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Snacking Pattern and Its Association with Body Mass Index and High Body Fat Percentage in Children

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ABSTRACT: *Background and purpose:* Snacking pattern is known to affect the body composition. Limited data is available on effect of snacking pattern on prevalence of obesity in Indian children. The objective of the study was to assess the prevalence of obesity and high body fat and correlate it with snacking pattern. *Methods:* A cross-sectional study was conducted in 155 children aged 10-11 years. Anthropometry was assessed and body composition was measured using TANITA body fat analyser (MC-780 MA). Three day 24-hour diet recall was used to analyse daily nutrient intake. A weighted food frequency questionnaire of snacks was used to assess snacking patterns and nutrient intake from snacks. *Results:* Of the 155 children 27.7% were overweight and 23.2% were obese. Forty-eight percentage children had body fat percentage above 75th percentile. Total snacks contributed around 47.3% of total daily energy, 47-48% of daily dietary fat and carbohydrates intake and about 39% of proteins intake. Individual regression equations showed that energy (R^2=0.037) and dietary fat (R^2 = 0.108) from snacks has a significant positive correlation with BMI ($p<0.05$). Total energy (R^2=0.027) and dietary fat (R^2=0.088) from snacks also had a significant positive correlation with fat percentage. *Conclusion:* Snacks contribute to almost 40-50% of daily nutrient intake in children. Nutrient intake from snacks had significant positive correlation with prevalence of overweight/ obesity. Immediate school based interventions to correct dietary and lifestyle factors need to be planned to prevent obesity.
Keywords: BMI, obesity, snacking pattern, nutrient intake

INTRODUCTION

Globally, the prevalence of childhood obesity in on rise. As per World Health Organization, worldwide prevalence of childhood obesity increased from 4% in 1975 to 18% in 2016. In Asia alone, over 340 million children and adolescents aged 5-19 years were overweight or obese in 2016 (1). Similar percentage of childhood obesity is observed in India. Pooled data of several studies on prevalence of overweight and obesity have shown that 19.3% Indian children suffer from childhood overweight and obesity (2). With 14.4 million obese children, India has the second highest prevalence of obese children in world (3).

Childhood obesity tends to continue in adulthood with 85% of obese children known to become obese adults (4,5). Adolescents have an odds ratio of 17.5 of becoming obese adults (6). Also, childhood obesity is associated with many health problems and is a pre-cursor for many non-communicable diseases (3) About one third of overweight or obese children exhibit features of metabolic syndrome including abdominal obesity, impaired glucose metabolism, hypertension and dyslipidaemia (7,8) As children with obesity are at an increasing risk of progressing to type 2 diabetes and cardio-vascular diseases in later life and hence early identification and preventive measures are very important (9)

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Visceral fat percentage has known to affect insulin resistance (10) and hypertension (11). Body fat deposition is also known to contribute to dyslipidaemia (12). Hence, body composition, more specifically body fat percentage can be used as a surrogate marker to assess risk of metabolic syndrome especially in children. Studies have shown that risk of metabolic syndrome can be established from body fat percentage either using odds ratio curves or by using body fat percentage thresholds (13).

A snack is distinguished from other food items based on time criterion, i.e. food that is consumed in between main meals (14). Internationally snacking has shown to contribute approximately 27% of daily nutrient intake in children (15). A review on snacking and obesity showed that snacking had a significant effect on BMI. Children who consumed large portioned snacks frequently had higher risk of being obese. Snacking was shown to independently affect weight gain in children (16). Recently a study illustrated very unhealthy snacking patterns in Indian children with 10% snacking on sweets, 30% on chocolates, 20% on pizza, 10% on soft drinks, and the remaining 10% on chips (17).

To the best of our knowledge, there is very limited Indian data on snacking and its effect on overweight/ obesity. Hence, the objective of the current study was to assess the prevalence of overweight and obesity in Indian children and to study its correlation with snacking pattern.

METHODOLOGY

A cross-sectional study was conducted in 155 children (79 boys, 76 girls) aged 10 – 11 years old studying in private schools in Mumbai. Three private schools were approached from suburbs of Mumbai City using purposive sampling to conduct the study out of which the permission was received from one school. The school authorities were given complete details of the study and a consent was obtained from the authorities to conduct the study. A written assent was also obtained from students before enrolling them in the study. Children with chronic medical conditions were excluded from the study. The study protocol was approved by ISBEC (Inter System Bio Medica Ethics Committee), Vile Parle (West), Mumbai.

Sample size calculation

Sample size was calculated in comparison to overall prevalence of overweight and obesity (36.6%) found in study in Chennai (18), India in children aged 6 to 11 years using Indian contemporary cut-offs. Hence, sample size was calculated with a known population prevalence of 37%, expected study incidence of 50%, to achieve 90% power of the study at alpha level of 0.05 using the following formula:

$$N = \frac{p_0 q_0 \left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \frac{\sqrt{p_1 q_1}}{p_0 q_0}\right)^2}{(p_1 - p_0)^2}$$

$$= \frac{0.37*0.63 \left(1.96+1.28 \frac{\sqrt{0.5*0.5}}{0.37*0.63}\right)^2}{(0.5-0.37)^2} = 149$$

Sample size was calculated to be 149, however the sample taken was 155.

P0 = population incidence = 0.37, P1 = study expected incidence = 0.50, N = Sample size of study, α = probability of type 1 error, β = Probability of type 2 error, *Z* = critical *Z* value of the given α or β, $q_0 = 1 - p_0$, $q_1 = 1 - p_1$

Anthropometry

Height and weight were measured and BMI was calculated. For height, a site of vertical wall and the horizontal floor was selected and the Stadiometer was fixed on the wall and height was measured to the nearest 1 mm. Weight was measured using a digital weighing scale. Average of three measurements for both height and weight were taken. BMI was calculated by dividing weight in kg by height in meter square. Height, weight and BMI for age *z*-scores were calculated in comparison to Indian reference data (19). Based on BMI for age *z*-score, children were classified as underweight (equivalent to adult BMI <18.5 kg/m^2), normal weight (equivalent to adult BMI 18.5 – 23 kg/m^2), overweight (equivalent to adult BMI of 23-26.9 kg/m^2), obese (equivalent to adult BMI of > 27 kg/m^2).

Body composition

Body fat percentage was measured using TANITA body fat analyser machine (Model MC 780 MA) (Tanita Corporation of American Inc, Illinois, USA. Before analysing body fat percentage, it was made sure that the children's foot pads were clean. Care was taken to ensure that children were not wearing any metallic object or carrying any cell phone while the body composition was analysed to avoid any hindrance in output. Minimum 2 hours' difference was maintained between measuring body composition and food intake, exercise and consumption of caffeinated drink (as it affects hydration levels). Body fat percentage of age *z*-score was calculated in comparison to Indian reference data (20). As per Indian reference, children above 75th percentile for fat mass and percentage are at an increased risk for obesity and hence based on body fat percentage children were classified as: normal (<75th percentile) and at risk (>75th percentile) (20).

Daily dietary intake

Dietary intake was assessed by 24-hour recall on 3 random days (non-consecutive) of a week including a holiday. Each child was asked about the intake of food items consumed during the day at breakfast, lunch, dinner, and snacks, using standard cups and spoons by trained investigators through a face-to-face interview. Daily nutrient intakes (energy, carbohydrates, proteins, dietary fats) were calculated using DietCal Software (version 8.0, 2017, Profound Tech Solutions). Percentage contribution of macro-nutrients to total calorie intake was calculated. Percentage recommended dietary allowance (RDA) intake for energy (boys: 2190 kcal/ day, girls: 2010 kcal/ day) and protein (boys: 39.9 g/day, girls 40.4 g/day) intake was calculated in comparison to Indian RDA (21).

A weighted food frequency questionnaire was used to evaluate intake of snacks in children. Children were asked whether they consumed snacks on a 5 point scale: daily, 3 times/ week, 1/ week, once/ fortnight or never. Snacks were classified as healthy (fruit based/ steamed/ roasted) or unhealthy (fried/ bakery/ confectionary & aerated drinks). Portion size was assessed using standard cups and spoons. Daily nutrient intake from snacks (energy, carbohydrates, proteins, fats) were calculated using Diet Cal Software (version 8.0, 2017, Profound Tech Solutions) for healthy and unhealthy snacks separately. Total nutrient intake from snacks was calculated by adding nutrient intake from healthy snack with nutrient intake from unhealthy snacks. Percentage contribution of macro-nutrients to total calorie intake was calculated. Percentage RDA intake for energy and protein intake was calculated in comparison to Indian RDA (21).

Contribution of nutrients from snacks (healthy/ unhealthy/ total) to daily nutrient intake was calculated by dividing the nutrient intake from snacks by daily nutrient intake * 100.

Statistical analysis

Analyses were performed using SPSS software for Windows (version 16.0, 2007, SPSS Inc, Chicago, IL). Data are presented as Mean±SD or Mean (minimum-maximum) or percentage. Independent sample *t* test was used to analyse the gender difference in nutrient intake of children. The frequency distributions were tabulated for food frequency intake of snacks according to gender and were compared using cross tabulations and Chi-square test. Simple linear regression was used to analyse the correlation between BMI and total daily energy intake. Simple linear regression was carried out separately for energy intake from total snacks and fat intake from total snacks on BMI or fat percentage to avoid co-linearity of dietary data. P-value <0.05 was considered to be statistically significant.

RESULTS

The mean age of boys in the current study was 10.3±0.3 years and was similar to that of girls (10.3±0.3 years) (p=0.854).

Anthropometry and body composition

Table 1 gives anthropometry and body composition of children in the study. There was no

significant difference in anthropometric parameters or body fat percentage of boys and girls (p>0.05).

Figure 1a and 1b shows prevalence underweight, overweight and obesity and high body fat percentage. Overall using BMI for age *z* scores in comparison to Indian reference (19), 27.7% were overweight and 23.2% were obese. There was no significant difference in prevalence of underweight, normal BMI, overweight or obesity when classified according to gender ($\chi 2$=1.158, p>0.05). When body fat percentage was compared to Indian reference standards (20), 47.7% children had high body fat percentage (at risk = body fat percentile >75th percentile). There was no significant difference in prevalence of high body fat % (>75th percentile when classified according to gender ($\chi 2$=4.689, p>0.05)

Table 1: Anthropometry and body composition of children

	Boys (n=79)	Girls (n=76)	Total (n=155)	P value
Height (cm)	140.9 ±7.0	141.5 ±6.6	141.2±6.8	0.598
Weight (kg)	37.6 ±9.1	38.1 ±9.7	37.7±9.4	0.607
BMI (kg/m^2)	18.6 ±3.8	18.8 ±4.1	18.7±3.9	0.748
Fat percentage (%)	22.9 ±11.6	24.5 ±12.3	23.6±11.9	0.395
Height for age *z*-score	0.27 ±1.02	0.32 ±0.97	0.29±0.99	0.757
Weight for age *z* -score	0.44 ±1.01	0.53 ±1.16	0.49±1.08	0.595
BMI for age *z* -score	0.42 ±1.12	0.48 ±1.22	0.45±1.17	0.743
Fat percentage for age *z* -score	0.48 ±0.91	0.32 ±1.32	0.40±1.16	0.392

Data presented as Mean±SD

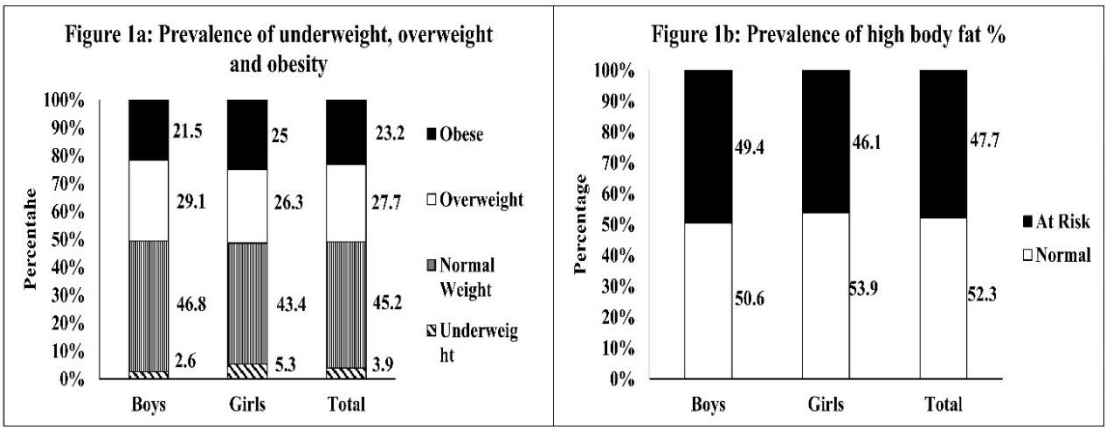

Fig: Prevalence of underweight, overweight and obesity using BMI categories (1a), high body fat percentage (1b)

Fig 1a: Underweight: equivalent to adult BMI <18.5 kg/m^2, Normal: equivalent to adult BMI 18.5 – 23 kg/m^2, Overweight: equivalent to adult BMI of 23-26.9 kg/m^2, Obese: equivalent to adult BMI of > 27 kg/m^2 (19).
Fig 1b: Normal: <75th percentile, At risk: >75th Percentile

Relations between BMI and body fat percentage

There was a significant association of BMI with body fat percentage in both boys (r=0.962) and girls (r=0.976) (p<0.05). To further evaluate the association of BMI with body fat percentage, cross tabulation of BMI status and body fat percentiles were computed ($\chi 2$=161.1, p<0.01). None of the underweight children had body fat percentile >75th percentile. All obese children had fat percentile >75th percentile and 76.7% overweight children had fat percentile >75th percentile. In fact, 7.1% of children with normal BMI also had fat percentile >75th percentile.

Dietary Intake

Table 2 gives dietary intake in study participants. Total daily energy intake was about 65.7% of the recommended dietary allowance indicating that energy intake was 34.3% less than the daily recommended intakes. Total protein intake was 87% of the recommended dietary allowance. Overall dietary fats contributed 31.6 % of the energy intake of the total diet. There was no significant difference in nutrient intake of boys and girls (p>0.05) (data not shown).

Total snacks contributed 47.3% of total daily energy, 47% of daily dietary fats, 48.1% carbohydrates intake and 38.6% of proteins intake. Of this, healthy snacks contributed to 12.6% of total daily energy, 6.5% of daily dietary fats, 16.6% carbohydrates intake and 9.8% of proteins intake. Unhealthy snacks contributed to 34.6% of total daily energy, 41.4% of daily dietary fats, 33.9% carbohydrates intake and 28.5% of proteins intake.

Table 2: Dietary intake in children

	Total for entire day	From total snack	From healthy snacks	From unhealthy snacks
Energy (kcal/day)	1380 (720-3440)	653 (127-1234)	174 (26-584)	478 (60-1105)
Carbohydrates (g/day)	203.8 (104-600)	95.6 (23-184)	31.3 (4-104)	64.2 (10-151)
Protein (g/day)	34.8 (17.6-62)	13.1 (2.1-24.3)	3.4 (1-13.3)	9.7 (1-22.9)
Dietary Fat (g/day)	47.8 (24.9-93.9)	23.4 (2.8-56.1)	3.1 (1-11.9)	19.9 (1.9-54.9)
RDA intake of energy (%)	65.7 (33-157)	30.9 (6-61)	8.3 (1.3-29)	22.6 (3-54)
RDA intake of Protein (%)	86.6 (44-156)	32.7 (5-60)	8.5 (0.5-33)	24.2 (2-57)
Percent energy carbohydrates (%)	59 (45-79)	59.5 (41-74)	72.8 (56-91)	54.8 (35-72)
Percent energy protein (%)	10.4 (5-15)	8.1 (5-11)	7.8 (1-11)	8.2 (5-13)
Percent energy dietary fat (%)	31.6 (15-44)	31.3 (18-51)	17.5 (8-34)	37.2 (20-55)

Data presented as Mean (minimum-maximum). RDA Energy: boys: 2190 kcal/ day, girls: 2010 kcal/ day; RDA protein: boys: 39.9 g/day, girls 40.4 g/day (21)

Table 3: Frequency of snack consumption

	Never (%)	Once in fortnight (%)	Once per week (%)	Thrice per week (%)	Daily (%)
Fruit and Vegetable based snacks (healthy)					
Fruits/ vegetable juices	11.6	40.9	5.2	9.1	2.6
Fruits	3.2	5.8	15.5	14.2	61.3
Steamed Snacks (healthy)					
Idli/ dosa/ uttapam	3.9	25.8	29.7	38.7	1.9
Dhokla/ khandavi/ patra	43.2	36.1	9	11.6	-
Bread & other bakery based snacks (unhealthy)					
Pav/ bread	2.6	20	34.8	35.5	7.1
Bakery/ puff/ cakes/ pastries	16.1	66.5	7.7	9	6
Biscuits/ cookies	12.4	28.1	26.1	18.3	15
Khari/ toast/ butter biscuits	11	14.8	18.7	23.2	32.3
Pizza	20	65.2	5.8	7.1	1.9
Sandwich	9	18.7	30.3	34.8	7.1
Burger	35.9	58.2	1.3	3.3	1.3
Indian Snacks (unhealthy)					
Samosa/ wada/ kachori	14.8	54.8	16.1	14.2	-
Chips/ farsan	8.4	26.6	27.3	29.2	8.4
Frankie/ rolls	31.6	55.5	6.5	5.2	1.3
Chaat/ sevpuri/ bhelpuri	20.6	54.2	12.3	11.6	1.3
Khakra/ thepla	25.8	20.6	18.7	25.2	9.7
Other snacks (unhealthy)					
Instant noodles	15.5	36.1	21.9	23.2	3.2
Ice cream	9	60	14.2	14.2	2.6
Chocolates	2.6	16.8	31	31	18.7
Energy drinks/ aerated drinks	11.6	23.2	18.7	22.6	23.9

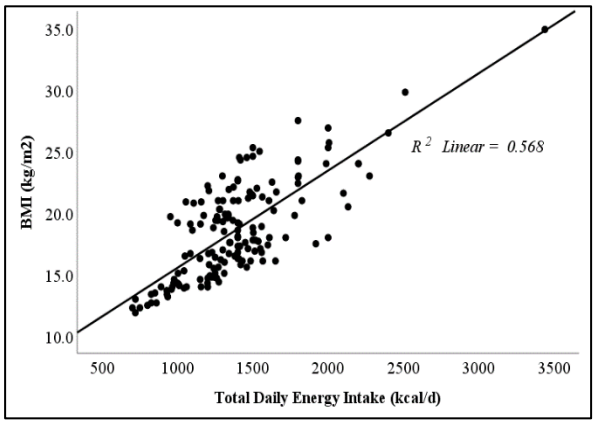

Fig 2: Correlation between BMI and total daily energy intake

Figure 2 gives correlation between BMI and total daily energy intake. BMI was significantly positively correlated with total daily energy intake in the current study ($R^2 = 0.568$)

Snacking pattern

Table 3 gives frequency of snacks consumed by children. The most commonly consumed healthy snack on daily basis was fruits. Steamed snacks such as idli/ dosa/ uttapam were also consumed by most participants on weekly basis. The most un-healthy food consumed on daily basis was khari/ toast or butter biscuits, chocolates and energy drink/ aerated drink. Pav/ Bread, biscuits/ cookies, sandwich, instant noodles, ice-cream and most Indian snacks were consumed by most children on weekly basis.

A regression analysis was run to determine the effect of total energy and dietary fats from snacks (separately to avoid co-linearity) on BMI and body fat

percentage. Overall the models were significant for effect of both energy and dietary fat intake from total snacks on BMI and body fat percentage. Energy (R^2 = 0.037) (Figure 3a) and dietary fat intake (R^2 = 0.108) (Figure 3b) from total snacks was significantly correlated with BMI (p<0.05). Dietary fat intake was significantly correlated fat percentage (R^2 = 0.088, p<0.05) (Figure 3d) whereas energy intake from snacks had marginal association with fat percentage (R^2 = 0.027, p=0.057) (Figure 3c).

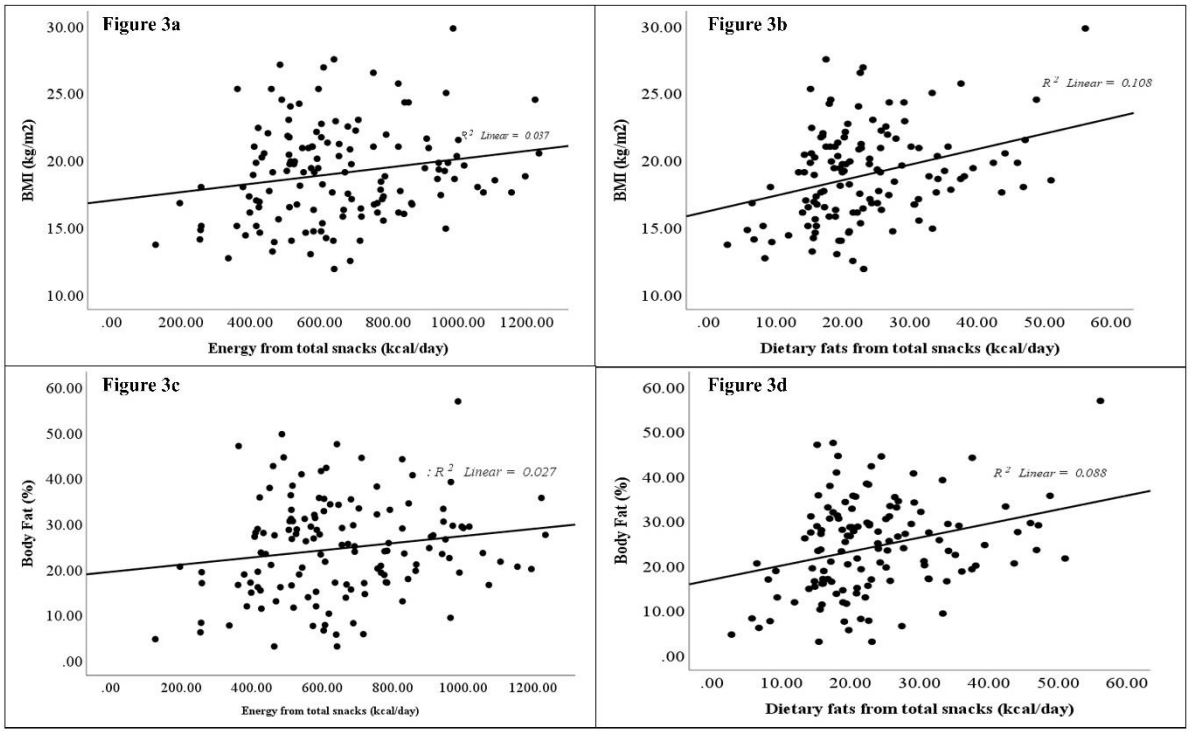

Fig 3: Correlation between BMI and total energy intake from snacks (a), BMI and dietary fats from snacks (b), body fat percentage and total energy intake from snacks (c) and body fat percentage and dietary fats from snacks (d)

DISCUSSION

The present study was conducted in children aged 10-11 years and highlights the increase in the risk of metabolic syndrome in this young age group. In the present study, we assessed the prevalence of overweight/ obesity and high body fat percentage and its correlation with nutrient intake from snacks. Almost 51% children in the study were overweight or obese in comparison to Indian reference curves for BMI. Along with high prevalence of overweight and obesity, 47.7% of children had fat percentage above 75th percentile putting them at additional risk of inflammation. Total energy and fat intake from snacks had a significant effect on both BMI and body fat percentage.

Prevalence of overweight and obesity varies across India. As per pooled data, the prevalence of overweight and obesity is found to be 19.3% across India (2). Using WHO cut-offs, Pan-India prevalence of overweight was found to be 11.1% and that of obesity was found to be 15.9% in Indian children aged 2-17 years (22). In another study conducted in 8-18 year-old children in Northern and Western India, using WHO cut-offs prevalence of overweight was found to be 18.5% and that of obesity was found to be 5.3% (23). Using International Obesity Task Force (IOTF) cut-offs, in 10-16-year-old children in Delhi, North India, prevalence of overweight was found to be 24.7% and that of obesity was found to be 7.4% (24). In a study conducted in Chennai, Southern India, in children aged 6-11 years using IOTF cut-offs prevalence of overweight was found to be 12% and prevalence of obesity was found to be 3.3%. In the same study, using contemporary cut-offs provided by Khadilkar et al and authors found prevalence of overweight to be 19% and that of obesity to be 17.6% (18). In the present study we had a higher prevalence of overweight (27.7%) and obesity (23.2%) as compared to other studies which may be due to the fact that we used the most recent cut-offs as proposed by Indian Academy of Paediatrics (19) which has a lower threshold cut-off to classify children as overweight and obese.

There are very few studies describing body fat percentage of children in India. In Delhi, body composition measured in children aged 10 years using dual energy x-ray absorptiometry showed body fat percentage of 25.5±10.4% in boys and that of 30.8±10.8% in girls (25). In a study conducted in Rural Health Training Centre of a medical college in Bengaluru, the mean body fat percentage was found to be 17.06±6.32% in boys aged 10 years and it was found to be 14.4±6.36% n girls aged 10 years when measured using bio-impedance technique (26). In a study conducted in Mumbai in children aged 10 years studying at private schools, body fat percentage was found to be 21±8.66% in boys and 21.3±5.5% in girls (27). In the same study, 11-year-old children from private schools had body fat percentage of 12.06±7.94% and 15.53±9.88% in boys and girls

respectively. Children in the present study had body fat percentage varying in comparison to previous studies, which may be due to the difference in method of measurement, the environmental factors or their diet.

In the study conducted in Rural Health Training Centre, they also found that about 18.8% children had high body fat percentage (26) whereas in the present study it was found that 48% children had body fat percentage above 75th percentile. The stark difference in prevalence of high body fat percentage in both the study was because in the previous study authors used arbitrary cut-offs of >30% to define children as having high body fat percentage whereas in the present study smoothed Indian percentile curves were used to identify children at high risk.

As per the Indian references curves, children having body fat percentage above 75th percentile are at risk of developing hypertension and other metabolic syndrome co-morbidities (20). With almost 48% of children in the present study having body fat percentage above 75th percentile (Figure 1b), this is an alarming concern to indicate that half of the young population is at risk of poor metabolic health.

The Asian Indian urban phenotype or lean obesity is defined as individuals having high body fat percentage and high waist to hip ratio at relatively low or normal body mass index (BMI) (28). That is despite having lower prevalence of obesity based on BMI, Asian Indians tend to have greater degree of body fat percentage. This phenomenon is referred to "thin-fat Indian Phenotype" (29). In the current study also, 7.1% children with normal BMI has body fat percentile >75th percentile.

There has been a drastic change in eating habits and food consumption in India over the last few decades. In a study conducted in 1155 children from New Delhi, India observed that 39% of children preferred fast foods such as pizzas, French fries and only 11% liked to eat fruits. The study also showed that 44% of children consumed one aerated drink per day (30). In another study from Pune, India on 760 children, it was observed that 79.07% children preferred snacks and fast foods the most, 11.8% preferred Indian sweets and only 3.5% preferred fruits (31). In the present study also, the frequency consumption of chips, Indian snacks was almost on weekly basis and some of them were even consumed by children thrice/ week. Almost 24% of children also consumed either energy drink or aerated drink daily. Indicating that there is a very high intake of low nutrient and high calorie food and snacks in children in the age group of young to older adolescents of that observed in other studies in India (17, 30-31).

Several studies have associated dietary eating habits, especially snacking with an increase in overweight/ obesity. Snacking has been considered one of the main contributors to increase in weight as snacking is association with an increased consumption of energy-dense, high-sugar, high-fat food (14). In a study on 400 children aged 11-13 years, prevalence of overweight/ obesity was 10.4%, 14.4%, 20.5%, respectively, in those consuming <15%, 15% to 10%, and >20% of their energy intake from snacks (14).

Even though total energy intake in the current study is only 65.7% of recommended dietary allowance, it needs to be noted that out of the 1380 kcal/ day consumption almost 47.3% i.e. 653 kcal/day were obtained from snacks. Apart from this it was also observed that intake of calories from fat was very high. Almost 31.6%, i.e 1/3rd of the total daily energy intake was from fats. Thus, the composition of the diet was very poor which may be one of the contributing factors for high prevalence of overweight and obesity in the current study.

Intake of high dietary fat and high sugar snacks are associated with an increase in BMI (32). Snacking on energy dense foods such as chocolate, snack bars, fried foods, condensed milk, fruit syrup and biscuit is shown to have a significant association with childhood obesity (33). Similarly, in the present study, BMI was significantly associated with total daily energy intake from snacks. Like other studies, total dietary fat intake from snacks was also correlated with both BMI and body fat indicating that consumption of high fat snacks increases the risk of overweight/ obesity (Figure 3 a – 3d).

Thus, to conclude present study indicates that almost 50% of children in India are overweight/ obese. Snacks contribute to almost 40-50% of daily nutrient intake in children with a major part coming from unhealthy snacks. The present study also highlights that the nutrient composition of snacks is shown to have a significant effect on BMI and body fat percentage of the children there by increasing their predisposition to an inflammatory state of the body. School based interventions with a focussed inputs towards guiding children for healthy snacking options and lifestyle factors need to be prioritized to prevent overweight/obesity and inflammatory state of their body which predisposes an early onset of non-communicable diseases.

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