Research

Nutritional Status and Body Fat of 12-36 Month Old Young Children from Mumbai, India

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Abstract

Background

Little data is available on body fat of young children and there is dearth of information on association between nutritional status and body fat of children below 3 years of age. Therefore the present study measured body fat assessed nutritional status and examined their association among children in Mumbai city.

Methods

Weight, height and percent body fat were measured in 1248 children aged 12- 36 months; weight and height were measured using standard methods. Percent body fat was determined using Bioimpedance analysis- BIA (Body stat- Quad scan 4000). Nutritional status i.e. Z scores – weight for age, height for age, weight for height, BMI for age) was assessed using WHO Anthro software.

Results

Among the 1248 children, only 2.8 % were wasted, 2.4% were underweight and 2.0 % were stunted, whereas 23.4%, 14.5%, 16.3% and 24.8% children had zscore above +2SD for WHZ, WAZ, HAZ and BAZ respectively. Mean percent body fat for the entire sample was (20.13 +2.37). Males had significantly higher body fat as compared to females. Age also influenced body fat significantly. Z score for weight for height, BMI for age and height for age showed significant association with percent body fat, but no association was seen with WAZ.

Conclusion

Children in -2 to -3 SD category tended to have higher body fat than children in normal nutritional status category.

Introduction

India has a very large proportion of undernourished young children. According to the National Family and Health Survey-3 (NFHS-3) conducted in 2005-06 [1], the prevalence of wasting was 16.5% among children under three years of age. The percentage of children who were stunted and underweight, during the same period was 46.3% and 37.0%. Under nutrition in early life, particularly *in utero*, compels the fetus to adapt to a suboptimal nutrient supply and results in early programming leading to increased risk of non-communicable diseases in adult life. This becomes more pronounced when in extra uterine life, the infant is provided with a diet/feeding pattern that places a burden on organs and tissues that are not capable enough to cope with this onslaught.

This essentially represents "a nutritional mismatch between energy intake, storage, and expenditure" Sarr, Yang and Regnault (2012) reported that adipocytes of fetuses that are growth retarded have increased lipogenic and adipogenic capacity [2]. Other alterations include hypoleptinemia, altered glucocorticoid signaling as well as chromatin remodeling, all of which increase the risk of adipose tissue accumulation and obesity and the consequent problems of insulin resistance and diabetes mellitus. Excess adipose tissue especially visceral fat increases insulin resistance and the risk of non – communicable diseases such as metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease [3-5].

According to the NFHS-3, in 2005-2006, 1.7 percent of children 12-17 months of age and 1.1 percent of children 18-23 months old had z scores above + 2SD for WHZ. The corresponding figures for percent children with WAZ scores above +2 SD were 0.3% and 0.2% respectively. The next round of the NFHS has been conducted but results are awaited especially related to overweight and obesity in young children.

It is well accepted that India faces a double burden of malnutrition, over-nutrition occurring simultaneously along with under nutrition among different population groups, which is of great concern [6,7]. Thus, childhood obesity has become a cause of concern [8-11].

There are very few reports in the literature on percent overweight and obesity in preschool children and reports on children below 36 months of age are scarcely available in the published literature. Kumar et al. reported that the prevalence of overweight and obesity among pre-school children in semi-urban South India was 4.5% and 1.4%, respectively [12]. Khadilkar and coworkers observed that among 2 to 17 yr old children, based on the IOTF classification, the percent of children who were overweight and obsese was 18.2%.

However, when the WHO standards were used the prevalence was much higher (23.9 %) [13].

Generally, body mass index is used to assess obesity but it does not indicate the amount of body fat. Hence study of body composition is better because body fat can be measured. Little data is available on body fat of young children and there is dearth of information on the association between nutritional status and body fat of children below 3 years of age. This is especially relevant because reports in the literature indicate that Indians/Asians have more body fat for the same body mass index than do Caucasians [14]. Therefore, the present study estimated body fat, assessed nutritional status and examined their association in a sample 1248 children in Mumbai city.

The percentage of infants who are born with low birth weight (LBW) in India is fairly high- 28 percent based on the data available from the national Family and Health Survey-3 conducted in 2005-2006. (UNICEF, 2014). In Maharashtra state, a survey of 3000 children conducted by the International Institute of Population Sciences and UNICEF (2013) indicated that 20% infants were low birth weight. Low birth weight is an indicator of fetal under nutrition and poor intrauterine growth. Early reports in the 1980's indicated that low birth weight infants were at greater risk for metabolic abnormalities, impaired glucose tolerance and type 2 diabetes in adulthood [15]. Yajnik and coworkers have reported that low birth weight from Pune babies (2500 g) had more adipose tissue relative to their birth weight as compared to babies from Southampton, UK [14]. Therefore we also examined whether children who were low birth weight continued to be malnourished at the time of the present study and whether children who were LBW differed in their percent body fat from children with normal birth weight.

Materials and Methods

Ethics: This study was approved by the Independent Ethics Committee Navi Mumbai.

Study Design: Cross-sectional, observational study.

Sampling Method: Snow ball sampling method was used.

Selection and Description of Participants: One thousand two hundred and forty eight children in the age group of 12-36 months, who were residents of Mumbai city and whose parents gave their consent for recruiting their children into the study, were included. The sample consisted of 619 children in the age group of 12.0-24.9 months old and 629 were aged 25.0-36.0 months. Background information on family size, father's and mother's working status, income, child's date of birth, gender, birth weight, gestational age was obtained by interviewing the mothers. Age was ascertained by checking the hospital delivery card. Written informed consent was obtained from the main caregiver i.e. mother/grandmother of the child. After obtaining written consent, anthropometric measurements were taken.

The inclusion and exclusion criteria were as follows.

Inclusion Criteria

- Healthy children as reported by mother

- Children who were not on any medication as reported by mother

- Child in the 1st or 2nd ordinal position.

- Index child in study should be born at least one year after the older sibling.

Exclusion Criteria

- Children with physical deformities

- Children on any prescribed medication.

- Child with cleft palate,

- Children who have had a major illness in the past three months including measles, hepatitis, diarrhea, pneumonia

- Children of Mothers with HIV- AIDS, Tuberculosis, STDs.

- Children of mothers who were below the age of 20 yrs at time of conception.

Anthropometric measurements

Each measurement was taken three times and the average was calculated.

Weight

A digital weighing scale with an easy to remove infant tray accurate to 0.1 kg was used (SECA 354, capacity 20kg) to weigh. For infants below 2 years of age the detachable tray was used and the child was placed in the middle of tray with light clothing. The reading was noted once the child was lying still. Each child was weighed three times and the average was calculated.

For children between 2 and 3 years, who could stand without support, the tray was detached from the leveled platform weighing scale, before weighing every child, the scale was tarred to zero before measurements were taken. Weight was taken without shoes and only light clothing.

Reading was taken when the child was standing still with the weight equally distributed on both feet. Three readings were taken using same method [16].

Height

For infants below 2 years of age, an infantometer (SECA 417, measuring range 10-100 cm) was used to measure length. The child was placed on the length board. The infant's head was held firmly with the crown of the head against the head board. The legs were straightened by applying gentle pressure. Holding the feet so that the toes pointed upward, the foot board was moved upward until it rested against the feet. Infant length was recorded as the distance between the head board and the foot board. Measurements were recorded to the nearest 0.1 cm.

For children above 2 years of age and who could stand erect, a stadiometer (SECA 213, measuring range 20-205cm) was used to measure stature. The mother was asked to remove the child's footwear. It was ensured that the child's feet were placed together, arms were held at the sides, legs straight and shoulders were relaxed and that the child's heels, buttocks, shoulders and back of the head were touching the vertical board of the stadiometer. Keeping the head in position, the head board was pulled to rest firmly on top of the head, ensuring that the hair was compressed.

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Measurements were recorded to the nearest 0.1cm (WHO, 2008). Standard deviation/ z scores were calculated for weight for age (WAZ), height for age (HAZ) and weight for height (WHZ) using the WHO Anthro Plus software (Version 3.2.2, 2011).

Percent Body Fat

It was determined by bioelectrical impedance analysis (BIA). BIA measurements were carried out with the child lying in a supine position on a bed by using the Bodystat QuadScan 4000 unit which has four electrodes. Two electrodes were placed on the right wrist with one just proximal to the third metacarpophalangeal joint (positive) and one next to the ulnar head (negative). Two electrodes were placed on the right ankle with one just proximal to the third metatarsophalangeal joint (positive) and one between the medial and lateral malleoli (negative). Body fat was measured at multifrequency (5, 50, 100, and 200 kHz).

Data Analysis

Data was entered using Microsoft Excel and analyzed using SPSS version 20. Tests applied were Linear regression and Analysis of Variance (ANOVA). Data was compared between age categories – 12 to 24 months and 24.1-36 months. ANOVA was applied to determine whether there were differences in z scores between age groups and gender, whether percent body fat of children differed among the nutritional status categories for WHZ, WAZ, HAZ and BAZ, as well as between birth weight categories. Linear regression analysis was used to determine if there was a correlation between z scores and percent body fat.

Results

Nutritional status of children: Mean z-scores for WHZ, WAZ, HAZ and BAZ differed significantly between age groups (Table 1). Mean WHZ and BAZ scores were higher for the older children aged 24.1 to 36 months, whereas the z-scores for WAZ and HAZ were higher for the younger age group of 12-24 months. Also, a significant difference was found between male and female children, with females having higher mean Z scores as compared to males for all four indicators. (WHZ: F= 5.354, p=0.021, WAZ: F= 36.148, p= 0.000, HAZ: F=175.224, p= 0.000, BAZ: F=18.968, p= 0.000)

Among the 1248 children, only 2.8 % were wasted, 2.4% were underweight (WAZ < 2SD), 2.0% were stunted and 2.6% had low BMI for age (Figure 1). Approximately half of the children had normal WHZ, WAZ and BAZ. However, based on WHZ and BAZ, almost one-fourth of the children were overweight/obese (> +2 SD). When WAZ was used as an indicator the percentage was less. A little less than one-fifth of the children were tall for their age (> +2 SD).

Percent Body Fat: Mean percent body fat for the entire sample was 20.4±3.0. Percent body fat differed significantly between sexes (F=5.074,p=0.000), with males having slightly higher body fat than females(Table 2). Age also influenced body fat significantly (F=35.908,p=0.000), as children in the two younger age groups had less body fat than the 25-36 month old children.

Percent Body Fat and Nutritional Status: Children with z-scores between -2 and -3 SD tended to have more body fat than children in normal nutritional status category, with significant differences between z score categories for WHZ, WAZ, HAZ and BAZ (Table 3).

Weight, Nutritional Status and Percent Body Fat: Birth weights for 48 children were not available. Therefore, data on birth weight was analyzed for 1200 children. Birth weights of children were categorized in four groups- <2500 grams, 2501-2750 grams, 2751 to 3000 grams, and >3000 grams. Among the 1200 children, 4.16% weighed less than 2500 grams, 68.08% children had birth weights between 2501 and 2999 grams, 27.4% children had a birthweight of 3000 -3499 grams and only 0.33% of children weighed more than 3500 grams. Mean birth weights were compared among the z score categories for current nutritional status, for all four indicators. Children with better current nutritional status as indicated by WAZ and BAZ had significantly higher mean birth weights(Table 4).

Percent Body Fat and Birthweight: Percent body fat of children was compared by birthweight category (Table 5), but there was no statistically significant difference.

Percent Body Fat, Birthweight and Current Nutritional Status: Further percent body fat was compared between z score categories for current nutritional status vis - à -vis birth weight category (Table 6). In the lower z score categories, percent body fat was significantly higher as compared to categories with normal z scores for WHZ,

Table 1: Mean z-scores for male and female children in the two age groups

Age group (months)	Gender	WHZ	WAZ	HAZ	BAZ
12-24	Male (n=319)	0.6 ± 1.7	0.8 ± 1.3	0.7 ± 1.8	0.5 ± 1.9
	Female (n=308)	0.8 ± 1.4	1.4 ± 1.1	1.6 ± 1.9	0.7 ± 1.5
	All children	0.7 ± 1.5	1.1 ± 1.2	1.2 ± 1.9	0.6 ± 1.7
24.1- 36	Male (n=312)	0.7 ± 1.4	0.3 ± 1.0	-0.3 ± 0.8	0.8 ± 1.5
	Female (317)	1.1 ± 1.2	0.9 ± 0.9	0.1 ± 0.9	1.2 ± 1.2
	All children	0.9 ± 1.3	0.6 ± 1.0	-0.1 ± 0.0	1.0 ± 1.4
F, p		3.053, 0.081	57.23,0.000	239.14,0.000	15.65,0.000
F, P (between age groups)		14.548, 0.000	344.559, 0.000	19.786,0.000	19.087,0.000

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Table 2: Mean Percent Body Fat Values by Sex and Age Group

Gender	12-17.99 months	18-23.99 months	24-36 months	F, p
Male	20.40 ± 2.35 (n=137)	20.13 ± 2.48 (n= 154)	20.65 ± 2.69 (n=332)	
Female	19.15 ± 2.28 (n=149)	19.41 ± 2.25 (n=142)	20.89 ± 2.67 (n=334)	5.074,
All children	19.75 ± 2.39 (n=286)	19.79 ± 2.39 (n=296)	20.77 ± 2.68 (n=666)	0.024
F , P	F= 20.532, p= 0.000	F= 6.931, p= 0.009	F= 1.259, p= 0.262	

Table 3: Percent Body Fat of Children in Different Categories of Nutritional Status (WHZ, WAZ, HAZ, BAZ)

Nutritional Status Category	WHZ		WAZ		HAZ		BAZ	
	N	Mean ± SD	N	Mean ± SD	n	Mean ± SD	N	Mean ± SD
≤ -2 SD	35	20.6 ± 3.6[a]	30	21.9 ± 4.2[d]	26	22.5 ± 4.6[d]	39	20.0 ± 2.8[a]
-1.99 to 0.99 SD	604	20.4 ± 2.7[a]	613	20.3 ± 2.6[a]	849	20.4 ± 2.5[a]	618	20.4 ± 2.7[a]
1 to 2 SD	318	19.8 ± 2.3[a,b]	424	20.3 ± 2.5[b]	170	20.6 ± 2.9[b]	297	19.8 ± 2.3[a,b]
> +2 SD	291	20.6 ± 2.5[a,c]	181	20.0 ± 2.5[c]	203	20.3 ± 2.2[c]	294	20.6 ± 2.5[a,c]
	F=6.286, p = 0.001		F= 4.689 p = 0.003		F=13.654 p = 0.000		F=5.747, p = 0.001	

Table 4: Mean Birth weight by Current Nutritional Status Categories

| Nutritional Status Catgeory	WHZ		WAZ		HAZ		BAZ	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
< -2 SD	31	2868 ± 132	11	2855± 69	25	2885 ± 121	11	2919 ± 97
-1.99 to 0.99 SD	580	2880 ± 163	828	2860 ± 177	568	2877 ± 165	588	2868 ± 173
1 to 2 SD	296	2861 ± 163	162	2883 ± 145	317	2863 ± 168	421	2860 ± 173
> +2 SD	293	2863 ± 175	199	2904 ± 125	290	2865 ± 168	180	2900 ± 115
	F= 1.175, p=0.318		F= 4.230, p= 0.006		F= 0.697, P=0.554		F= 2.938, p= 0.032	

Table 5: Percent Body Fat of Children by Birth weight Category

Birth weight category (grams)	N	Mean ± SD	Minimum	Maximum	F, p
<_2500	50	20.70 ± 1.93	15.90	24.30	
2500-2750	114	20.18 ± 2.33	15.90	24.80	1.250,
2751- 3000	944	20.10 ± 2.40	14.90	25.90	0.290
>3000	92	20.33 ± 2.50	14.90	24.50	
Total	1200	20.15± 2.39	14.90	25.90	

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Table 6: Percent Body Fat of Children Compared to Birthweight and Nutritional Status.

Birth weight category	Nutritional Status Category	WHZ		HAZ		WAZ		BAZ	
<2500 (n=50)	<-2	1*	21.50	-	-	-	-	-	-
	-1.99 to 1.0	22	21.52 ± 1.47	23	21.52 ± 1.45	44	20.90 ± 1.88	29	21.28 ± 1.74
	1.01 to 2.0	16	19.28 ± 2.01	17	19.38 ± 1.99	5	18.84 ± 1.71	20	20.15 ± 1.20
	>2.01	11	21.06 ± 1.64	10	21.06 ± 1.73	1	21.50	1	17.5
	F, p	21.06, 1.64		7.983, 0.001		2.826, 0.069		3.476, 0.039	
2500 – 2750 (n=114)	<-2	3	20.30 ± 3.02	3	20.30 ± 3.01			1	19.90
	-1.99 to 1.0	55	19.98 ± 2.46	55	20.02 ± 2.44	84	20.40 ± 2.21	56	20.24 ± 2.32
	1.01 to 2.0	28	20.20 ± 2.18	29	20.36 ± 2.26	13	20.15 ± 2.65	45	20.06 ± 2.35
	>2.01	28	20.56 ± 2.25	27	20.35 ± 2.23	17	19.18 ± 2.60	12	20.45 ± 2.59
	F, p	0.381, 0.767		0.191, 0.902		1.966, 0.145		0.105, 0.957	
2751 – 3000 (n=944)	<-2	27	19.33 ± 2.14	22	19.61 ± 2.03	11	20.60 ± 2.47	10	19.40 ± 1.60
	-1.99 to 1.0	454	20.02 ± 2.35	442	20.06 ± 2.35	638	20.26 ± 2.44	457	20.02 ± 2.35
	1.01 to 2.0	230	19.75 ± 2.24	245	19.72 ± 2.28	133	20.09 ± 2.36	327	20.21 ± 2.45
	>2.01	233	20.60 ± 2.60	235	20.60 ± 2.57	162	19.43 ± 2.14	150	20.12 ± 2.50
	F, p	6.059, 0.000		5.832, 0.001		5.325, 0.001		0.654, 0.581	
>3000 (n=92)	<-2	-	-	-	-	-	-	-	-
	-1.99 to 1.0	49	20.70 ± 2.53	48	20.78 ± 2.59	62	20.59 ± 2.67	46	20.75 ± 2.67
	1.01 to 2.0	22	19.66 ± 2.26	26	19.54 ± 2.12	11	20.16 ± 2.74	29	20.65 ± 2.35
	>2.01	21	20.19 ± 2.72	18	20.28 ± 2.73	19	19.58 ± 1.76	17	18.68 ± 1.71
	F, p	1.366, 0.261		2.085, 0.130		1.197, 0.307		4.898, 0.010	

*represents number of children

Figure 1: Percent Children in Different Nutritional Status Categories
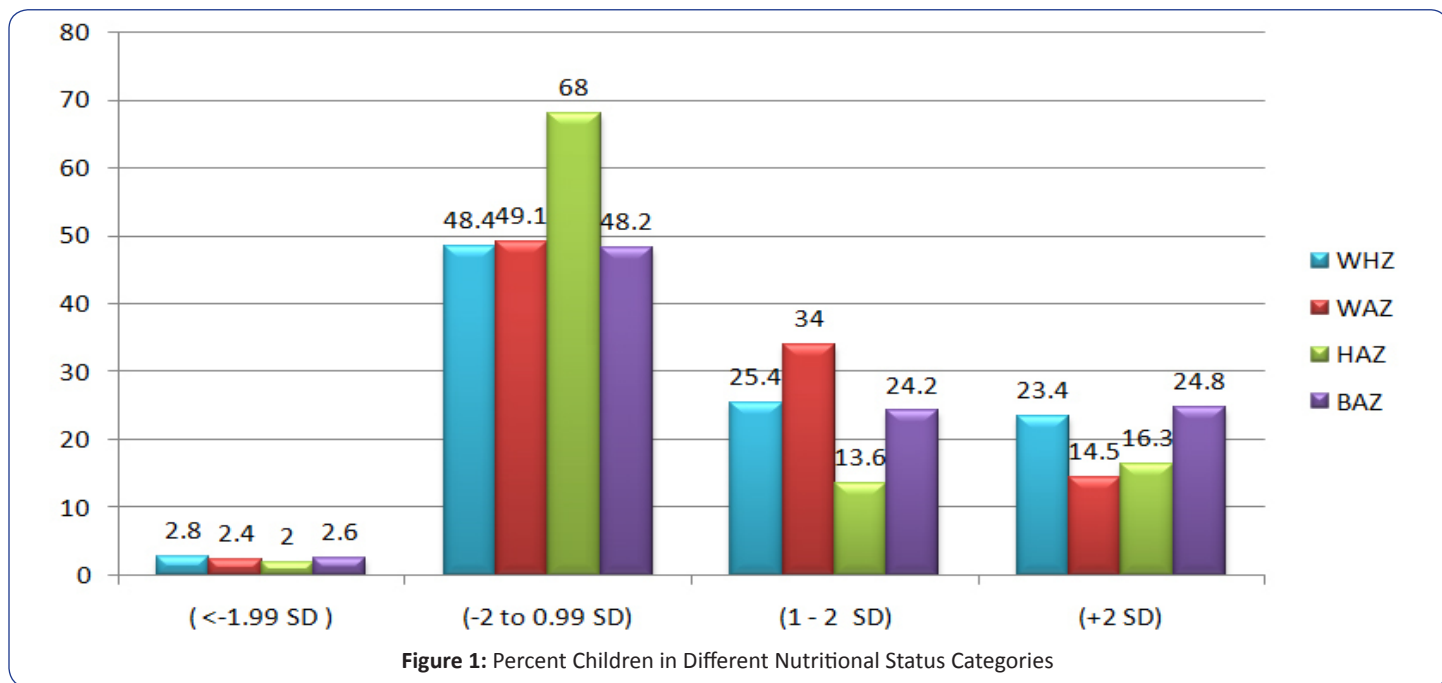
HAZ, WAZ and BAZ (Table 6).

Linear regression was applied using z score as the independent variable and percent body fat as the dependent variable. Results showed that except for Z scores for BMI (BAZ), the z scores for the other three indicators were negatively and significantly correlated with percent body fat.

(WHZ: r = - 0.049, p = 0.041, HAZ: r = - 0.140, p = 0.000, WAZ: r = - 0.135, p = 0.000, BAZ: r = - 0.029, p = 0.157).

Discussion

Nutritional status during infancy, childhood and adolescence are in focus from the public health perspective, with one of the main concerns being to prevent non communicable diseases in adulthood. Hence, study of nutritional status, body composition especially body fat and diets of children is essential. The number of overweight or obese infants and young children (aged 0 to 5 years) increased from 32 million globally in 1990 to 42 million in 2013. It is estimated that if current trends continue, by 2025, the number of overweight or obese infants and young children globally will increase to 70 million. (WHO, 2014) [17].

In the present study, very few children were undernourished, in contrast to the NFHS-4 data for Maharashtra state of which Mumbai city is the capital. Data for Maharashtra state indicates that a substantial percentage of young children are undernourished. The percentage of children under 5 years of age who were wasted (WHZ < - 2 SD) was 24.9 % and the percentage whose WAZ i.e. wasted were below minus two standard deviations was 30.7% (NFHS-4, 2015-16) [18]. The low prevalence of under nutrition that we observed may be because we did not have many children from highly underprivileged and deprived families.

Our study is one of the first studies to measure percent body fat of young Indian children. Overall our data showed that older children had higher body fat as compared to the other two younger age groups and children in Z score of -2SD and -3SD category had higher body fat as compared to normal nutritional status categories. There are very few studies on body fat of children less than 5 years of age. Bandana et al. studied children in the age group 6 to 24 months. They reported that the mean percent body fat was 14.21 ± 4.27% for boys and 20.15 ± 7.06% for girls [19]. Sheikh et al. studied children with a mean age of 26.8 ± 14.48 months for boys and 30.2 ± 15.82 for girls. They reported that mean percent body fat was 17.2 ± 1.49 for boys and 19.7 ± 1.56 for girls [20]. The values observed for mean percent body fat are in a similar range as reported by these two groups of investigators.

However, in our study, boys had more percent body fat (20.39 ± 2.51) than did the girls (19.82 ± 2.40). Joey et al. studied children from the United States in the age group of 3-8 years with mean percent body fat of 16.8 ±3.3 [21], which is fairly similar to the percent body fat observed in the present study.

Further, we observed that males had slightly higher body fat as compared to females. Sexual dimorphism is not uncommon although in mammals, females tend to be smaller than their male counterparts in contrast to other species [22]. The findings of the present study are in contrast with the report by Fields et al. who reported that gender differences in body composition can be found among newborns, with girls exhibiting a significantly higher amount in relative fat mass and a lower amount in lean body mass in comparison to newborn boys. These authors stated that gender differences disappear by 6 months of age [23]. In the present study, although the percent body fat for children of both sexes was in the same range of values, yet the mean values differed significantly by gender.

Childhood nutritional stunting, an indicator of chronic malnutrition, has been suggested as one factor contributing to high rates of obesity in developing countries because of the observed association between stunting and adolescent and adult obesity [24,25]. In the present study, stunted children with z scores below -3 and -2 standard deviations had higher body fat (24.8 + 3.6, 22.2 ± 4.1) as compared to normal children (20.4 ± 2.5).

Studies have shown that early under nutrition is associated with overweight, especially with increased abdominal fat [26-28]. Walker et al. reported that the accumulation of abdominal fat was higher in stunted children with low body mass index (BMI) and low body fat, compared with that of normal stature [29].

Respiratory quotient (RQ) and total energy expenditure in stunted and non-stunted children were compared in a cross-sectional study carried out by Hoffman et al. in low-income areas residing in Sao Paulo city, Brazil. The stunted group showed significantly higher RQ and, consequently, lower fat oxidation, demonstrating that stunting is associated with important metabolic changes, and indicating a higher susceptibility of stunted children to accumulate body fat [30].

Stunted children have been found to have a lower fasting fat oxidation rate compared with nonstunted children from the same community, a factor that strongly predicts excess weight gain in other at-risk populations [31-33]. Reduced fat oxidation can contribute to obesity over time because fat that is not oxidized must be stored. In addition, the increased carbohydrate oxidation that may occur in parallel with decreased fat oxidation is likely to increase hunger according to the energy regulation theory by Flatt, 1995, which is based on the assumption that carbohydrate stores are a signal for hunger. Increased hunger would further favor excess weight gain by promoting increased energy intake [34].

When the association between percent body fat was examined in relation to birth weight, it was observed that percent body fat was very slightly higher among children who were low birth weight compared to children with normal birth weight. However, in the present study, only 50 children had birth weights <2500 grams. This is because our study design did not include birth weight as a variable. However, at the time of data collection, information on birth weight was recorded.

It would be worthwhile to study the association between body fat of young children between 1 and 3 years of cross-sectionally and to undertake longitudinal follow up postnatally, of a cohort of low birth babies and compare them with normal weight young Indian children, especially comparing children from urban slums, rural

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and tribal areas.

We analyzed our data in order to examine the current nutritional status of children whose birth weights were below 2500 g and compared them to children in the higher birth weight categories.

Our findings showed that none of the children who were low birth weight, had z scores for WHZ, HAZ and WAZ below -2SD category, and had normal nutritional status. This indicates that catch up growth must have occurred among these children from birth to current age.

Catch-up growth has advantages in terms of improved neurodevelopment, enhanced immune function, and final adult height. However, there are also certain disadvantages such as increased fat mass, and obesity and increased risk of type 2 diabetes mellitus, cardiovascular disease Monteiro and Victora stated that small-for-gestational age children have a tendency to accumulate intra-abdominal fat mass. It is not clear whether this is due to low birth weight itself, rapid postnatal catch-up growth, or a combination of both [35]. Earlier, Dulloo et al., reported similar findings. They stated that the insulin resistance seen in SGA children with catch-up growth and thrifty "catch-up fat phenotype" may be caused by complex interactions between earlier reprogramming and nutritional abundance during the postnatal period [36].

Sarr, Yang and Regnault pointed out that in animals, mothers/dams subjected to protein deficiency during pregnancy, the offspring were obese. In humans, among male offspring born after the Dutch famine in 1944-45, the prevalence of adiposity was higher at 19 years of age and they had more truncal and abdominal fat. They have identified several mechanisms that may program the fetus for increased risk of adiposity in postnatal life. These include alterations in fetal adipose tissue morphology and metabolism such as hypoleptinemia, expression and partitioning of leptin receptors, enhanced activity of, peroxisome proliferators-activated receptor-γ (PPARγ) which is a transcription factor regulator of adipose tissue and co regulators, increase in the expression and activity of fatty acid synthase. Alterations also occur in glucose metabolism such as up regulation of glycolysis. Other changes are increased expression of fetal hypothalamic neuropeptide Y (NPY), and reduction in noradrenergic sympathetic innervations of adipose tissue, modifications in the methylation status of adipogenic and lipogenic genes in hepatic and adipose tissues [2].

Stettler et al. in his longitudinal cohort with 300 African Americans born at full term was followed from birth to 20 y of age where rapid weight gain was defined as an increase in weight for- age ≥ 1 SD between birth and 4 months, reported that the rate of an infant's weight gain in the first year can help predict the likelihood of developing obesity or overweight in early adulthood [37]. Several researchers [3,38,39] have indicated that the risk is greater when catch-up growth occurs early in life.

Ong et al. noted that SGA children who showed catch-up growth between 0 and 2 years of age were fatter and had more central fat distribution at 5 years than other children [3]. These mechanisms through which rapid weight gain during infancy and childhood increase fat mass are not fully understood. It may be due to the rapid

weight gain and accumulation of central fat which poses greater demands on organ function [40]. This may result in an unfavorable metabolic profile such as insulin resistance and elevated blood pressure. If food consumption drastically increases postnatally and during childhood and results in subsequent obesity, the adaptations made by the fetus are no longer useful and are inappropriate for their programming [41,42]. Postnatal factors, such as nutrition, may contribute to or modify these associations and, therefore, represent potential targets for prevention against excess gains in visceral and subcutaneous abdominal fat. Thus, low birth weight followed by rapid weight gain during early postnatal life has been associated with increased long-term risks for central obesity, insulin resistance, impaired glucose tolerance, type 2 diabetes, and cardiovascular disease [38, 39, 43].

However, because our study had only BIA and skin fold thickness measurements methods for the assessment of body fat measures we were unable to identify at what age or when these excess gains in fat compartments occurs in children. This phenomenon needs to be studied on a large enough sample with adequate number of children in different birth weight categories.

Acknowledgment

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