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Original article

PATTERNS OF SEXUAL DIMORPHISM IN ANTHROPOMETRIC VARIABLES: FINDINGS FROM A SLUM-DWELLING CHILD POPULATION IN HABRA, NORTH 24 PARGANAS, WEST BENGAL

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ABSTRACT

Introduction:
The term "sexual dimorphism" refers to physical characteristics, such as height, weight, and body fat distribution, which differ between males and females. These variations arise from environmental, hormonal, and genetic factors, which are further influenced by lifestyle, diet, and socioeconomic conditions. Addressing health disparities in marginalized populations requires an understanding of how these factors affect the anthropometric discrepancies between boys and girls.

Objectives:
The study aims to analyze the variation and to explore the extent of sexual dimorphism in anthropometric characteristics (height, weight, head circumference, MUAC, waist and hip circumference, biceps and triceps skinfold thickness) among slum-dwelling children.

Material and Methods:
In the slum regions of Habra, North 24 Parganas, 580 children between the ages of 4 to 11 years participated in a cross-sectional survey. Socioeconomic data were gathered using a pre-tested data collection sheet (scheduled form), and all anthropometric measures were taken using established anthropometric procedures.

Results:
Based on the t-test, sexual dimorphism is significant in height ($p < 0.001$), weight ($p < 0.001$), head circumference ($p = 0.004$), waist circumference ($p < 0.001$), and biceps skinfold thickness ($p = 0.029$).According to Cohen's d formula, among all anthropometric measurements, height ($d = 0.43$) and weight ($d = 0.38$) suggest a moderate effect size, while other measurements have a smaller effect size. Socio-economic interaction analysis revealed that income level significantly interacted with sex to influence weight, waist circumference, head circumference, hip circumference and biceps ($p<0.05$). In terms of height, weight, head circumference, hip circumference and triceps, maternal occupation also shows a significant interaction with sex, suggesting that socioeconomic circumstances significantly influence sex-based variances.

Conclusion:
In this population, boys tend to the slightly taller and heavier, as height and weight show moderate sexual dimorphism. In other anthropometric characteristics, no strong sexual dimorphism is observed. The significant sex-socioeconomic interactions suggest that growth patterns are not solely biologically determined but are strongly influenced by income and parental occupation.

KEY WORDS: Height, weight, Head circumference, MUAC, Waist circumference, Hip circumference, Biceps, Triceps, Sexual dimorphism, Slum-dwelling children, socioeconomic factors

INTRODUCTION:

Sexual dimorphism refers to physical differences between males and females beyond reproductive organs, including height, weight, fat distribution, and muscle mass. These differences emerge due to genetic, hormonal, and

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environmental factors, which can be further influenced by socioeconomic conditions, nutrition, and lifestyle. Slum dwellers, due to limited access to nutrition, healthcare, and sanitation, often experience stunted growth and malnutrition. Understanding how these factors influence anthropometric differences between boys and girls is crucial for addressing health inequalities in marginalized populations. The majority of the research that has been done on Indian slum communities has concentrated on socioeconomic determinants of child health, growth deficiencies, or overall patterns in malnutrition. Nevertheless, very few studies particularly look at sexual dimorphism in anthropometric measures in slum settings, and even fewer look at regional differences within West Bengal. Despite evidence that local living conditions can have a substantial impact on children's growth trajectories, little is known about the distinct sociocultural and economic features of Habra's slum neighbourhoods. Thus, by evaluating patterns of sexual dimorphism in important anthropometric characteristics among children living in slums in Habra, North 24 Parganas, this study aims to close this crucial gap. Developing tailored, sex-sensitive nutrition requires an understanding of the differences in growth patterns between boys and girls under unfavourable living conditions.

A large number of studies show that children's fat patterns consistently differ by sex. Previous studies found that females had far higher percentages of body fat and skinfolds; there were no sex differences or signs of increased truncal adiposity in the fat patterning indicators. The mean waist-hip ratio was higher for the boys (0.96±0.04) than for the girls (0.93±0.04) ($P<0.001$). Because boys had smaller hip circumferences, which indicated less gluteal obesity, the ratio was higher in boys. This implies that sexual dimorphism in fat patterning is evident even at this young age, with girls exhibiting higher levels of subcutaneous adiposity, which is mostly caused by gluteal fat (Webster-Gandy et al., 2003). While all of these studies support early-onset variations in fat distribution, they also provide conflicting information about truncal adiposity, indicating that not all fat indicators are consistent across populations. In terms of growth status, boys have higher weight and height-for-age Z-scores (HAZ), while girls are more likely to have higher body fat percentages (De Onis et al., 2012). Males ranged in height from 43 to 51.9 cm, while females ranged from 40.5 to 53 cm. Males and females had head lengths of 12.5% to 15.5% and 12.5% to 14.5%, respectively. With regard to age and sex, within and across racial groupings, there are significant differences in body proportions and absolute measurements (Bansal et al., 2013). The average height of males was 137.62 cm, while that of females was 135.85 cm. This seems statistically significant, as indicated by the P value of 0.035 determined by the student's t-test (Moeed et al., 2017). Although the extent of these differences varies among research and population, these results consistently reveal that girls exhibit higher levels of adiposity while boys show better linear growth. Indicators based on circumference provide more information about dimorphic growth trends. Mitra et al. (2017) concluded that the mean values of the boys' head circumference, chest circumference, and waist circumference were higher than those of the girls'. In terms of circumference and mid-upper-arm circumference, girls' mean values are higher than boys'. These highlight sex-specific differences in fat and muscle

distribution. These results suggest that girls exhibit higher values in markers related to upper arm fat and nutritional reserves, whereas boys typically have larger measures in main body circumferences. This difference highlights the need to take into account a variety of anthropometric parameters when comparing boys and girls because sexual dimorphism does not follow a single consistent pattern across all circumference indicators. Additionally, socioeconomic indicators such as parental education, occupation, and household income have been typically associated with children's anthropometric status. The role of women's education and employment is improving child nutritional status regardless of gender (Black et al., 2013). This demonstrates a crucial interaction: socioeconomic circumstances can either increase or decrease the disparities in body size and fat patterning, while biological sex plays a role. However, many current research approaches biological and environmental influences independently, leaving a gap in our understanding of how these variables jointly determine sexual dimorphism, despite the obvious importance of socioeconomic issues.

In general, the studies show identifiable patterns of sexual dimorphism in growth markers, body proportions and fat distribution. However, findings continue to change depending on the situation, and very little study combines anthropometric variations with socioeconomic limitations. This emphasizes the need for research on disadvantaged groups like children living in slums, where environmental challenges may change or exacerbate growth discrepancies between boys and girls.

OBJECTIVES:

1. To assess and compare key anthropometric characteristics (height, weight, MUAC, WC, HC, triceps, biceps) between boys and girls in slum dwellers.
2. To investigate how sex-based variations in anthropometric growth patterns are influenced by socioeconomic factors like family income, parental occupation.
3. To quantify the extent of sexual dimorphism across the measured anthropometric variables and to find patterns of sex-specific malnutrition.

MATERIAL AND METHODS:

In order to examine differences in growth patterns, 580 children, both boys and girls, between the ages of 4 to 11 years participated in this cross-sectional study. Slum-clusters were chosen using a multistage sampling technique. Standardized methods were used to gather all anthropometric data, including height, weight, MUAC, waist and hip circumferences, and skinfold measures like the triceps and biceps. An anthropometer and a digital scale were used to measure height and weight. Various circumferences were measured using a non-stretchable tape. A Harpenden skinfold caliper was used to measure skinfolds, such as the triceps and biceps. Every assessment was made twice, and all socioeconomic data were collected through structured interviews. The statistical test comprised Cohen's d for effect size and an independent t-test for sex-based differences. Regression analysis was used to examine the influence of socioeconomic factors. Data were analyzed using SPSS v.16.

RESULTS:

Table 1 provides a detailed breakdown of the mean and standard deviation for each anthropometric variable across boys, girls, and combined samples. The values indicate on average, boys are taller (119.5 cm) and heavier than girls. Head circumference shows minimal differences between boys (48.90 cm) and girls (48.35 cm). MUAC, WC, and HC are slightly higher in boys, but the differences are not substantial.

Table 2 represents the impact of sex and socio-economic interactions on growth parameters using regression analysis. The p-value of weight and waist circumference are highly significant, while head circumference, biceps, and triceps show significance. This suggests that income levels interact with sex to influence these growth parameters. In the case of sex and father's occupation, only the triceps show a highly significant effect (p= 0.003). On the other hand, height, weight, head circumference, biceps, and triceps are significantly affected by sex-mother occupation interaction, which suggests maternal occupation plays a crucial role in influencing sex-related growth variations.

Fig. 1 depicts the interaction effects of sex and income levels on different anthropometric variables. Boys tend to have higher height and weight than girls, regardless of income level. Head circumferences increase with income in both sexes, showing a positive correlation with higher socio-economic status. MUAC and WC are significantly higher in the sustained income group. A similar trend is observed in hip circumference, biceps, and triceps. This suggests a better nutrition and overall health status in the sustained income group contribute to greater muscle and fat deposition.

Table 1: Sex-based variation in anthropometric variables

Anthropometric characteristics	Mean			SD		
	Boys	Girls	Combined	Boys	Girls	Combined
Height (cm)	119.53	113.34	116.47	14.03	14.79	14.73
Weight (kg)	20.69	18.50	19.60	5.61	5.88	5.84
Head Circumference(cm)	48.90	48.35	48.63	2.33	2.22	2.29
MUAC (cm)	17.69	16.82	17.26	8.27	7.46	7.88
Waist Circumference(cm)	52.69	51.27	51.98	4.63	4.52	4.62
Hip Circumference (cm)	54.43	52.79	53.62	10.75	10.30	10.55
Biceps (cm)	4.50	4.21	4.36	1.62	1.51	1.57
Triceps (cm)	7.55	7.21	7.38	2.32	2.17	2.25

Table 2: Sex and Socio-economic interactions on growth

Regression model (p-value)								
	Height	Weight	HC	MUAC	WC	HC	Biceps	Triceps
Sex income interaction	0.956	0.000**	0.005*	0.127	0.000**	0.105	0.023*	0.050*
Sex father's occupation Interaction	0.815	0.617	0.917	0.443	0.185	0.759	0.594	0.003**
Sex mother's occupation interaction	0.009*	0.004*	0.000**	0.832	0.081	0.067	0.005**	0.028*
p* - significant p** - Highly significant HC: Head circumference; WC: Waist circumference; HC: Hip circumference								

Fig. 2 shows parental employment status influences anthropometric characteristics. In most cases, children from daily labourer families show better growth trends in height, and weight compared to those from unemployed families. A similar trend is observed in Fig. 3 also. Children from employed families tend to have better anthropometric outcomes, possibly due to improved nutrition and living conditions.

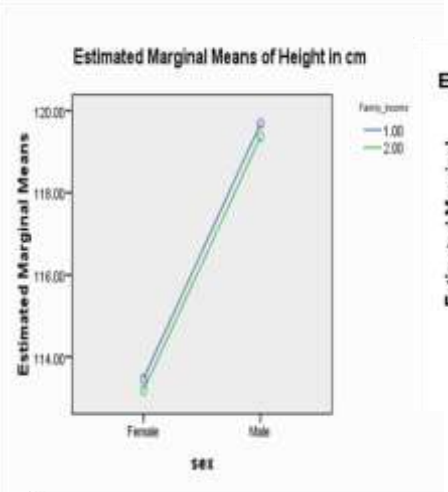
Table 3 represents the significance of differences in anthropometric characteristics between boys and girls. In height, the p-value indicates a statistical significance and a discernible difference in height between boys and girls, as indicated by the moderate effect size indicated by Cohen's d value. In weight, the most significant difference is observed. In the case of Waist circumference, head circumference shows slight but significant sexual dimorphism. In the case of biceps, though, the effect size is small, and the p-value suggests a notable difference between boys and girls. No significant differences are noticed in MUAC, hip circumference, and triceps.

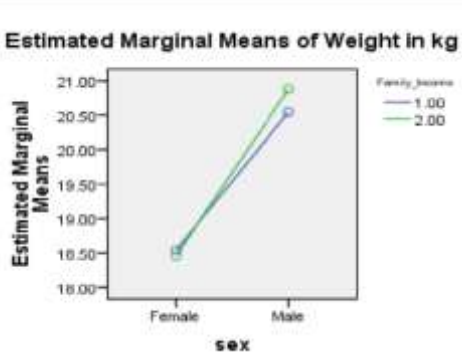
DISCUSSION:

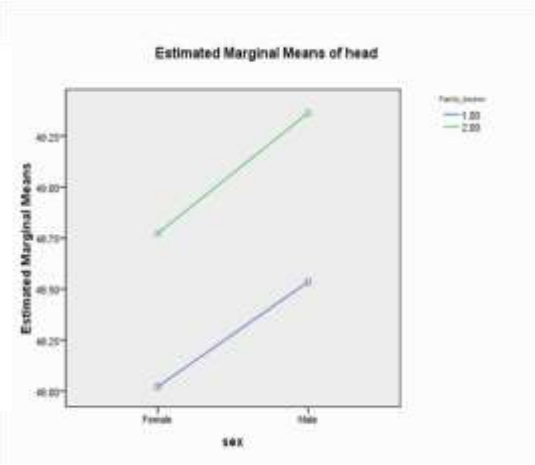
The study reveals that boys were heavier and taller than girls in this slum sample, which is in line with extensive analyses that demonstrate that sex differences in weight and linear growth continue to exist in many low- and middle-income contexts, though the size of these differences varies depending on the setting and nutritional environment. systematic review discovered context-dependent sex variations in under nutrition indicators across numerous populations(Thurstans et al., 2020). Another study showed persisting sex patterns in stunting and growth trends worldwide(de Onis et al., 2012).These two studies together support the current findings that basic dimorphism in height and weight frequently persists even under socioeconomic stress.

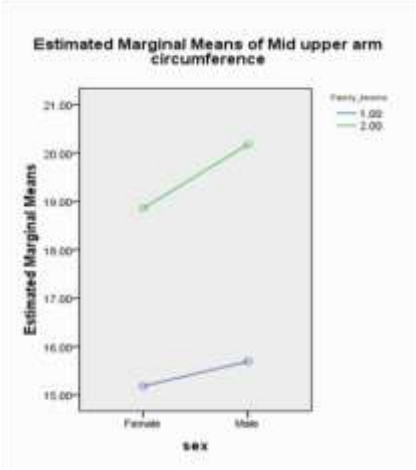
There are significant sex differences in waist circumference-boys having a greater mean waist circumference is consistent with recent analyses that indicate sex disparities in trends in abdominal adiposity and waist circumference in relation to BMI across several nations. Similar studies highlight that waist circumference may reveal more distinct sex patterns than certain other anthropometric measurements and demonstrate sex-specific secular changes in waist circumference. Similarly significant sex differences in core measurements are reported by research creating age- and sex-specific waist circumference percentiles for Indian children. These results suggest that central adiposity measures are reasonable comparators for our findings since they can show sex differences in childhood(Sánchez-Romero et al., 2024).

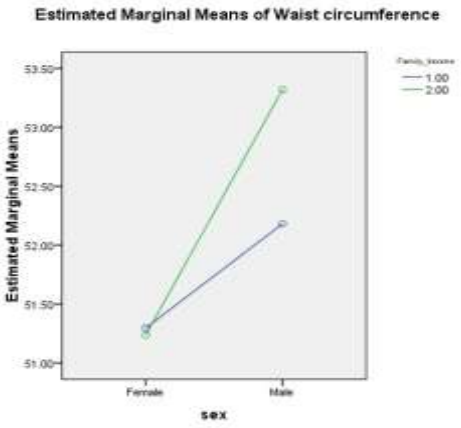
Fig. 1: Sex and income level interaction on anthropometric variables

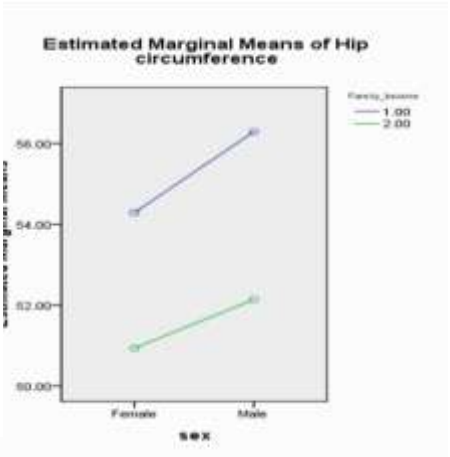


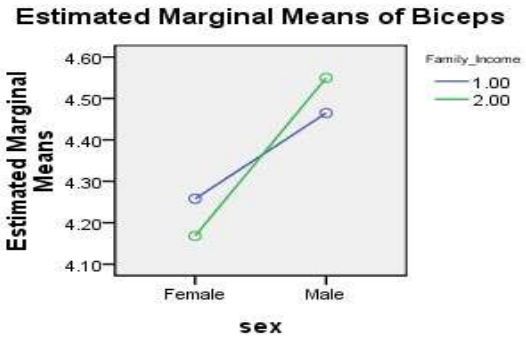


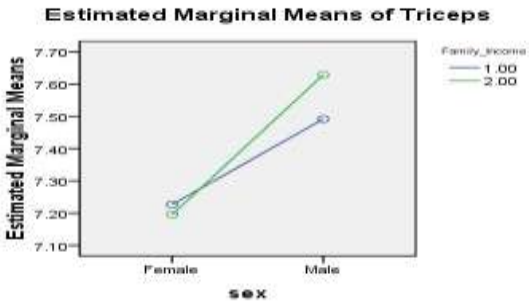












1-Basic income group (<8000), 2- Sustained income group (≥8000)

Fig. 2:Sex and Father's occupation interaction on anthropometric variables

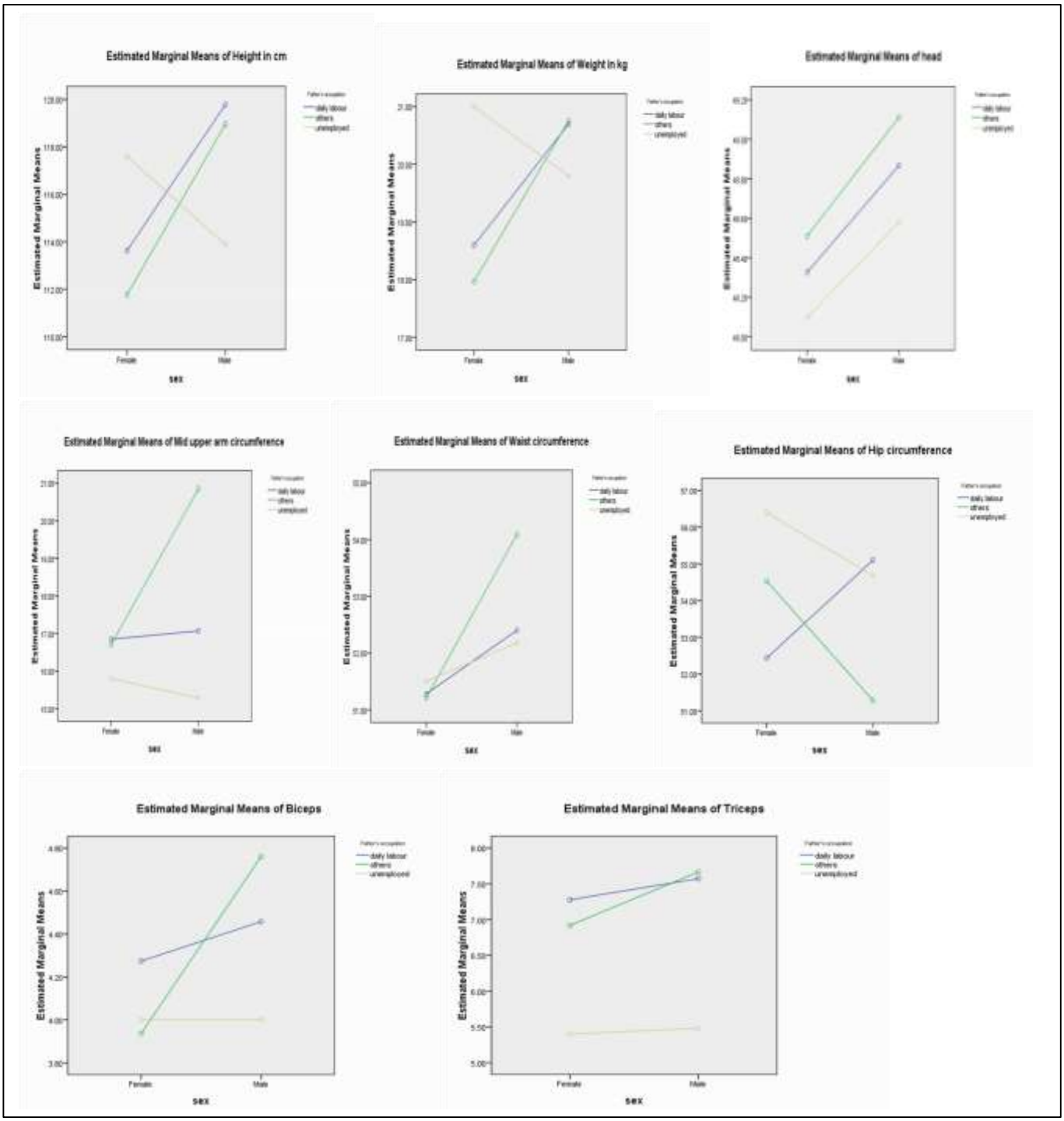


Fig. 3: Sex and Mother's occupation interaction on anthropometric variables

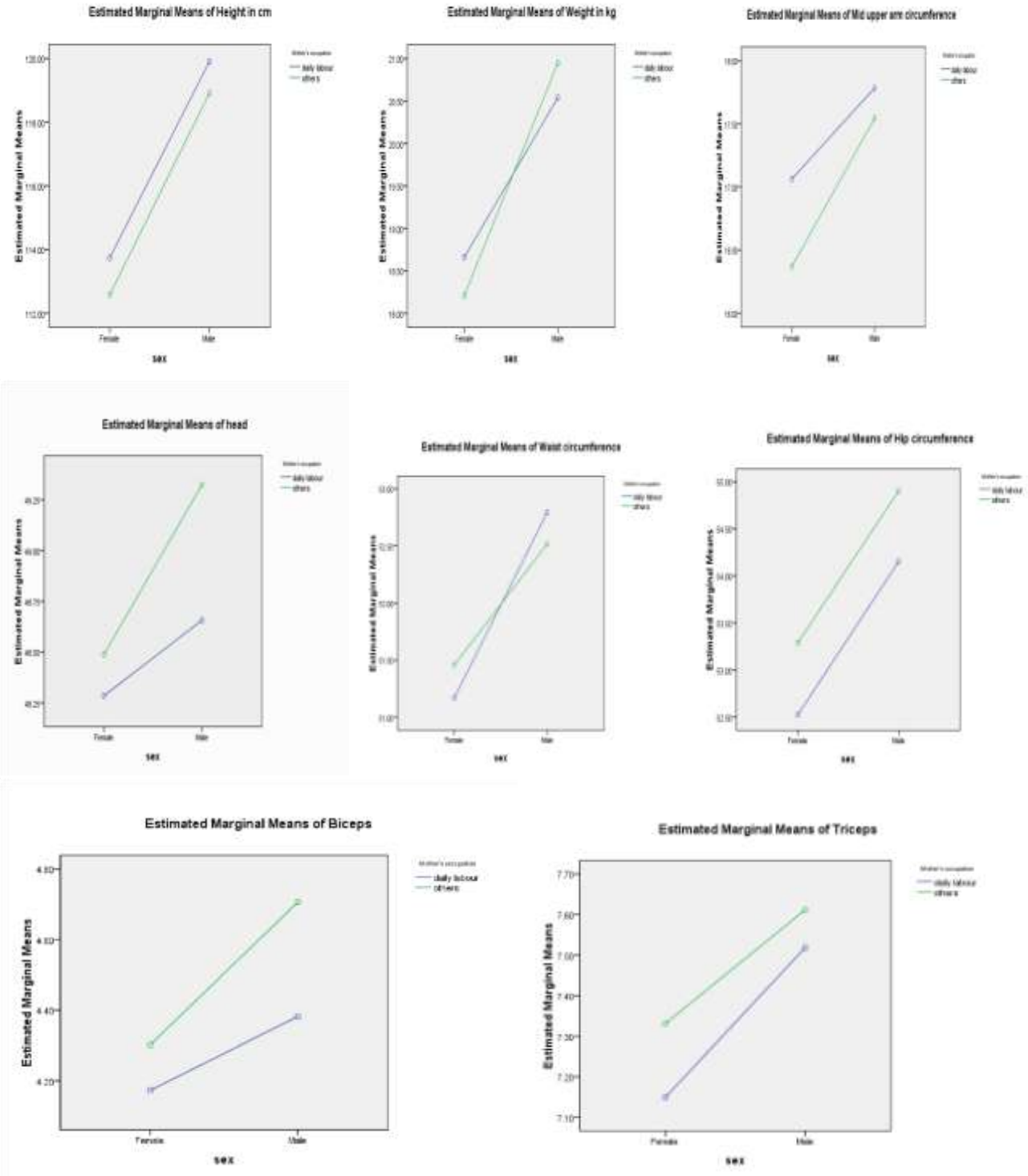


Table 3:Sex-wise comparison of anthropometric characteristics using independent t-test and effect size (Cohen's d)

Anthropometric Characteristics	T-test(p-value)	Cohen's d (d value)
Height	0.000**	0.43
Weight	0.000**	0.38
Head Circumference	0.004*	0.24
MUAC	0.182	0.11
Waist Circumference	0.000**	0.31
Hip Circumference	0.061	0.16
Biceps	0.029*	0.19
Triceps	0.069	0.15
p* - significant p** - Highly significant		

Fat-pattern dimorphism may be selectively expressed in this population, as evidenced by the considerable difference seen for biceps skinfolds but not triceps. Sex variations in fat deposition are frequently site-specific, and some subcutaneous measures reveal sex differences earlier than others, according to older research (Webster-Gandy et al., 2003).

Numerous community and slum studies have shown that MUAC is more sensitive to acute or household-level nutritional status than to biological sex, which is consistent with the lack of sex differences for MUAC and hip circumference. The non-significant sex differences we found can be explained by the fact that MUAC frequently reflects short-term nutritional shortfalls that affect both sexes similarly in poor settings, according to recent diagnostic and field investigations (Jasani et al., 2024).

Recent and foundational research relating parental socioeconomic position and mother empowerment with child growth supports the important sex*socioeconomic interactions, particularly the effect of household income and maternal occupation. A prior study documented how household resources and maternal factors shape child anthropometry (Black et al., 2013).Our findings also align with this, which show stronger improvements in some anthropometric measures with higher income or maternal employment and sex-specific interaction effects.

Overall the pattern in this slum population-selective dimorphism in some adiposity indicators and moderate dimorphism in linear growth, along with socioeconomic modulation of sex effects-is in line with regional and multi-country findings that biological sex differences endure but are context-sensitive. Certain sex differences may be lessened in situations of chronic deprivation (particularly in measures that are sensitive to immediate nutrition, such as MUAC), while others (such as height,

weight and some central adiposity indicators) may still be noticeable or exhibit sex-specific responsiveness to better home resources. These parallels highlight the necessity of socioeconomically aware, gender-sensitive treatments in impoverished areas(Thurstans et al., 2020).

CONCLUSION:

In this present study, it is found that boys tend to the slightly taller and heavier in this population. Sexual dimorphism is evident in height, weight, waist circumference, and biceps. However, other anthropometric measurements such as MUAC, hip circumference, and triceps do not indicate any significant sex-based variation, suggesting that dimorphism is trait-specific and affected by environmental and socioeconomic conditions. These results demonstrate how the limitations of their living conditions, in addition to biological variations, influence the growth patterns of children living in slums. This study's finding about the relationship between sex, parental occupation, and income demonstrate how important socioeconomic factors are in shaping a child's development. From the standpoint of public health in general, this implies that enhancing living conditions and nutritional quality in impoverished areas may contribute to decrease in growth disparities. Regardless of gender, increasing maternal employment possibilities, improving home income stability, and guaranteeing access to sufficient nutrition and healthcare may have a good impact on children's development. In order to enhance child health and lessen inequality among vulnerable populations residing in slum regions, this study emphasizes the significance of addressing both biological and socio-environmental determinants.

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