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Double burden of malnutrition among Indian schoolchildren and its measurement: a cross-sectional study in a single school

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ABSTRACT

Objective This cross-sectional study set in a single school on the outskirts of a large city aimed to document the extent of double burden of malnutrition (coexistence of overnutrition and undernutrition) among Indian schoolchildren from lower socioeconomic groups, and to determine if mid-upper arm circumference (MUAC) can be used as a proxy for body mass index (BMI).

Subjects The total number of participants was 1444, comprising 424 girls and 1020 boys belonging to playgroups and grades 1 to 7.

Measurements Anthropometric measurements, such as participants' MUAC, height and weight were measured using standard techniques. Descriptive statistics for BMI and MUAC were obtained based on gender; z-scores were computed using age-specific and sex-specific WHO reference data. The distribution of variables was calculated for three groups: girls, boys and all participants. Homogeneous subsets for BMI and MUAC were identified in the three groups. Age-wise comparisons of BMI and MUAC were conducted for each gender.

Main outcome measures (1) To know if MUAC and BMI are correlated among boys and girls. (2) To study BMI and MUAC z-score distribution among the participants.

Results MUAC was positively correlated with BMI in both boys and girls. The following BMI z-score distribution was observed: severe acute malnutrition (SAM), 5 (0.3%); moderate acute malnutrition (MAM), 146 (10.1%) and undernourished, at risk of MAM/SAM, 141 (9.8%); obese, 21 (1.5%); overweight, 36 (2.5%) and pre-obese, 136 (9.4%). The distribution of categories of children based on MUAC z-scores was: SAM, 7 (0.5%); MAM, 181 (12.5%) and undernourished, at risk of MAM/SAM, 181 (12.5%); obese, 19 (1.3%); overweight, 178 (12.3%) and pre-obese, 135 (9.3%).

Conclusions SAM/MAM/undernourished states and obesity/overweight/pre-obese states, indicating undernutrition more than overweight, coexist among Indian schoolchildren from lower middle/lower socioeconomic categories. BMI and MUAC were significantly correlated. MUAC identifies both undernutrition and overnutrition by early detection of aberrant growth.

What is known about the subject?

- ► Emerging economies face a dual problem of under-nutrition and overnutrition.
- ► Detecting these problems using height-based parameters is not easy in a low-resource setting.

What this study adds?

This study suggests that mid-upperarm circumference is a simple, valid and single measure for identifying this dual problem in a low-resource setting, and undernutrition is a bigger problem than obesity.
Undernutrition and overnutrition coexist in low and middle income countries.

INTRODUCTION

The double burden of undernutrition and overnutrition is an emerging international problem. According to estimates from 129 countries with available data, 57 experience serious problems of both undernourished children and overweight adults.[1] The relationship between undernutrition and overweight status and obesity is deeper than coexistence. The double burden of malnutrition (DBM) refers to the coexistence of both undernutrition and overnutrition within individuals, households and populations and across the life course. 'Across the life course' refers to the phenomenon that undernutrition early in life contributes to an increased propensity for overnutrition during adulthood.[2] The occurrence of DBM is attributed to a complex interplay of nutritional transitions (shifting from an active to a sedentary lifestyle, demographic transitions, etc) from high fertility and early deaths to low fertility and ageing populations and epidemiological transitions from communicable to non-communicable diseases.[2]

Later in the life course, the double burden of disease is characterised by the coexistence of communicable (infectious disease) and non-communicable diseases. Prior to the 1970s, obesity was a relatively rare condition, even in the wealthiest of nations,[3] whereas undernutrition was a major problem, and nutrition supplementation was the main intervention. Thus, obesity is a relatively new problem in need of attention. A systematic review of obesity and socioeconomic status in low- and middle-income countries concluded that child obesity is more prevalent among affluent groups in such countries.[4] This may be attributed to improved access to surplus/excess food and a higher degree of urbanisation and technological progress in these economies that render activities less laborious, resulting in less energy expenditure.[5] Furthermore, childhood obesity is a strong predictor of adult obesity. For instance, a Japanese study revealed that approximately one-third of obese children grew into obese adults.[6] Therefore, early detection of excessive weight gain, and action to prevent its progress, is more likely to succeed than attempting to reverse obesity later.

Body mass index (BMI)-for-age, the internationally recommended measure of obesity, suggests that Asians are at an increased risk of cardiometabolic disorders, even at lower BMI levels, because of a considerably higher body fat percentage.[7] Therefore, the WHO recommends lowering the BMI cut-offs for being considered 'overweight' among Asian adults[8] in light of the increased health risks. Early detection of overweight status has become very important in Asia.

The selection of height-based parameters, such as BMI for the detection of overweight/obese children in low-resource settings, has limitations because of the shortage of stadiometers and trained paramedical staff. A simpler proxy for BMI that parallels the use of abdominal girth for detecting visceral obesity needs to be developed.[9] The mid-upper arm circumference (MUAC) appears to be a promising alternative in this regard.[10–14] A recent study from the Netherlands reaffirmed that, compared with BMI, MUAC is a valid measure for detecting overweight/obesity, and thus is a good alternative to BMI.[15] Health workers are familiar with MUAC measurement, as it has been commonly used for identifying severe acute undernutrition among young (6 to 60 months of age) children.[16]

To our knowledge, few studies have focused on the coexistence of undernutrition and overnutrition in India. The present study was conducted to document the extent of DBM among Indian schoolchildren, a key group for intervention, using BMI and MUAC distributions. The study also examined whether MUAC can be used as a proxy for BMI, so that MUAC can detect trends toward obesity or severe acute malnutrition (SAM).

PARTICIPANTS AND METHODS

Setting

A single school cross-sectional study was conducted with schoolchildren from the outskirts of Pune, India. This study was part of the Maharashtra Institute of Medical Education and Research (MIMER) Medical College and Hospital's outreach activities regarding annual school health check-ups. A schedule of classwise health check-ups was developed in consultation with the school authorities who, in turn, sought parents' permission. A majority of the children belonged to lower and lower-middle socioeconomic categories. Children between 3 and 5 years were from a playgroup, and those between 6 and 12 years belonged to grades 1 to 7.

Anthropometric measurements

Anthropometric measurements, such as MUAC, height and weight, were taken from each participant using standard techniques. Height (cm) was measured on a stadiometer (Easy Care) without shoes. Weight (kg) was measured using a digital weighing machine (Meditrin Instruments) in light clothes and without shoes. MUAC (cm) was measured using a non-elastic plastic tape at the midway between the olecranon and acromion processes on the upper left arm. During these measurements, the participant was in a comfortable standing position and was asked to look straight ahead with his/her shoulders in a neutral position. The participant's arm was straightened, and we ensured that the tape was neither too tight nor too loose.

Statistical tools

Open Source Statistical Software PSPP V.1.0.1 was used for all analyses, and a p value ≤0.05 was considered statistically significant. Mean and SD, median, IQR and z-scores for BMI and MUAC were computed by sex for participants with complete measurements. Z-scores were computed using age-specific and sex-specific reference data from the WHO.[17] The distribution of variables was calculated among all participants together and separately for boys and girls. Homogeneous subsets for BMI and MUAC were identified in these three groups. Age-wise comparisons of BMI and MUAC were calculated for both girls and boys.

Patient involvement

Patients were not directly involved in the design of this study.

RESULTS

The total number of participants was 1444, comprising 424 girls and 1020 boys. The distribution of z- scores among all participants is shown in figures 1 and 2. Age, height, weight, MUAC and BMI were all significantly different between girls and boys; boys had higher values for all parameters (online supplementary tables 1 and 2). As expected, BMI and MUAC showed age-wise differences for all participants, combined and separately, for boys and girls, between the ages of 3 to 16 years (online supplementary tables 3 and 4). Tukey's honest significant difference (HSD) test for homogeneous subsets revealed a significant shift in mean BMI at 3, 6 and 10 years (online supplementary table 5), whereas for MUAC, the

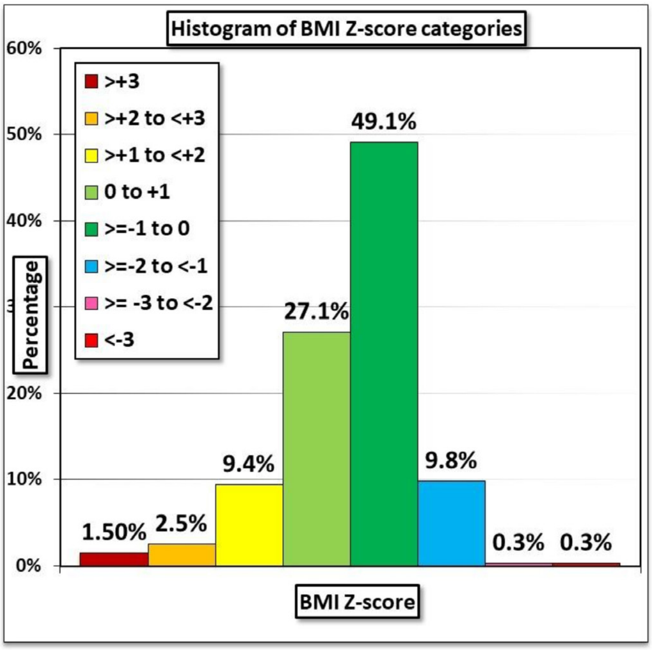

Figure 1 Histogram showing BMI Z-score categories. BMI, body mass index.

shift occurred at 4, 6 and 9 years (online supplementary table 6). Thereafter, MUAC changed significantly almost every year until the age of 16. Thus, in contrast to BMI, MUAC had more age-dependent variability. BMI change with age was minimal in girls (only at age 14) compared with changes in boys at 6, 10, 12 and 14 years. Girls had six homogeneous subsets for MUAC, with the first significant rise at age 4 years, compared with nine subsets in boys, with the first shift at age 5. Thus, changes in BMI and MUAC were more frequent in boys. MUAC was

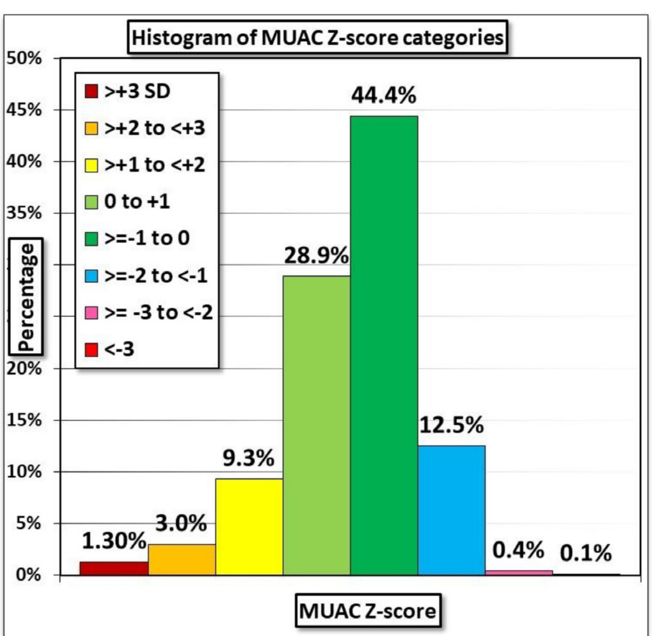

Figure 2 Histogram showing MUAC Z-score categories. MUAC, mid-upper arm circumference.

associated with weight, height and BMI both in girls and boys (tables 1 and 2).

The distribution of clinical categories of nutritional status with respect to BMI and MUAC is shown in table 3.

DISCUSSION

The present study suggests that DBM has reached Indian schoolchildren of lower middle or lower socioeconomic statuses, which calls for urgent action. Importantly, the present results identify children at the brink of sliding into severe forms of undernutrition and overnutrition. The present study also suggests using a single and simpler method, MUAC, for detecting both forms of malnutrition by monitoring growth during routine health check-ups.

The World Health Assembly targets were considered in crafting the 2030 development agenda and are referred to in target 2.2 of the Sustainable Development Goals to 'end all forms of malnutrition'. The reference to 'all forms of malnutrition' is important for acknowledging the existence of the double burden of undernutrition and overweight status. While the drivers of the double burden of malnutrition are varied and often insidious, their effects present a clear case for urgent action and demand an integrated response. Using a single tool for detecting both forms of malnutrition integrates and simplifies the process.

To our knowledge, few studies have focussed on this aspect of growth among children in India, as well as other emerging economies. The girls were outnumbered by boys (424 vs 1020). This may be due to the traditional gender norms that push girls into helping with household chores and sibling care, resulting in school dropouts. Based on BMI z-Scores, 5 (0.3%) and 5 (0.3%) belonged to SAM and moderateacute malnutrition (MAM) categories, respectively, and 21 (1.5%) and 36 (3.9%) children were classified as obese and overweight, respectively. MUAC z-scores suggested the following distribution: SAM −1 (0.1%), MAM − 4 (0.4%), obesity −19 (1.3%) and overweight −43 (4.3%). An even greater number of children were leaning toward SAM or MAM as well as obesity or overweight. Children who are not yet at the BMI-for-age threshold for the current definition of SAM or MAM (and childhood obesity or overweight) may be at an increased risk of developing severe forms of undernutrition or obesity. One of the present study's aims was to identify these target groups so that these children's needs could be addressed.

The first target group, undernourished children (BMI or MUAC z-score between −1 and −2 SD), is at risk of sliding into MAM or SAM. The second group, pre-obese children (BMI or MUAC z-score between 1 and 2 SD), is at risk of progressing to overweight/obesity. Based on the BMI z-scores, 181 (12.5%) were undernourished, and 136 (9.4%) were pre-obese. The equivalent numbers for MUAC were 181 (12.5%) for SAM and MAM risk and 135 (9.3%) for obesity, respectively. More children were at risk of severe undernutrition than of overnutrition.

Table 1 Correlations between anthropometric parameters among girls (N=424)

Variables		MUAC	Body weight (kg)	Height (cm)	BMI
MUAC	Pearson correlation	1	0.897*	0.700*	0.826*
	P value		7.34E-152	1.21E-63	6.86E-107
Body weight (kg)	Pearson correlation	0.897*	1	0.866*	0.776*
	P value	7.34E-152		2.85E-129	1.93E-86
Height (cm)	Pearson correlation	0.700*	0.866*	1	0.385*
	P value	1.21E-63	2.85E-129		2.16E-16
BMI	Pearson correlation	0.826*	0.776*	0.385*	1
	P value	6.86E-107	1.93E-86	2.16E-16	

*Correlation is significant at the 0.01 level (two-tailed).
BMI, body mass index; MUAC, mid-upper arm circumference.

These target groups may develop more severe forms of malnutrition if corrective measures are delayed. The first step in that direction is to plan face-to-face counselling sessions with parents and children. School programmes are effective at preventing childhood obesity by fostering more physical activities and recommending healthier diets.[18] Counselling for the target groups will have to be done, keeping in mind that within low-resource settings, places for play may be scarce, sports infrastructure may be poor and recreational centres may be lacking.[19] Similarly, low family income is linked to greater consumption of low-quality nutrition and fast food.[20]

Importantly, MUAC as a single tool can facilitate this cohesive intervention by detecting both undernutrition and overnutrition during routine growth monitoring without a height-dependent parameter, such as BMI (figure 1). This is because BMI and MUAC are significantly correlated with each other. However, monitoring for obesity should begin even earlier, as the most rapid weight gain occurs between ages 2 and 6 years among obese adolescents.[21]

While India's economy has been growing at an impressive rate, the country still has the highest number of stunted children in the world (46.8 million), representing one-third of the global total of stunted children under age 5.[22] Stunting is associated with being overweight among children in countries that are undergoing a nutritional transition.[23] Economic improvements are accompanied by a conspicuous change in dietary patterns in the form of increased fat intake[5] compounded by exposure to food advertising on television leading to fast food and soft drink consumption and obesity.[24] This, coupled with low physical activity, contributes to an increasing prevalence of obesity among adults, which accompanies the first wave of a cluster of non-communicable diseases, such as hypertension and diabetes mellitus, called 'the new world syndrome'.[25] It should be noted, however, that there has not been the same level of agreement on the classification of obesity for children and adolescents as there is for adults.[26]

To summarise, until recently, India has considered undernutrition to be a major problem, and nutrition supplementation has been the key intervention. At the national level, India is at stage 1 of the obesity transition with wide subnational variations.[27] Our study may help in the surveillance effort to address underserved populations.[27] With improved availability of food, a double burden of malnutrition is emerging that needs to be concurrently addressed. The present study observed the coexistence of obesity, overweight and pre-obese, and SAM, MAM and undernourished states among Indian school children in lower-middle and lower socioeconomic

Table 2 Correlations between anthropometric parameters among boys (N=1020)

Variables		MUAC	Body weight (kg)	Height (cm)	BMI
MUAC	Pearson correlation	1	0.911*	0.780*	0.847*
	P value		0.0001	9.60E-210	2.21E-281
Body weight (kg)	Pearson correlation	0.911*	1	0.886*	0.861*
	P value	0.0001		0.0001	1.25E-301
Height (cm)	Pearson correlation	0.780*	0.886*	1	0.564*
	P value	9.60E-210	0.0001		1.02E-86
BMI	Pearson correlation	0.847*	0.861*	.564*	1
	P value	2.21E-281	1.25E-301	1.02E-86	

*Correlation is significant at the 0.01 level (two-tailed).
BMI, body mass index; MUAC, mid-upper arm circumference.

Table 3 Distribution of nutrition conditions based on BMI and MUAC z-scores*

Condition	Based on BMI z-scores No (%)	Based on MUAC z-scores No (%)
Pre-obese	BMI >1 to 2 SD 136 (9.4%)	MUAC >1 to 2SD 135 (9.3%)
Overweight	BMI >2 to 3 SD 36 (2.5%)	MUAC >2 to 3SD 43 (3.0%)
Obese	BMI >3 SD 21 (1.5%)	MUAC >3 SD 19 (1.3%)
Possible risk of underweight	BMI <-1 to –2 SD 141 (9.8%)	MUAC ≤–1 to –2 SD 181 (12.5%)
Thin	BMI <-2 to –3 SD 5 (0.3%)	MUAC <-2 to –3 SD 6 (0.4%)
Severely thin	BMI <-3 SD 5 (0.3%)	MUAC <-3 SD 1 (0.1%)

*Modified WHO Classification of nutrition conditions based on anthropometry.
BMI, body mass index; MUAC, mid-upper arm circumference.

levels. Second, the present results revealed a significant correlation between BMI and MUAC. This study provides evidence to suggest that MUAC is a valid, single measurement for identifying this dual problem of aberrant growth and overnutrition on the one hand and undernutrition on the other, through extended routine growth monitoring of children. However, more studies are required to establish the validity and reliability of this tool.

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Competing interests None declared.

Patient consent for publication Not required.

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository.

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