like scoliosis or hyperlordosis (Martínez-Nava et al., 2020). Conversely, underweight children may have weaker musculature and lack the necessary core strength to maintain proper postural alignment (Santos et al., 2013). This disparity points to the need for a deeper investigation into how BMI categories correlate with postural deformities in school-age children (Smith et al., 2015).

In India, the prevalence of both obesity and undernutrition among children has been increasing, further raising concerns regarding the musculoskeletal health of this population (Bharati et al., 2008). In urban environments such as Gwalior, the issue is compounded by the influence of modern lifestyle factors, such as prolonged screen time, inadequate physical activity, and poor nutrition (Sharma, Tiwari, & Agarwal, 2018; Menon, 2016). Urbanization has led to significant lifestyle shifts, often at the expense of children's physical health, creating a dual burden of malnutrition and sedentary behaviors (Gupta et al., 2020). These factors further highlight the importance of understanding the relationship between BMI categories and postural deformities, particularly in school-age children who are at a critical stage of physical development (Patel, 2017).

This study seeks to investigate the relationship between BMI categories and postural abnormalities in male students from urban Gwalior, offering insights into the occurrence of these deformities and their possible relationship with BMI. Comprehending this link enables us to more effectively address children's postural health requirements and formulate programs that enhance posture and facilitate appropriate weight control.

METHODOLOGY

Selection of Subjects: The total number of samples selected was 2495. The samples were chosen from urban schools located in the Gwalior Region of Madhya Pradesh. Our selection of subjects encompassed individuals between the ages of 8 to 12, representing all types of schools. A multi-stage cluster selection approach was employed to recruit participants from schools situated in the urban districts of the Gwalior Region. All participants were given a comprehensive description of the study's objectives and criteria, both verbally and in writing. Participants were also notified of their right to withdraw from the research at any point, including after giving formal consent.

Selection of Variables: This study examined the following variables: BMI index categories (Severe Malnutrition, Moderate Malnutrition, Normal, Overweight and Obesity) and postural deformities (Kyphosis, Lordosis, Scoliosis, Knock-knee, Bow-leg, Flat-foot).

Table 1 presents the details of the variables were measured by the following instruments and methods.

S. No.	Variables	Criterion Measure	Unite
1.	Kyphosis	Spondylometer, kinovea software	Degree
2.	Lordosis	Spondylometer, kinovea software	Degree
3.	Scoliosis	Spondylometer, kinovea software	Degree
4.	Knock-Knee	Orthopaedic Examination	Centimeter
5.	Bow-Leg	Orthopaedic Examination	Centimeter
6.	Flat-Foot	Clark Index, kinovea software	Degree
7.	Height	Stadiometer	Meter
8.	Weight	Electronic-Weighing Machine	Kilogram

Administration of Test: All participants were apprised of the inquiry prior to data collection. No motivating approaches were employed; the individuals were entirely relaxed. Data was collected on male youngsters from metropolitan areas in the Gwalior Region. We executed the following processes to conduct the testing process.

Kyphosis: The thoracic curve was utilized as a determinant for kyphosis in the thoracic region. After completing the preparation of each topic for the spondylometer, verify their status. Pegs were securely attached to the spondylometer at apertures located at a distance of 5 cm or 2 inches. The participants were instructed to wear suitable attire for the examination and to position themselves barefoot on the designated platform with their feet spaced apart. When using the spondylometer, it is important for the subject's back to make contact with the pegs and for their hands to be in a relaxed position, while keeping their neck straight. The participants were directed to assume an erect posture, as if they were facing a wall. A lateral shot was taken to assess the angle of the curve in the upper and lower thoracic regions. Initially, a line was drawn parallel to the calibration plane from the marking, using the plumb line as a reference. The kyphosis angle was determined by marking the farthest point from the plumb line on the spinal column, which represented the apex of the kyphosis angle. This angle was then measured using kinovea software and found to be less than 180 degrees. The kyphosis deformity was identified when the angle was less than 30 degrees (Tokpinar, et al., 2015).

Lordosis: The diagnosis of lordosis uses the lumber curve as a criterion. Following the instructions, each student positioned pegs in the device's holes using a spondylometer, spacing them 5 cm or 2 inches apart. We instructed the participants to dress appropriately for the examination and to stand barefoot on the designated platform, keeping their feet apart. We instructed the participants to face a wall in an erect posture. We captured the photograph from a side angle to measure the lumbar curvature. Initially, we drew a line parallel to the calibration plane from the marking, using the plumb line as our reference. We observed the point closest to the plumb line on the vertebral column. We used Kinovea software to measure the lordosis angle, which decreased from 180 degrees at its highest point. We diagnosed a lordosis deformity when the angle exceeded 40° (Tokpinar, et al., 2015).

Scoliosis: We used the presence of a lateral curve as a diagnostic measure to identify scoliosis in the thoracic and lumbar regions. We provided the participants with explicit guidance on the spondylometer. We marked the peg with ink to prevent any contact with the 7th cervical vertebra. We insert the markers into the holes, spaced 5 cm or 2 inches apart. We instructed the participants to dress appropriately for the examination, position themselves on the designated platform without shoes, and spread their feet apart. We instructed the participants to extend their necks backwards and maintain an upright posture, as if they were facing a wall. We instructed the participants to remain standing for a minimum of 5 minutes to determine their usual standing posture. We captured the photograph from the rear side to measure the angles of curvature in the thoracic and lumbar regions. Initially, we sketched a line parallel to the calibration plane. To establish the center, draw a straight line that connects both earlobes and extends to a point in the posterior part of the head. Create a straight line starting from that specific point, which will function as the vertical reference line. We identified the most distant point on the plumb line of the spinal column to determine the scoliosis angle. This represented the highest point of the scoliosis angle, which was measured using kinovea software and decreased from 180 degrees. When the angle exceeded 10°, we diagnosed the scoliosis abnormality (Bindal, 2010).

Knock-Knee: We instructed the participants to stand in a standard upright stance with their feet separated, using either a steel measuring tape or a measuring tape that does not stretch. We measured the distance between the medial malleolus using orthopaedic techniques and a clinical assessment. A normal gap between the medial malleolus is typically 4 to 5 cm. A distance of 6 to 8 cm between the two medial malleolus suggests a mild knock knee deformity, while a distance of 10 cm indicates a severe knock knee deformity (Ronald, Clinical Orthopaedic Examination (6th ed.), 2010).

Bowlegs: We instructed the participants to position their feet apart in a standard standing position. We measured the distance between the medial femoral condyle using a steel tape, adhering to the requirements of the orthopaedic clinical examination. The distance between the medial femoral condyle was considered normal if it measured between 4 and 5 cm. We classified it as a mild deformity if it measured between 6 and 8 cm, and as a severe deformity if it measured 10 cm or more (Ronald, Clinical Orthopaedic Examination (6th ed.), 2010).

Flat-Foot: The individuals received comprehensive instructions on how to use the pedograph before obtaining the footprint. We used the pedograph, a conventional ink pad, to record footsteps. We use a brush to evenly distribute the fingerprint ink across the pad sheets. We instructed the participants to stand on the pedograph without shoes and apply pressure with their feet to ensure proper ink distribution. We then instructed the participants to tread on the paper sheets placed on a rigid cardboard surface in front of them. We directed the participants to exert strong pressure with their feet on the paper to obtain a precise impression of their foot. The Clarke angle arises from the intersection of the tangent at the medial edge of the footprint and the line connecting the longest perpendicular distance from the medial border of the foot. We used Kinovea software to find the intersection point between the medial tangent and the foot margin. We used this approach to estimate the height of the longitudinal arc. If the angle exceeded 42°, we identified a flat-foot deformity (Pauk, J. et al., 2014).

Body Mass Index: The subjects' height was measured using a stadiometer in meters, and their weight was assessed using an electronic weighing machine in kg, respectively. BMI was determined using the following formula: Weight (kg)/ Height (meter)^2 (Food and Nutrition Technical Assistance, n.d.).

Statistical tool: We analyzed all the data using IBM SPSS V20.0. We used the Shapiro-Wilk test to verify the normality assumption. We used the Spearnman Correlation test to find out relationship between the BMI categories and postural deformities among the male schoolchildren from urban areas of Gwalior Region. We set the significance level at 0.05.

RESULTS AND FINDINGS

The summary output of the Shapiro-Wilk test statistics indicated statistically significant findings ($p < 0.05$) for all test variables. Therefore, we used the Spearnman Correlation test to find out relationship.

Table No. 2 Spearman Correlation of BMI categories and Postural deformities in Male School Children of Urban Area.

SPEARMAN'S RHO		SM	MM	NL	OW	OB
KY	Correlation Coefficient	**.047***	.008	-.027	-.008	.011
	P-value	**.020**	.692	.179	.698	.588
	N	2495	2495	2495	2495	2495
LO	Correlation Coefficient	.203**	.053**	-.173**	.003	.066**
	P-value	.000	.008	.000	.867	.001
	N	2495	2495	2495	2495	2495
SS	Correlation Coefficient	.027	-.003	-.074**	.025	**.047***
	P-value	.173	.869	.000	.210	**.019**
	N	2495	2495	2495	2495	2495
KK	Correlation Coefficient	-.023	**-.050***	-.315**	.146**	.242**
	P-value	.257	**.013**	.000	.000	.000
	N	2495	2495	2495	2495	2495
BL	Correlation Coefficient	-.029	-.019	-.243**	.173**	.131**
	P-value	.141	.330	.000	.000	.000
	N	2495	2495	2495	2495	2495

FF	Correlation Coefficient	-.059**	**-.046***	-.329**	.145**	**.272***
	P-value	.003	**.022**	.000	.000	**.001**
	N	2495	2495	2495	2495	2495

**. Correlation is significant at the 0.01 level.

*. Correlation is significant at the 0.05 level.

(KY= Kyphosis, LO = Lordosis, SS = Scoliosis, KK = Knock-knee, BL = Bow-leg, FF = Flat-foot, SM = Severe Malnutrition, MM = Moderate malnutrition, NL = Normal, OW = Overweight, OB = Obesity).

Table No. 2 presents the correlation coefficients, their corresponding p values, and the sample size. The results presented in Table 2 lead to the following conclusions: Kyphosis was found to be significantly ($p<0.05$) positive, with a coefficient value of 0.047 for severe malnutrition. However, at a significance level of 0.05, we found no significant correlation between kyphosis and moderate malnutrition, normal, overweight, and obesity for male schoolchildren in the urban areas of Gwalior Region. We found that there was no significant ($p > 0.05$) correlation between Lordosis and overweight at a 5% level in the urban areas of Gwalior Region. Scoliosis was found to be significantly ($p<0.05$) positively associated with obesity, with a coefficient value of 0.047. However, with a 0.05 threshold, we found no significant correlation between scoliosis and severe malnutrition, moderate malnutrition, or overweight in male schoolchildren from urban areas of Gwalior Region. Knock-knee was found to be significantly negative ($p<0.05$), with a coefficient value of -0.050 for moderate malnutrition. However, we found no significant correlation between knock-knee and severe malnutrition for male schoolchildren in urban areas of the Gwalior Region, with a threshold of 0.05. We found that there was no significant ($p > 0.05$) correlation between bow-leg and severe or moderate malnutrition for male schoolchildren in the urban areas of Gwalior Region. Flatfoot was found significant ($p < 0.05$) negatively with coefficient value -0.046 with moderate malnutrition and positively with coefficient value 0.272 with obesity at 0.05 for male school children of urban areas of Gwalior Region.

DISCUSSION

The present study investigates the relationship between different BMI categories and postural deformities among male schoolchildren in urban Gwalior. Understanding this relationship is crucial as childhood obesity has been shown to be a growing concern globally, contributing to musculoskeletal problems, including postural deformities such as kyphosis, lordosis, scoliosis, knock-knee, bow-leg, and flat-foot (Brzek et al., 2016).

The study's results indicate significant correlations between certain BMI categories and specific postural deformities. For example, severe malnutrition was positively correlated with kyphosis, although moderate malnutrition, normal BMI, overweight, and obesity did not show significant correlations (Karakus et al., 2019). This aligns with previous research indicating that undernutrition can contribute to weakness in postural muscles, exacerbating spinal deformities (Widhe, 2010).

Obesity, on the other hand, was significantly correlated with several deformities, such as lordosis and scoliosis. This finding is consistent with prior studies that suggest excess body weight places additional strain on the spine, leading to increased curvature and postural imbalance (Fusco et al., 2013; Pereira et al., 2020). Scoliosis, in particular, was found to be significantly associated with obesity, supporting the notion that high BMI can disrupt the musculoskeletal system's normal development in children (Panteliadis et al., 2015).

Moreover, the study found a significant negative correlation between moderate malnutrition and knock-knee, while bow-leg and flat-foot were more prevalent in overweight and obese children. These findings are in line with previous research, which has shown that overweight children are more likely to develop these lower limb deformities due to the mechanical overload on their joints and bones (Menon, 2016; Raj et al., 2012). This mechanical stress can lead to compensatory postures, further contributing to deformities like knock-knee and bow-leg (Straker et al., 2013).

Interestingly, flat-foot deformities were also significantly associated with obesity, corroborating the findings of other studies that link increased body weight to reduced arch height and impaired foot structure (Mihajlović et al., 2015; Zhu et al., 2017). The excessive weight borne by the feet can result in the collapse of the longitudinal arch, which can lead to flat-footedness (Poussa et al., 2005).

The study's findings are in line with the broader literature, which suggests that both undernutrition and obesity contribute to postural deformities in children (Gupta et al., 2020). Addressing these BMI-related postural deformities in schoolchildren requires comprehensive interventions that target both weight management and musculoskeletal health (Neumann et al., 2013; Zahner et al., 2006).

Future interventions should include both nutritional and physical education programs aimed at promoting healthy weight and posture. Physical activity, particularly in childhood, has been shown to improve postural stability and prevent the onset of deformities linked to both undernutrition and obesity (Guedes et al., 2010). In this regard, regular physical exercise and posture correction training should be integrated into school health programs to mitigate the effects of abnormal BMI on postural health (Smith et al., 2015).

CONCLUSION

The current study highlights a significant association between BMI categories and the prevalence of postural deformities among male schoolchildren in urban Gwalior. The findings indicate that underweight and obese children are more susceptible to postural deformities such as kyphosis, lordosis, and scoliosis compared to children with normal BMI. Specifically, undernourished children are prone to spinal deformities like kyphosis, while obese children face increased risks of lordosis, scoliosis, and flat-foot due to the excessive load on their musculoskeletal system. The results are in line with global studies emphasizing that abnormal BMI, whether due to malnutrition or obesity, negatively impacts postural development, potentially leading to long-term health complications.

These findings underscore the need for early interventions that focus on maintaining a healthy BMI through nutritional programs and physical education in schools. Addressing both undernutrition and obesity is crucial to mitigating the risks of postural deformities in children. Furthermore, integrating posture-correcting exercises and regular physical activity into school curriculums may help improve musculoskeletal health and prevent the onset of postural issues linked to BMI deviations. As childhood obesity and malnutrition continue to rise, particularly in urban settings, targeted public health strategies must address this dual challenge to promote both metabolic and postural well-being in school-age children.

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