Doi: 10.32677/IJCH.2017.v04.i04.005

Original Article

Nutrient intakes from solid/semisolid foods and body fat of children 12-36 months of age in Mumbai city, India

Namrata Nitin Bagle, Shobha Anand Udipi

From Department of Food Science and Nutrition, Shreemati Nathibai Damodar Thackersey Women's University, Mumbai, Maharashtra, India

Correspondence to: Namrata Nitin Bagle, Department of Food Science and Nutrition, Shreemati Nathibai Damodar Thackersey Women's University, Mumbai - 400 049, Maharashtra, India. E-mail: namrata_nb29@yahoo.com

Received - 15 May 2017 Initial Review - 07 June 2017 Published Online - 06 October 2017

ABSTRACT

Background: Few reports are available on the association between feeding practices and body fat of young Asian Indian children. Indian children have "thin-fat" syndrome, i.e., they tend to have higher body fat at lower body mass index, placing them at risk of non-communicable diseases. **Objectives:** The objective of this study is to examine whether young children's nutrient intakes are associated with body fat. **Materials and Methods:** Percent body fat measured by bioelectric impedance and nutrient intakes estimated from three 24-h diet recalls were studied in 1200 children, aged 12-36 months. Average intakes of macronutrients and micronutrients were calculated. Nutrient intakes were compared by quintiles of body fat. **Results:** Mean body fat was 20.13±2.37%, with older children having more body fat than younger children. Males had more body fat than females. Percent body fat was not only correlated with macronutrient intakes but also was positively correlated with iron, zinc intakes, and thiamine. Body fat was negatively associated with calcium, fiber, and Vitamin A intakes but was positively associated with intakes of animal protein and from milk and milk products. Children in the highest quintile of body fat had lower calcium intakes those in lower quintiles. Animal protein intakes increased from Quintile 1 to Quintile 4 of body fat. Male children aged 12-24 months in the second and third quintile had higher mean protein intakes than in the other quintiles. Female children in the highest quintile of body fat had lower mean animal protein intakes. Breastfed children aged 24-36 months old in Quintile 1 had lower protein intakes from milk and milk products than in the other four quintiles. Among non-breastfed male children, those in the fifth quintile had lowest intake of milk protein**.** **Conclusion:** Diets given to young children should be adequate in micronutrients and fiber, and there should not be too much emphasis on dairy protein only.

Key words: *Adiposity, Animal protein, Body fat, Calcium, Micronutrient intakes, Milk protein*

Dietary preferences and habits are established during the first 2 years of life [1], which can influence children's nutritional status, future health, and well-being and have an impact on long-term health [2]. After 6 months, and especially between 1 and 2 years of age, there is a transition from breast milk to other foods. This may make children vulnerable to either nutritional inadequacy if their diets are not appropriate and lack essential nutrients or excesses. Studies in different countries have shown that children's eating patterns have changed over the years, with the trends being eating more food away from home [3]. Seo et al. [4] highlighted that dietary diversity is associated with child's nutritional status and growth. Similar trends were observed by Lohia and Udipi [5], who studied the quality and quantity of complementary foods fed to 446 children aged 6-24 months from urban slums of Mumbai, India, in terms of food frequency and dietary diversity. Diversity of diets fed to children aged <12 months was low compared to children above 12 months of age. Furthermore, dietary diversity was significantly higher for non-breastfed than for breastfed children. Low diversity and low frequency of feeding complementary foods were major factors determining the nutritional status of the children.

The diet and nutrition survey of infants and young children [6] conducted on 2683 infants and young children aged between 4 and 18 months, in the UK, indicated that diet quality changed after 12 months, with a decline in consumption of micronutrient-fortified foods and milks, and an increase in the consumption of foods high in energy and in fat, sugar, and salt [7]. Similarly, trends were found in the feeding infants and toddlers study (2008) in the USA, which showed deterioration in dietary quality, nutritional inadequacies, and increased risk of overweight, obesity, and non-communicable disease in later life [8]. Several investigators have examined the influence of early nutrition on the risk of obesity later in life.

Protein intake, especially animal protein intake, in the early years apparently influences linear growth [8]. A systematic review by Hornell [9] on protein intakes from 0 to 18 years of age indicated that higher protein intake before the age of 2 years was associated with increased growth and higher body mass index (BMI). The association between high-protein intake in early life and later obesity may occur through growth factors that stimulate growth and promote adipocyte proliferation [10]. These reports have relevance to Indian children because Indian babies in contrast to Caucasian infants have more visceral, deep, and superficial subcutaneous adipose tissue; a fat distribution pattern that puts them at higher risk of diabetes [11]. However, few reports in the literature are available on body fat of young Indian children under 3 years of age in relation to their nutrient intakes. Therefore, we measured the body fat of children in this age group and estimated their intakes of the three macronutrients, fiber, selected minerals, and vitamins from all foods except breast milk, to examine whether nutrient intakes influence body fat. We focused on 12-36 months because the first 1000 days of life are critical and dietary practices are established in this period. Furthermore, this age group has been less focused on for the study of diets, nutrient intakes, and body composition.

MATERIALS AND METHODS

This study was approved by the Independent Ethics Committee, Navi Mumbai (31st August, 2013, IEC NO. 21/13). The study was carried out between September 2013 and February 2016. The sample consisted of 1200 children between the ages of 12 and 36 months from different socioeconomic strata who were residents of Mumbai city and whose parents consented to participate in the study. Sample selection was done by snowball sampling method. Children were selected from different areas of Mumbai city and suburbs through home visits for children from upper-income families. Children from urban slums were recruited by conducting health camps in four spatially discrete locations in the city as per the inclusion and exclusion criteria.

Inclusion criteria were healthy young children aged 12-36 months with birth order one or two and interval of at least 1 year between two children. Healthy children were considered as reported by mothers, and the child was not on any medication. Children were excluded if they were mentally or physically challenged, were suffering from physical deformities, cleft palate, or had a major illness such as hepatitis, diarrhea, and measles in the past 3 months, children of mothers who were below the age of 20 years at time of conception, or if the mother was suffering from HIV-AIDS, tuberculosis, and sexually transmitted diseases. Written informed consent was obtained from the parents of the selected children.

Percent body fat was determined by bioelectrical impedance analysis (BIA) using the body stat quads can 4000 unit. BIA measurements were carried out with the child lying in a supine position on a bed. The equipment has four electrodes; two electrodes were placed on the right wrist with one just proximal to the third metatarsophalangeal 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 multifrequencies (5, 50, 100, and 200 kHz). Data on dietary intakes were collected using the three-pass method, from mothers by the 24-h dietary recall, semi-quantitative weighment methods on 2 weekdays, and one weekend with an interval of 2 days between two consecutive diet recall [12]. Nutrient intakes on the 3 days were estimated separately, and the average was calculated. Briefly, the procedure was as follows:

- Caregivers were first asked to recall all the food items given to the child on the previous day, from the time the child woke up in the morning ending with the last food item/beverage at night. Foods eaten at home/outside, including any food supplement provided, were noted along with the time of consumption.
- Thereafter, the amount of each item consumed by the child was recorded in household measures or numbers and dimensions, which were equated with standard measures. For items such as biscuits, bread, and chapattis/bhakris (Indian flat bread), the number consumed was recorded and the dimensions measured.
- Finally, for each recipe/preparation, the raw ingredients used for the entire household were measured and/or weighed. The yield was then recorded using household measures, and thereafter, equated with standard measures. For food items prepared/eaten outside the home, recipes were constructed from similar dishes eaten in the home or from the information available on standardized recipes.
- Commonly consumed cooked foods (n=127) standardized in the laboratory, and nutrient contents were entered in the database. Similarly, nutrient contents of various processed foods such as biscuits, cookies, chocolates, and commercial beverages were taken from the label information provided by manufacturers.

The CS dietary software provided by Harvest Plus was used to estimate intakes of energy, protein, fat, iron, zinc, calcium, Vitamin C, and Vitamin A (retinol equivalents), based on the nutritive values of raw Indian foods. The software takes into account loses during cooking and processing given by the National Institute of Nutrition (2010).

Data on nutrient intakes were exported from the software to Microsoft Excel. Nutrient intakes were compared by gender, age group, and between breastfed and non-breastfed children. Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) version 20. Tests applied were multivariate analysis of variance (MANOVA), one-way analysis of variance, with Bonferroni and multiple regressions. A p=0.05 was considered statistically significant.

RESULTS

Among the 1200 children studied, 624 were breastfed, 476 with being 12-24 months of age, and 148 were between 24.1 and 36 months of age. Nutrient intakes of male children did not differ significantly from female children (Table 1). Comparison between children aged 12-24 and 24.1-36 months showed that except for iron and Vitamin C, all nutrient intakes of the older

Table 1: Nutrient intakes by age group, gender, and breastfeeding status

Gender	Breastfeeding status	Energy (kcal)	Protein (g)	Lipid (g)	CHO (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	Vitamin C (mg)	Folate (µg)	Vitamin A (RAE)
12-24 months												
Male	Breastfed (n=237)	668±329[1]	21.5±10.9	22.1±11.5	95.5±49.9	3.8±2.6	377±270	2.3±1.2	0.9±0.5	9.6±5.3	46.7±27.2	3.9±10.9
	Non-breastfed (n=63)	735±340	22.8±9.8	22.9±10.1	109.7±57.1	4.3±2.4	380±211	2.4±1.2	1.0±0.5	9.8±5.1	48.5±22.0	2.1±7.0
Female	Breastfed (n=239)	664±351	20.7±11.3	21.7±12.0	97.1±54.5	4.1±3.3	358±269	2.1±1.2	0.8±0.5	9.5±6.0	43.4±28.9	5.5±15.1
	Non-breastfed (n=61)	763±361	23.9±11.2	25.0±12.3	111.6±58.7	4.5±2.9	415±274	2.4±1.3	1.0±0.5	9.3±4.8	50.5±25.9	2.2±7.4
Total	Breastfed (n=476)	666±340	21.1±11.1	21.9±11.8	96.3±52.2	3.9±3.0	368±269	2.2±1.2	0.8±0.5	9.5±5.6	45.0±28.1	4.7±13.2
	Non-breastfed (n=124)	749±350	23.4±10.5	23.9±11.2	110.7±57.7	4.4±2.6	397±243	2.4±1.3	1.0±0.5	9.5±4.9	49.5±23.9	2.2±7.2
24.1-36 months												
Male	Breastfed (n=71)	628±313	20.0±9.4	21.2±10.9	90.8±49.7	3.4±2.3	306±204	2.4±1.6	0.8±0.5	10.0±6.2	44.0±23.7	1.1±4.2
	Non-breastfed (n=229)	643±308	20.2±9.0	21.1±9.8	94.2±50.9	3.7±2.3	332±201	2.1±1.1	0.8±0.5	10.0±6.2	42.7±21.7	1.6±6.7
Female	Breastfed (n=77)	614±333	18.8±9.3	20.1±11.1	91.7±54.8	3.7±2.6	284±183	2.0±1.2	0.8±0.6	10.5±7.3	38.5±21.8	0.6±3.4
	Non-breastfed (n=223)	627±300	19.7±8.5	20.8±9.7	91.1±49.8	3.5±2.3	314±186	2.1±1.2	0.8±0.5	9.9±5.9	42.6±20.1	1.1±5.2
Total	Breastfed (n=148)	621±322	19.4±9.3	20.6±11.0	91.3±52.3	3.5±2.4	295±193	2.2±1.4	0.8±0.5	10.3±6.8	41.1±22.8	0.8±3.8
	Non-breastfed (n=452)	635±304	20.0±8.8	20.9±9.8	92.6±50.3	3.6±2.3	323±194	2.1±1.2	0.8±0.5	10.0±6.0	42.7±20.9	1.4±6.0
F, p (overall)		7.482, 0.006	9.322, 0.002	5.572, 0.018	5.351, 0.021	8.462, 0.004	18.585, 0.000	1.927, 0.165	3.928, 0.048	2.306, 0.129	6.712, 0.10	28.507, 0.000
F, p (gender)		0.004, 0.981	0.218, 0.641	0.013, 0.908	0.007, 0.932	0.900, 0.343	0.135, 0.714	3.367, 0.067	0.652, 0.420	0.007, 0.935	1.066, 0.302	0.074, 0.786
F, p (breastfeeding status)		4.529, 0.034	4.169, 0.041	2.269, 0.132	4.749, 0.030	1.694, 0.193	3.217, 0.073	0.917, 0.338	5.105, 0.024	0.133, 0.716	3.005, 0.083	2.315, 0.128
F, p (age groups)		12.328, 0.000	13.802, 0.000	8.053, 0.005	10.243, 0.001	10.197, 0.001	21.025, 0.000	3.013, 0.083	8.873, 0.003	2.085, 0.149	9.840, 0.002	12.504, 0.000

[1]Mean±SD. RAE: Retinol activity equivalents, SD: Standard deviation

age group were significantly lower than those of children aged 12-24 months. Non-breastfed children of 12-24 months old had significantly higher intakes of energy, protein, carbohydrate, and fiber than their breastfed counterparts (Table 1). However, there was not much difference among the older children between breastfed and non-breastfed children.

Nutritional adequacy of diets was assessed by calculating intakes of energy, protein, calcium, zinc, and Vitamin C as a percentage of intakes recommended by the World Health Organization for breastfed children and non-breastfed children [13]. Percent nutrient adequacies were compared by gender, age group, and between breastfed and non-breastfed children. Nutrient adequacy did not differ significantly by gender (energy - F=0.034, p=0.853, protein - F=0.701, p=0.403, calcium - F=1.130, p=0.288, iron - F=3.122, p=0.077, zinc - F=1.911, p=0.167, and Vitamin C - F=0.001, p=0.974) (Table 2).

However, comparison by age group showed that percent adequacies of all nutrients were significantly higher for the 12-24 months old than the older children, except for Vitamin C. Further, diets of breastfed children, especially 12-24 months old, were more adequate in energy (F=5.859, p=0.016), protein (F=6.435, p=0.011), and calcium (F=14.063, p=0.000) than non-breastfed children. However, there was no significant difference for adequacy with of iron, zinc, and Vitamin C.

Percent children whose diets provided adequate amounts of nutrients were calculated (Table 3). Energy intakes were adequate for approximately half the breastfed children, with the younger age group being better off. Non-breastfed children were worse off since energy intakes were adequate for one-fourth of the children, although a much higher percentage of children's diets were adequate in protein. Adequacy of calcium intake was lower among non-breastfed children with only two-fifths of the older children and half of the younger children having adequate calcium intakes.

Overall mean percent body fat for the 1200 children was 20.30±2.59%. Mean values by breastfeeding status, gender, and age group are given in Table 4. Male children had slightly but significantly higher percent body fat than did female children.

Nutrient intakes of children were compared by quintiles of body fat using analysis of variance (Tables 5 and 6). The quintiles (Q) for percent body fat were Q1 (14.9-17.5%), Q2 (17.51-19.8%), Q3 (19.81-20.8%), Q4 (20.81-22.5%), and Q5 (22.51-25.9%). Only 1% of the children in the present study received Vitamin A supplements. There was no significant difference in the intakes of energy, protein, lipids, carbohydrate, fiber, zinc, and iron between children in the five body fat quintiles. However, among body fat quintiles, children in lowest quintile had significantly higher calcium intakes than in highest two quintiles.

Animal protein intakes were compared between quintiles of body fat (Table 7). Mean animal protein intake of children in Quintile 1 was significantly lower than those in the third and fourth quintiles. Mean animal protein intakes (g/day) in the five quintiles were: Q1 - 7.7±3.5, Q2 - 8.2±3.3, Q3 - 8.9±3.8, Q4 - 8.9±5.1, and Q5 - 8.0±3.9. Male children aged 12-24 months in the second and third quintiles of body fat had higher mean protein intakes, regardless of breastfeeding status than children in the lowest and highest quintile of body fat. However, among female children, those in the highest quintile of body fat had the lowest mean intake, whereas those in the lowest quintile had highest mean animal protein intake.

Further, protein intakes from milk and milk products were compared between body fat quintiles since most of the animal protein was contributed by milk and milk products. Mean intakes of milk protein were significantly lower in the first (7.6±3.5 g/d) and fifth Quintiles (7.8±3.9 g/d) compared to Quintile 3 (8.8±3.8 g/d) and Quintile 4 (8.9±5.0 g/d). For children in Quintile 2, mean intake (8.1±3.3 g/d) did not differ from intakes of children in Quintiles 1 and 5.

Table 2: Comparison of percent nutrient adequacy by age groups, gender, and breastfeeding status

Breastfeeding status	Gender	Age (mo)	Energy (%)	Protein (%)	Calcium (%)	Iron (%)	Zinc (%)	Vitamin C (%)
Breastfed	Male	12-24	122±55	432±198	189±122	20±10	15±8	119±61
		24.1-36	116±57	403±190	170±107	18±10	14±8	123±76
	Female	12-24	126±61	422±200	181±126	18±9	14±8	120±73
		24.1-36	112±55	389±173	159±94	17±10	13±9	121±75
	Both sexes	12-24	124±58	428±199	186±124	19±10	15±9	120±67
		24.1-36	114±56	396±181	165±100	18±11	14±9	122±76
Non-breastfed	Male	12-24	78±41	201±107	110±80	19±10	14±9	32±19
		24.1-36	72±33	184±76	88±52	19±10	13±8	34±21
	Female	12-24	76±41	198±112	109±83	18±10	13±8	31±19
		24.1-36	72±35	179±80	84±53	18±10	12±8	37±23
	Both sexes	12-24	77±41	199±110	110±81	19±10	13±8	32±19
		24.1-36	72±34	182±78	86±53	18±10	13±8	36±22
F, p (overall)			211.787, 0.000	526.347, 0.000	157.464, 0.000	0.103, 0.749	8.247, 0.004	674.653, 0.000
F, p (gender)			0.034, 0.853	0.701, 0.403	1.130, 0.288	3.122, 0.077	1.911, 0.167	0.001, 0.974
F, p (breastfeeding status)			213.908, 0.000	519.042, 0.000	169.309, 0.000	0.164, 0.686	9.648, 0.002	622.091, 0.000
F, p (age groups)			5.859, 0.016	6.435, 0.011	14.063, 0.000	1.126, 0.289	3.356, 0.067	0.822, 0.365

Table 3: Distribution of children according to nutrient adequacy by age group, gender, and breastfeeding status

Breastfeeding status	Age (mo)	Gender	Energy		Protein		Calcium		Iron		Zinc		Vitamin C	
			≤99.99	≥100	≤99.99	≥100	≤99.99	≥100	≤99.99	≥100	≤99.99	≥100	≤99.99	≥100
Breastfed	12-24	Male (n=170)	83 (48.8)	87 (51.2)	8 (4.7)	163 (95.3)	51 (30.0)	119 (70.0)	170 (100)	0	170 (100)	0	56 (32.9)	114 (67.1)
		Female (n=134)	63 (47.0)	71 (53.0)	9 (6.7)	125 (93.3)	38 (28.4)	96 (71.6)	134 (100)	0	134 (100)	0	48 (35.8)	86 (64.2)
	24.1-36	Male (n=204)	110 (53.9)	94 (46.1)	17 (8.3)	187 (91.7)	64 (31.4)	140 (68.6)	204 (100)	0	204 (100)	0	67 (32.8)	137 (67.2)
		Female (n=219)	126 (57.5)	93 (42.5)	18 (8.2)	201 (91.8)	75 (34.2)	144 (65.8)	219 (100)	0	219 (100)	0	74 (33.8)	145 (66.2)
Non-breastfed	12-24	Male (n=130)	91 (70.0)	39 (30.0)	20 (15.4)	110 (84.6)	61 (46.9)	69 (53.1)	130 (100)	0	130 (100)	0	130 (100)	0
		Female (n=166)	121 (72.9)	45 (27.1)	27 (16.3)	139 (83.7)	74 (44.6)	92 (55.4)	166 (100)	0	166 (100)	0	166 (100)	0
	24.1-36	Male (n=96)	72 (75.0)	24 (25.0)	16 (16.7)	80 (83.3)	51 (53.1)	45 (46.9)	96 (100)	0	96 (100)	0	96 (100)	0
		Female (n=81)	63 (77.8)	18 (22.2)	16 (19.8)	65 (80.2)	47 (58)	34 (42.0)	81 (100)	0	81 (100)	0	81 (100)	0
χ^2, p			1.010, 0.344		0.694, 0.459		0.173, 0.722		0.1200		0.1200		1.387, 0.263	

Table 4: Mean percent body fat values by breastfeeding status sex and age

Breastfeeding status	Sex	12-24 months	24.1-36 months	Total	F, p
Breastfed	Male	20.20±2.38 (n=237)	21.20±1.64 (n=71)	20.43±2.27 (n=308)	8.298, 0.004
	Female	19.23±2.03 (n=239)	20.28±2.03 (n=77)	19.49±2.07 (n=316)	
	Total	19.71±2.26 (n=476)	20.72±1.90 (n=148)	19.95±2.22 (n=624)	
Non-breastfed	Male	20.29±2.43 (n=63)	20.29±2.65 (n=229)	20.29±2.60 (n=292)	
	Female	19.25±2.33 (n=61)	20.72±2.41 (n=223)	20.41±2.47 (n=284)	
	Total	19.78±2.43 (n=124)	20.50±2.54 (n=452)	20.35±2.53 (n=576)	
Total	Male	20.22±2.38 (n=300)	20.51±2.48 (n=300)	20.36±2.43 (n=600)	
	Female	19.24±2.09 (n=300)	20.61±2.33 (n=300)	19.92±2.31 (n=600)	
	Total	19.73±2.29 (n=600)	20.56±2.40 (n=600)	20.14±2.38 (n=1200)	

Table 5: Comparison of Macro-nutrient Intakes between Quintiles of Body Fat

Nutrients	Q1 (14.9%-17.5%)		Q2 (17.51% - 19.8%)		Q3 (19.81% - 20.8%)		Q4 (20.81%-22.5%)		Q5 (22.51% - 25.9)		F, p
	Male n=103	Female n=114	Male n=97	Female n=120	Male n=116	Female n=126	Male n=117	Female n=96	Male n=126	Female n=93	
Energy (Kcal) 12-24 months											
Breastfed	691±330	584±301	666±337	686±326	696±262	764±377	614±368	692±394	678±342	611±295	0.461, 0.765
Non breastfed	915±242	715±365	670±358	775±328	686±370	0±0 **	777±375	845±373	694±252	0±0 **	
24.1-36 months											
Breastfed	1023±199	910±360	84 ± *	0±0 **	631±323	592±343	453±294	672±364	676±280	597±292	
Non breastfed	651±305	655±297	597±291	576±300	653±292	629±288	688±283	637±318	712±461	616±306	
Protein (g) 12-24 months											
Breastfed	22.7±11.9	18.1±8.7	21.0±10.5	20.7±8.3	22.3±7.8	21.2±9.3	19.7±12.8	22.8±14.6	22.2±11.6	18.8±7.4	0.865, 0.485
Non breastfed	27.6±7.1	22.4±11.3	21.2±10.3	24.4±8.6	20.7±11.8	0±0**	23.6±8.4	26.4±11.8	24.2±10.2	0±0 **	
24.1-36 months											
Breastfed	33.0±2.1	23.5±6.2	1.8 ± *	0±0 **	19.2±8.4	17.6±8.8	15.3±11.5	21.2±11.8	21.9±8.5	19.7±9.5	
Non breastfed	20.4±8.5	21.1±7.9	18.6±8.3	18.3±8.6	20.6±8.4	19.8±8.4	20.8±5.8	19.4±8.6	23.2±16	19.2±8.9	
Carbohydrate (g) 12-24 months											
Breastfed	95.9±46.2	85.9±49.6	96.5±51.3	103.3±54.3	100.4±44	115.3±61.9	86.8±54.2	98.3±56.2	96.9±52	89.5±49.7	0.431, 0.786
Non breastfed	139.4±46.8	105.1±59.9	99.1±59.8	112.0±59.3	104.1±57.9	0±0 **	116.6±59.3	123±57.6	94.7±22	0±0 **	
24.1-36 months											
Breastfed	154.4±50.5	140.8±70.9	13.6 ± *	0±0 **	93.6±54.3	88.8±57.4	63.1±39.1	99.8±55.6	95.7±43.8	87.0±45.6	
Non breastfed	95.9±51.5	95.1±53	86.5±48.3	81.5±50.3	95.8±48.8	90.9±45.7	102.9±51.4	93.8±52.2	102.3±67.8	89.9±49.2	
Lipid (g) 12-24 months											
Breastfed	24.2±13.4	18.7±9.2	21.6±11.7	21.7±10.8	22.8±8.1	25.6±13.2	20.7±12.7	22.9±13.8	22.1±11.6	20.2±10.2	0.496, 0.739
Non breastfed	28.1±5.4	22.9±12.2	21.1±10.2	25.9±8.9	20.6±11.1	0±0**	23.3±15.4	28.3±13.5	24.4±13.9	0±0 **	
24.1-36 months											
Breastfed	29.6±0.8	31.6±11	2.1 ± *	0±0 **	21±10.8	19.4±11.4	15.2±10.5	21.5±12.7	23.4±10.5	19.2±9.5	
Non breastfed	20.8±9	20.8±7.2	19.7±9.3	19.6±9.4	21.2±9.2	20.9±10.2	23.2±9.5	21.4±10.9	24.4±16.1	20.6±10.6	
Fibre (g) 12-24 months											
Breastfed	3.5±2.3	3.5±2.5	3.8±2.5	4.1±2.9	3.6±1.9	4.9±3.3	3.6±3.2	4.6±4	4.1±3	3.4±2.5	1.082, 0.364
Non breastfed	5.4±1.8	4.1±2.6	4±2.5	4.8±2.8	3.4±2.3	0±0 **	4.6±3	5.0±3.3	2.3±0.5	0±0 **	
24.1-36 months											
Breastfed	5.7±2.4	6.3±4	0.3 ± *	0±0 **	3.7±2.5	3.6±2.7	2.5±1.3	4.0±2.8	3.4±2.3	3.4±1.7	
Non breastfed	3.8±2.2	3.7±2.2	3.4±2.1	3.3±2.2	3.7±2.1	3.3±2.3	4±2.7	3.6±2.4	4.5±3.9	3.4±2.3	

'*' SD cannot be calculated as only one subject in that category. '' No subject in this category.**

Table 6: Comparison of Vitamin and Mineral Intakes between Quintiles of Body Fat

Nutrients	Q1 (14.9%-17.5%)		Q2 (17.51% - 19.8%)		Q3 (19.81% - 20.8%)		Q4 (20.81%-22.5%)		Q5 (22.51% - 25.9)		F, p
	Male n=103	Female n=114	Male n=97	Female n=120	Male n=116	Female n=126	Male n=117	Female n=96	Male n=126	Female n=93	
Calcium (mg) 12-24 months											
Breastfed	431.6±332.8	318.4±185.3	354.4±261.9	288.2±184.3	365.7±201.8	331.5±205.9	372±288.6	442.4±350.3	393.8±280.7	296.3±188.3	0.431, 0.010
Non breastfed	478±137.5	389.5±283.5	362.4±202.6	459.9±115.8	323.5±241	0±0**	331.1±361.7	443.9±309.1	326.8±286.8	0±0 **	
24-36 months											
Breastfed	601.2±53.5	359.2±63.1	42.3 ± *	0±0 **	278.1±174.5	261±162.5	263.7±232.5	333±247.1	334.9±210.7	305.7±209.3	
Non breastfed	337.9±175.7	363.0±161.8	310.9±180.5	333.5±186.5	335.0±179.9	300.6±206.9	299.6±162.5	291.2±179.3	399.4±397.7	295±192	
Iron (mg) 12-24 months											
Breastfed	2.5±1.5	1.8±1	2.2±1.1	2.1±0.9	2.5±1.2	2.0±1.0	2.1±1.3	2.3±1.3	2.3±1.1	2.1±1.2	1.601, 0.172
Non breastfed	2.7±0.9	2.2±1.1	2.2±1.3	2.4±1.3	2.5±1.4	0±0**	2.7±0.3	2.9±1.6	4.6±2.5	0±0 **	
24.1-36 months											
Breastfed	3.6±0.6	1.8±0.5	0.2 ± *	0±0**	2.1±1.2	1.8±1.1	1.9±1.7	2.4±1.6	2.9±1.7	2.3±1.3	
Non breastfed	2.1±1.1	2.1±0.9	1.9±1.1	1.7±1.1	2.3±1.2	2.3±1.3	2.1±0.9	2.2±1.3	2.2±1.2	2.2±1.4	
Zinc (mg) 12-24 months											
Breastfed	0.9±0.6	0.7±0.5	0.8±0.6	0.8±0.5	0.9±0.5	0.9±0.5	0.8±0.5	0.9±0.5	1.0±0.5	0.7±0.5	6.390, 0.816
Non breastfed	1.1±0.4	0.9±0.5	0.9±0.6	1.1±0.5	1±0.6	0±0**	1.1±0.6	1.1±0.5	1.1±0.1	0±0 **	
24.1-36 months											
Breastfed	1.5±0.1	1.0±0.3	0.1 ± *	0±0**	0.8±0.5	0.7±0.5	0.7±0.6	1.0±0.6	0.9±0.5	0.8±0.6	
Non breastfed	0.9±0.5	0.8±0.5	0.8±0.5	0.7±0.5	0.9±0.5	0.8±0.5	0.7±0.4	0.8±0.5	0.8±0.5	0.8±0.5	
Vitamin A (mg) 12-24 months											
Breastfed	1.7±5.3	6.9±15.6	3.0±8.3	1.4±6.1	2.5±8.6	2.3±7.2	9.3±17.6	7.2±17.4	3.2±10.4	6.2±18.4	4.681, 0.001
Non breastfed	2.3±8.6	2.8±9.2	2.1±7.1	0±0 **	0±0 **	0±0 **	2.1±4.8	2.1±5.1	7.4±10.4	0±0 **	
24.1-36 months											
Breastfed	0±0 **	0±0 **	0±0 **	0±0 **	0±0 **	0.9±4.4	2.1±6.7	0±0 **	1.9±5	0±0 **	
Non breastfed	1.5±6.9	1.7±7	2.0±7.9	1.4±6.7	1.9±6.7	1.0±5.2	0±0 **	0.9±3.9	0±0 **	0.8±3.7	

'*' SD cannot be calculated as only one subject in that category. '' No subject in this category.**

Table 7: Comparison of intakes from animal protein with quintiles of body fat

Nutrients	Q1 (14.9-17.5%)		Q2 (17.51-19.8%)		Q3 (19.81-20.8%)		Q4 (20.81-22.5%)		Q5 (22.51-25.9%)		F, p
	Male n=103	Female n=114	Male n=97	Female n=120	Male n=116	Female n=126	Male n=117	Female n=96	Male n=126	Female n=93	
Total animal proteins (g/day) 12-24 months											
Breastfed	7.5±3.5	7.7±4.2	8.8±1.9	6.9±1.9	8.9±3.5	9.6±4.2	7.9±3.4	9.6±5.3	6.7±4.3	9.3±3.4	3.846, 0.004
Non-breastfed	7.9±3.8	8.8±3.5	8.3±3.6	8.1±2.6	8.5±4.0	8.1±1.5	7.3±3.4	8.3±4.4	7.6±4.7	7.4±2.6	
24.1-36 months											
Breastfed	6.1±2.8	7.8±3.0	7.8±2.6	9.6±5.4	6.9±2.4	8.4±4.1	6.9±4.0	10.5±6.4	8.1±3.3	8.7±4.6	
Non-breastfed	10.1±4.9	8.0±0.0	7.9±3.7	8.4±2.1	9.5±3.9	11.3±5.3	8.6±2.8	12.1±7.1	7.5±2.3	9.1±4.2	
Milk and milk products (g/day)											
12-24 months											
Breastfed	7.6±3.5	7.5±4.1	8.8±1.8	6.9±1.9	9.1±3.4	9.5±4.2	7.9±3.3	9.9±4.0	6.5±4.1	6.2±3.4	5.227, 0.000
Non-breastfed	8.1±3.9	8.7±3.5	8.2±3.6	8.1±2.5	8.6±4.0	8.0±1.5	7.5±3.4	8.6±4.2	7.6±4.7	7.3±2.7	
24.1-36 months											
Breastfed	5.9±2.9	7.6±2.8	7.6±2.6	9.3±5.5	6.6±2.4	8.3±4.1	7.1±3.8	10.4±6.4	7.8±3.3	8.6±4.6	
Non-breastfed	9.9±4.8	8.8±0.0	7.8±3.7	8.2±2.0	9.7±3.7	11.2±5.3	8.7±2.8	12.0±7.1	7.3±2.3	9.1±4.2	

Multiple linear regression analysis was done, wherein energy, protein, lipids, carbohydrate, fiber, iron, zinc, calcium, and Vitamin A were entered into the equation with percent body fat as the dependent variable. The multiple R was 0.181 (F=2.878, p=0.000). A significant negative association with body fat was seen with intakes of calcium (beta=−0.167, t=−2.123, p=0.036), Vitamin A (beta=−0.170, t=−2.305, p=0.021), and fiber (beta=−0.122, t=−1.890, p=0.059). A positive association was observed with iron (beta=0.030, t=0.498, p=0.168) and thiamine intakes (beta=0.142, t=2.433, p=0.015).

DISCUSSION

Fat stores serve as a store of energy and insulation to maintain a body temperature of infants and young children [14]. However, adipose tissue, especially white adipose tissue, is a source of pro-inflammatory molecules which increase the risk of metabolic syndrome, diabetes mellitus, cardiovascular disease, and polycystic ovarian disease in later life [15,16].

In the present study, macronutrient intakes did not influence percent body fat. However, animal protein intakes and intake from milk protein were lower in the lowest quintile of body fat. Earlier, Michaelsen and Greer [17] and Foterek et al. [18] showed that protein intake is associated with body fat. Rolland-Cachera [19] observed that a high-fat low-protein diet which is characteristic of breast milk suits the nutritional needs in early childhood. They mooted the "early protein" hypothesis that if protein intake is high and exceeds metabolic requirements, it could contribute to more weight gain during infancy, and thus, increase fatness and the risk of obesity. Similarly, Weijs et al. [20] found in a prospective longitudinal study in the Netherlands that animal protein in the 1st year of life could increase the risk of overweight among children later at 8 years of age.

Dietary intakes of protein, particularly, animal protein have been shown to induce insulin and/or insulin-like growth factors-1 secretion, thereby increasing adipose tissue and muscle mass, which induce an early adiposity rebound [19,21]. Koletzko et al. [22] reported that high-protein intakes may reduce secretion of growth hormone as well as lipolysis, thus favoring fat deposition with the associated risk of increased body fat. However, in another study, Koletzko et al. [23] observed that lower protein intakes were associated with lower weight up to 2 years of age. At the end of the 1st year of life, children's diets undergo tremendous changes with a shift from breast milk to cow's milk and inclusion of semisolids and solids. This appears to be a critical period during which the animal protein intake, especially from dairy foods may influence the risk of obesity, through its effects on body composition [24]. The findings of the present study also show that animal protein intake is associated with body fat. Children in the highest quintile of body fat had slightly lower mean intakes of animal and milk protein than those in the lower quintiles. Further studies are required on young children.

We observed that calcium intakes were inversely associated with body fat. Skinner et al. [14] and Carruth and Skinner [25] reported that higher mean calcium intake was associated with lower body fat in Caucasian children, 2-96 months of age. Further, our data showed a negative association of percent body fat with fiber and Vitamin A intakes. Children whose diets contained more dietary fiber had comparatively lower body fat than did children with lower intakes of dietary fiber. Foods containing more fiber can increase dietary bulk and confer greater satiety, resulting in less energy intake and thereby less accumulation of body fat. Furthermore, fiber serves as a substrate for fermentation by the gut microflora which produces short-chain fatty acids [26].

The Vitamin A intakes of these children were very low, and the mean intake was approximately four percent of the recommended dietary allowance (0-20.33%, mean 4.13%). Such low Vitamin A intakes may contribute to the thin-fat syndrome in Asian Indian children. Zulet et al. [27] observed in young healthy adults that Vitamin A intakes were negatively associated with adiposity, and morbidly obese individuals had lower serum retinol. Vitamin A may influence adiposity by one of the several mechanisms. Valdés-Ramos et al. [28] reported that retinoid may be involved in abiogenesis as well as hepatic lipid metabolism. *In vitro* studies show that micromolar concentrations of retinoic acid blocked differentiation of pre-adipocyte into adipocytes and could prevent adipocyte differentiation during abiogenesis [29]. Further, we observed that intakes in the two highest quintiles of body fat were slightly high, although their intakes were highly inadequate.

In Mexican school-age children, García et al. [30] observed that zinc, iron, and Vitamin A were associated with inflammation indicated by C-reactive protein values or insulin or body fat. Zinc has been shown to play a role in adipose tissue regulation and metabolism [31-34]. Iron deficiency is a global public health problem as is obesity. Lower serum iron concentrations with increasing BMI were observed by Manios et al. [35]. In the US-NHANES survey [36], the percentage of overweight adolescents with low serum ferritin was two times more as compared to normal weight adolescents. Similar trends have been reported from Israel [37], Iran [38], and China [39]. Tussing-Humphreys et al. [40], in the US, observed that iron deficiency and BMI were strongly linked across all races, ages, and regardless of dietary intake. These data indicate that in adolescents lower serum iron availability is associated with increasing lean adipose tissue mass that is characterized by macrophage infiltration and local production of pro-inflammatory cytokines such as interleukin-1, interleukin-6, and tumor-necrosis-factor-α that sustain a low-grade systemic inflammatory milieu [41]. There is a dearth of studies in India, although anemia is a public health problem, across all age groups. This needs to be investigated in the Indian context. Sanad et al. [42] observed that iron uptake from the duodenum was limited in obese compared to normal weight children.

Our study had some limitations and strengths. The strength was the fairly large sample size and is one of the first Indian studies to focus on diet and nutrient intakes of children below 3 years of age. Limitations were as follows: No standards are available for assessing body fat in this age group years of age; hence, we were unable to determine the percentage of children who had higher than desirable amount of body fat and how their body fat was associated with nutrient intakes.

CONCLUSION

Our data point out that diet patterns and nutrient intakes in under three children may well influence the body fat. The low adequacy of diets with respect to intakes of iron, zinc, Vitamin A, and Vitamin C indicates that these children were fed more of milk and energy-dense foods that were not good sources of micronutrients. Our findings point to the need for further work in this area in terms of sources and amounts of macronutrients and to determine whether nutritional education to mothers to provide balanced diets can modify the percent body fat.

REFERENCES

1. Birch L, Savage JS, Ventura A. Influences on the development of children's eating behaviours: From infancy to adolescence. Can J Diet Pract Res. 2007;68(1):S1-56.
2. Summerbell CD, Douthwaite W, Whittaker V, Elis LJ, Hillier F, Smit S, et al. The association between diet and physical activity and subsequent excess weight gain and obesity assessed at 5 years of age or older: A systematic review of the epidemiological evidence. Int J Obes Lond. 2009;3 3 Suppl 3:S1-92.
3. Paeratakul S, Ferdinand DP, Champagne CM, Ryan DH, Bray GA. Fast-food consumption among US adults and children: Dietary and nutrient intake profile. J Am Diet Assoc. 2003;103(10):1332-8.
4. Seo HS, Lee SK, Nam S. Factors influencing fast food consumption behaviors of middle-school students in Seoul: An application of theory of planned behaviors. Nutr Res Pract. 2011;5:169-78.
5. Lohia N, Udipi SA. Infant and child feeding index reflects feeding practices, nutritional status of urban slum children. BMC Pediatr. 2014;14:290.
6. Lennox A, Sommerville J, Ong K. Diet and Nutrition Survey of Infants and Young Children. London: Public Health England; 2011.
7. Dwyer JT, Butte NF, Deming DM, Siega-Riz AM, Reidy KC. Feeding infants and toddlers study 2008: Progress, continuing concerns, and implications. J Am Diet Assoc. 2010;110 12 Suppl:S60-7.
8. Hoppe C, Mølgaard C, Thomsen BL, Juul A, Michaelsen KF. Protein intake at 9 mo of age is associated with body size but not with body fat in 10-y-old Danish children. Am J Clin Nutr. 2004;79(3):494-501.
9. Hörnell A, Lagström H, Lande B, Thorsdottir I. Protein intake from 0 to 18 years of age and its relation to health: A systematic literature review for the 5th Nordic nutrition recommendations. Food Nutr Res. 2013;57.
10. Hoppe C, Udam TR, Lauritzen L, Mølgaard C, Juul A, Michaelsen KF. Animal protein intake, serum insulin-like growth factor I, and growth in healthy 2.5-y-old Danish children. Am J Clin Nutr. 2004;80(2):447-52.
11. Deshmukh US, Lubree HG, Yajnik CS. Intrauterine Programming of Non-Communicable Disease: Role of Maternal Micronutrients. Sight Life Mag. 2011;25(2):16-22.
12. Grewal NK, Mosdøl A, Aunan MB, Monsen C, Torheim LE. Development and pilot testing of 24-hour multiple-pass recall to assess dietary intake of toddlers of Somali-and Iraqi-born mothers living in Norway. Nutrients. 2014;6(6):2333-47.
13. World Health Organisation. Complementary Feeding Of Young Children in Developing Countries. A Review of Current Scientific Knowledge. Geneva: WHO; 1998.
14. Skinner JD, Bounds W, Carruth BR, Ziegler P. Longitudinal calcium intake is negatively related to children's body fat indexes. J Am Diet Assoc. 2003;103(12):1626-31.
15. Halberg N, Wernstedt-Asterholm I, Scherer PE. The adipocyte as an endocrine ce ll. Endocrinol Metab Clin North Am. 2008;37(3):753-68.
16. Hauner H. Secretory factors from human adipose tissue and their functional role. Proc Nutr Soc. 2005;64(2):163-9.
17. Michaelsen KF, Greer FR. Protein needs early in life and long-term health. Am J Clin Nutr. 2014;99(3):718S-22.
18. Foterek K, Hilbig A, Kersting M, Alexy U. Age and time trends in the diet of young children: Results of the DONALD study. *Eur J Nutr. 2016;*55:611-20.
19. Rolland-Cachera MF. Prediction of adult body composition from infant and child measurements. In: Davies PS, Cole TJ, editors. Body Composition

Techniques in Health and Disease. Cambridge, United Kingdom: Cambridge University Press; 1995. p. 100-45.
20. Weijs PJ, Kool LM, van Baar NM, van der Zee SC. High beverage sugar as well as high animal protein intake at infancy may increase overweight risk at 8 years: A prospective longitudinal pilot study. Nutr J. 2011;10:95.
21. Wabitsch M, Hauner H, Heinze E, Teller WM. The role of growth hormone/insulin-like growth factors in adipocyte differentiation. Metabolism. 1995;44 10 Suppl 4:45-9.
22. Koletzko B, von Kries R, Closa R, Escribano J, Scaglioni S, Giovannini M, et al. Can infant feeding choices modulate later obesity risk? Am J Clin Nutr. 2009;89(5):1502S-8.
23. Koletzko B, von Kries R, Closa R, Escribano J, Scaglioni S, Giovannini M, et al. Lower protein in infant formula is associated with lower weight up to age 2 y: A randomized clinical trial. Am J Clin Nutr. 2009;89(9):1836-45.
24. Gunther LB, Remer T, Anja K, Anette EB. Early protein intake and later obesity risk: Which protein sources at which time points throughout infancy and childhood are important for body mass index and body fat percentage at 7 y of age? Am J Clin Nutr. 2007;86:1765-2.
25. Carruth BR, Skinner JD. The role of dietary calcium and other nutrients in moderating body fat in preschool children. Int J Obes Relat Metab Disord. 2001;25(4):559-66.
26. Welberg JW, Monkelbaan JF, de Vries EG, Muskiet FA, Cats A, Oremus ET, et al. Effects of supplemental dietary calcium on quantitative and qualitative fecal fat excretion in man. Ann Nutr Metab. 1994;38(4):185-91.
27. Zulet MA, Puchau B, Hermsdorff HH, Navarro C, Martínez JA. Vitamin A intake is inversely related with adiposity in healthy young adults. J Nutr Sci Vitaminol Tokyo. 2008;54(4):347-52.
28. Valdés-Ramos R, Guadarrama-López AL, Martínez-Carrillo BE, Benítez-Arciniega AD. Vitamins and Type 2 diabetes mellitus. Endocr Metab Immune Disord Drug Targets. 2015;15(1):54-63.
29. Landrier JF, Marcotorchino J, Tourniaire F. Lipophilic micro nutrients and adipose tissue biology. Nutrients. 2012;4(11):1622-49.
30. García OP, Ronquillo D, del Carmen Caamaño M, Martínez G, Camacho M, López V, et al. Zinc, iron and vitamins A, C and e are associated with obesity, inflammation, lipid profile and insulin resistance in Mexican school-aged children. Nutrients. 2013;5(12):5012-30.
31. Bing C, Mracek T, Gao D, Trayhurn P. Zinc-a2-glycoprotein: An adipokine modulator of body fat mass? Int J Obes Lond. 2010;34(11):1559-65.
32. Troche C, Aydemir TB, Cousins RJ. Zinc transporter Slc39a14 regulates inflammatory signalling associated with hypertrophic adiposity. Am J Physiol Endocrinol Metab. 2016;310(4):E258-68.
33. Liu MJ, Bao S, Bolin ER, Burris DL, Xu X, Sun Q, et al. Zinc deficiency augments leptin production and exacerbates macrophage infiltration into adipose tissue in mice fed a high-fat diet. J Nutr. 2013;143(7):1036-45.
34. Tinkov AA, Popova EV, Gatiatulina ER, Skalnaya AA, Yakovenko EN, Alchinova IB, et al. Decreased adipose tissue zinc content is associated with metabolic parameters in high fat fed Wistar rats. Acta Sci Pol Technol Aliment. 2016;15(1):99-105.
35. Manios Y, Moschonis G, Chrousos GP, Lionis C, Mougios V, Kantilafti M, et al. The double burden of obesity and iron deficiency on children and adolescents in Greece: The Healthy Growth Study. J Hum Nutr Diet. 2013;26(6):470-8.
36. Nead KG, Halterman JS, Kaczorowski JM, Auinger P, Weitzman M. Overweight children and adolescents: A risk group for iron deficiency. Pediatrics. 2004;114(1):104-8.
37. Pinhas-Hamiel O, Newfield RS, Koren I, Agmon A, Lilos P, Phillip M. Greater prevalence of iron deficiency in overweight and obese children and adolescents. Int J Obes Relat Metab Disord. 2003;27(3):416-8.
38. Moayeri H, Bidad K, Zadhoush S, Gholami N, Anari S. Increasing prevalence of iron deficiency in overweight and obese children and adolescents (Tehran adolescent obesity study). Eur J Pediatr. 2006;165(11):813-4.
39. Shi Z, Lien N, Kumar BN, Dalen I, Holmboe-Ottesen G. The sociodemographic correlates of nutritional status of school adolescents in Jiangsu Province, China. J Adolesc Health. 2005;37(4):313-22.
40. Tussing-Humphreys LM, Liang H, Nemeth E, Freels S, Braunschweig CA. Excess adiposity, inflammation, and iron-deficiency in female adolescents. J Am Diet Assoc. 2009;109(2):297-302.
41. Weisberg SP, McCann D, Desai M, Rosenbaum M, Leibel RL, Ferrante AW Jr. Obesity is associated with macrophage accumulation in adipose tissue. J Clin Invest. 2003;112(12):1796-808.
42. Sanad M, Osman M, Gharib A. Obesity modulate serum hepcidin and treatment outcome of iron deficiency anemia in children: A case control study. Ital J Pediatr. 2011;37:34.

Funding: None; Conflict of Interest: None Stated.

How to cite this article: Bagle NN, Udipi SA. Nutrient intakes from solid/semisolid foods and body fat of children 12-36 months of age in Mumbai city, India. Indian J Child Health. 2017; 4(4):478-487.