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Growth Percentiles for Body Mass Index of Children from North-Western India

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ABSTRACT:

Introduction: *As compared to developed western world, population specific normative reference data on body mass index (BMI) of Indian children are scarce. In view of this, we attempted to establish age and gender specific percentiles for BMI of children hailing from north-western parts of India, so as to diagnose children with obesity or under nutrition.*

Methods: *Body weight and height were cross-sectionally measured amongst 2098 (Male: 1278, Female: 820) normal, healthy children aged 2 to 14 years of North-western Indian origin representing mixed socio-economic strata, following standardized anthropometric techniques in the Growth Laboratory and Growth Clinic of the department of Pediatrics, PGIMER, Chandigarh. Age and gender specific BMI was calculated by dividing weight (kg) by square of height (m^2). Mean±SD and percentiles (3^{rd}, 5^{th}, 10^{th}, 25^{th}, 75^{th}, 85^{th}, 90^{th}, 95^{th}, and 97th) were calculated after applying Healy's correction.*

Results: *Body mass index increased from 15.2±2.08 kg/m^2 to 15.58±2.99 kg/m^2 in males and from 15.3±1.6 kg/m^2 to 16.8±1.7 kg/m^2 in females, from 2 to 14 years. Gender differences in general, remained statistically non-significant. As compared to their Indian and western counterparts, our study children possessed lower BMI, that may be attributed to their affiliation to different environmental, ethnic/racial stocks.*

Conclusions: *Children having BMI for age more than 85^{th} and 95^{th} percentile should be treated as cases of overweight and obesity respectively while, BMI less than 5^{th} percentile be considered as thinness.*

Key Words: *Growth Percentiles, BMI, Under-nutrition, Obesity, Overweight, Indian Children*

INTRODUCTION

Body Mass Index (BMI) is an important anthropometric measure of body build to evaluate nutritional state of individuals. BMI as an index of obesity or under nutrition (Goldbourt and Medalie 1974, Keys et al. 1972) is widely used for clinical, research and epidemiological purposes (Davies and Lucas 1989). Measuring BMI and tracking it over time offers a simple and reliable way to predict health related outcome. The healthy range for BMI in children and adolescents varies, based on age, gender (Kuczmarski et al. 2002) and their racial/ethnic affiliation. Based on BMI-for-age, different definitions of overweight and obesity for children and adolescents of Caucasian origin given by the World Health Organization (2006, 2007), Centers for Disease Control and Prevention (Ogden et al. 2002), International Obesity Task Force (Monasta et al. 2011) have yielded varied prevalence estimates for overweight, obesity and thinness. As compared to their western counterparts, similar information on Indian children who exhibit greater ethnic diversity is scarce. However, in this regard, reference values given by Indian Academy of Pediatrics (IAP 2015), are noteworthy. In view of existence of substantial environmental, socio-economic, ethnic and genetic variation amongst different Indian population groups, standards/references developed for one population group should not be made for another population group to detect growth aberrations and nutritional deficits. To overcome this problem, we established age and gender specific percentile grids for BMI of normal, healthy children representing North-western parts of India.

MATERIAL and METHODS

A total of 2098 (Male: 1278, Female: 820) normal, healthy children aged >2 to 14 years, born to parents representing mixed socio-economic strata and residing in north-western parts of India, envisaged sample for this cross-sectional study. These children visited Growth Clinic of department of Pediatrics, PGIMER, Chandigarh, India for routine health check-ups, immunization, nutritional and growth assessment etc. Children suspected to be suffering from any disease of central nervous system, congenital anomalies, chronic diseases, severe under-nutrition, cranio-facial and physical anomalies were excluded. Informed consent of parents of the children to participate in this study was obtained. The study has been approved by the Institute Ethics Committee as well as Department Review Board.

Each child was measured for body weight and height using standardized anthropometric instruments and techniques (Weiner and Lourie 1969) in the Growth Laboratory and Growth Clinic of the department of Pediatrics, PGIMER, Chandigarh between 1994 to 2018 following cross-sectional growth research design. The body weight was measured with an 'Electronic Weighing Scale' (Make: Avery, Capacity: 100kg, Least count: 50g). A Stadiometer (Make: Holtain Limited, Crymych, Dyfed, UK, Least count: 1mm) was used to measure height of children. The same instruments were used throughout the entire study tenure. Accuracy of the instruments was periodically checked prior to the beginning of each measurement session. The magnitude of intra/inter rater error was ±50g for body weight and ±1mm for height. BMI [Body weight (kg)/ height^2 (meter)] of each child was calculated.

Statistical Considerations:

Mean, SD were computed for BMI at each age amongst male and female children. Student's unpaired t-test was used to compute gender differences. A total of 9 age and gender specific percentiles (i.e. 3rd, 10th, 25th, 50th, 75th, 85th, 90th, 95th and 97th) were obtained for BMI from ages 2 to 14 years. Arithmetic mean served the purpose of 50th percentile. To minimize effect of age-grouping on variance of population of measurements, Healy's (1962) correction was applied to the standard deviation to obtain corrected SD which finally was used to compute percentiles.

Healy's (1962) correction: Corrected SD= $\sqrt{}$ SD^2-b^2/12

Where, SD is standard deviation and b is rate of growth (obtained as a difference between two mean values of consecutive ages).

The corrected SD was used to compute percentiles using following formulae given by Tanner et al. (1966):

3rd and 97th percentile = $\bar{x}$±1.881 corrected SD

5th and 95th percentile = $\bar{x}$±1.65 corrected SD

10th and 90th percentile = $\bar{x}$±1.282 corrected SD

25th and 75th percentile = $\bar{x}$ ±0.675 corrected SD

Where $\bar{x}$ is the mean and SD the standard deviation.

The calculation of 85th percentile was done as per formulae given by Sastry (2007)

RESULTS

The mean (SD) and percentiles for BMI of normal children aged >2 to 14 years are shown in Table 1-3 . BMI amongst male children measured 15.2±2.08 kg/m^2 at 2 year, and 15.58±2.99 kg/m^2 at 14 years. In female children BMI grew from 15.3±1.60 kg/m^2 at 2 year to 16.8±1.76 kg/m^2 by 14 years. Male children possessed higher BMI than their female counterparts between 4 to 6 years whereafter, females took lead over males. Gender differences became statistically significant at 3 ($p \leq 0.05$), 8 ($p \leq 0.01$), 10, 11, 12 ($p \leq 0.001$) years (Table 1).

DISCUSSION

A strong association between overweight and obesity as determined by body mass index and high concentrations of metabolic syndrome (a cluster of hyperglycemia, dyslipidemia, and hypertension) has been demonstrated (Vazquez et al. 2007, Al-Bachir and Bakir 2017). Therefore, early detection of its derangement becomes necessary to prevent and manage consequent health related hazards.

During growing years, BMI shows an interesting growth trajectory. Generally, it rapidly increases during the first year of life thereafter, it decreases to reach a nadir at around 6 years of age. Afterwards, BMI experiences a consistent increase throughout childhood, and this second rise is termed as 'Adiposity Rebound'. Various studies have shown a relationship between early adiposity rebound and non-communicable diseases such as insulin resistance/type 2 diabetes mellitus and cardiovascular disease (Mo-Suwan et al. 2017), not only in adulthood but also around onset of adolescence. It has been observed that the timing of adiposity rebound could account for about 30% of adult obesity that often begins in childhood (Dietz 2000). BMI amongst male and female normal children representing present study showed a slow decrease from 2 to 6 years. Thereafter, it grew uninterruptedly upto 14 years (Fig 1 and 2). This shows that adiposity rebound in our children occurred after the age of 6 years. While, it was respectively noticed at 5 and 6 years of age amongst American female and male children (Ogden et al. 2002). On the contrary, adiposity rebound occurred even before the age of 5 years in Indian children (IAP 2015) and those studied by WHO (2007). However, no specific trend could be observed with regard to development of gender differences, as these demonstrated a bi-directional trend.

Mean BMI in our children of both sexes being at 50th percentile of IAP growth references (Khadilkar et al. 2015) at 5 years, decreased to traverse around 25th centile in females and continued between 10th to 25th centile in males till 14 years. Pattern-wise, 50th percentile for BMI of our female children ran between 10th to 25th percentile of the American children (Ogden et al. 2002) until 14 years while, that of the male children did so until 12 years; whereafter, it deflected to run below 10th percentile. The 95th and 85th BMI centiles of our study children were lesser than their normal American counterparts, throughout.

The lower BMI values of our normal children as compared to their American and Indian counterparts may be attributed to their affiliation to different environmental, racial/ethnic and socio-economic backgrounds and thus calls for having lower BMI cut-offs for detection of overweight and obesity in Indian populations. These findings corroborate with those of Singh et al. (2011) who argued in favor of having lower BMI cut offs for Indian populations. Observing Asian Indians as more prone to adiposity and central adiposity at a lower BMI than their counterparts of western origins (Khadilkar et al. 2012), a lower BMI cut-off has also been suggested by the World Health Organization (WHO 2000) and IOTF (Cole et al. 2000) for these populations. Similarly, Itani et al. (2020) suggested that the ethnic factor should be taken into account as a popular BMI cut-off point established for classifying obesity in certain populations (i.e. western populations) cannot be applied by default in others. Hence, the use of age and gender specific BMI percentile values presented for north-western Indian children, may be made to detect malnutrition (over and under-nutrition) to prevent future complications.

Conflict of Interest: None

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Table 1: Mean, SD and Gender Differences of BMI (kg/m^2) of Male and Female Children

Age (±Years)	Male			Female			Gender differences (p-value)
	N	Mean	SD	N	Mean	SD	
2.0	113	15.20	2.08	82	15.30	1.60	0.745
3.0	121	15.0	1.29	91	14.72	1.68	0.014*
4.0	141	14.68	1.43	101	14.56	1.64	0.193
5.0	144	14.65	1.55	96	14.12	1.39	0.094
6.0	115	14.28	1.72	85	14.03	1.73	0.751
7.0	102	14.11	1.78	70	14.13	1.69	0.274
8.0	108	14.41	1.44	75	14.37	2.03	0.009**
9.0	129	14.46	2.05	60	14.77	1.92	0.828
10.0	119	14.87	1.42	65	15.04	2.38	0.000***
11.0	78	14.92	1.76	53	15.26	1.41	0.003**
12.0	50	15.17	2.08	23	16.07	3.04	0.001***
13.0	38	15.27	1.92	11	16.29	2.56	0.198
14.0	20	15.58	2.99	8	16.80	1.76	0.196

***p≤0.05, **p≤0.01, ***p≤0.001, df= n-2**

Table 2: Percentiles for BMI (kg/m^2) in Male Children

Age (Years)	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
2.0	12.37	12.74	13.34	14.32	15.20	16.49	17.05	17.47	18.06	18.44
3.0	12.28	12.58	13.05	13.82	15.00	15.55	15.83	16.32	16.79	17.09
4.0	11.97	12.30	12.82	13.69	14.68	15.62	15.95	16.49	17.02	17.35
5.0	11.37	11.73	12.30	13.24	14.65	15.33	15.79	16.27	16.84	17.20
6.0	10.86	11.26	11.90	12.94	14.28	15.28	15.80	16.33	16.96	17.36
7.0	11.07	11.48	12.13	13.21	14.11	15.61	16.26	16.69	17.34	17.75
8.0	11.76	12.09	12.62	13.49	14.40	15.43	15.80	16.30	16.83	17.16
9.0	11.02	11.49	12.24	13.49	14.45	16.00	16.50	17.50	18.25	18.73
10.0	12.25	12.58	13.10	13.97	14.87	15.88	16.30	16.75	17.27	17.60
11.0	11.87	12.27	12.92	13.99	14.92	16.36	17.08	17.43	18.08	18.48
12.0	11.36	11.84	12.61	13.87	15.17	16.68	17.40	17.94	18.71	19.19
13.0	11.96	12.41	13.12	14.28	15.27	16.88	17.51	18.05	18.75	19.20
14.0	10.92	11.60	12.70	14.51	15.58	18.53	20.00	20.34	21.43	22.12

Table 3: Percentiles for BMI (kg/m^2) in Female Children

Age (Years)	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
2.0	11.58	12.03	12.76	13.97	15.30	16.65	17.00	17.85	18.58	19.04
3.0	11.59	11.97	12.58	13.60	14.72	15.85	16.44	16.86	17.48	17.86
4.0	11.48	11.86	12.46	13.46	14.56	15.67	16.05	16.67	17.27	17.65
5.0	11.51	11.83	12.34	13.19	14.12	15.06	15.40	15.91	16.42	16.74
6.0	10.78	11.18	11.81	12.86	14.03	15.20	15.66	16.25	16.88	17.28
7.0	10.95	11.34	11.96	12.99	14.13	15.28	15.63	16.31	16.94	17.33
8.0	10.57	11.04	11.78	13.01	14.37	15.74	16.31	16.97	17.72	18.19
9.0	11.16	11.61	12.31	13.48	14.76	16.06	16.46	17.23	17.93	18.37
10.0	10.56	11.11	11.99	13.43	15.04	16.65	17.07	18.10	18.98	19.53
11.0	10.93	11.46	12.31	13.71	15.25	16.80	17.50	18.21	19.05	19.58
12.0	10.37	11.07	12.19	14.03	16.07	18.12	19.00	19.97	21.08	21.78
13.0	11.47	12.06	13.01	14.56	16.29	18.02	18.70	19.58	20.52	21.11
14.0	13.51	13.91	14.56	15.62	16.80	17.99	18.71	19.05	19.69	20.10

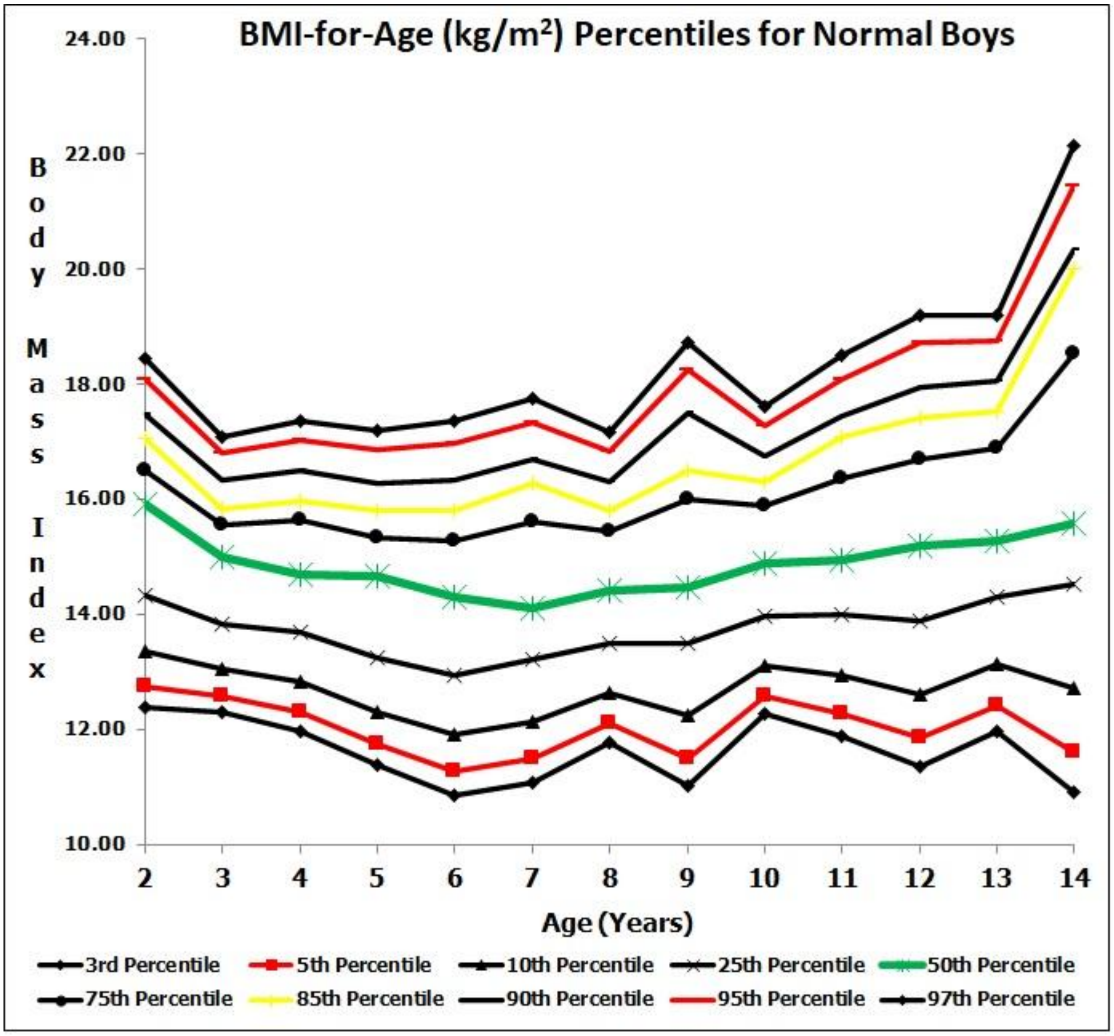

Fig 1: BMI-for-Age (kg/m^2) Percentiles for Normal Boys

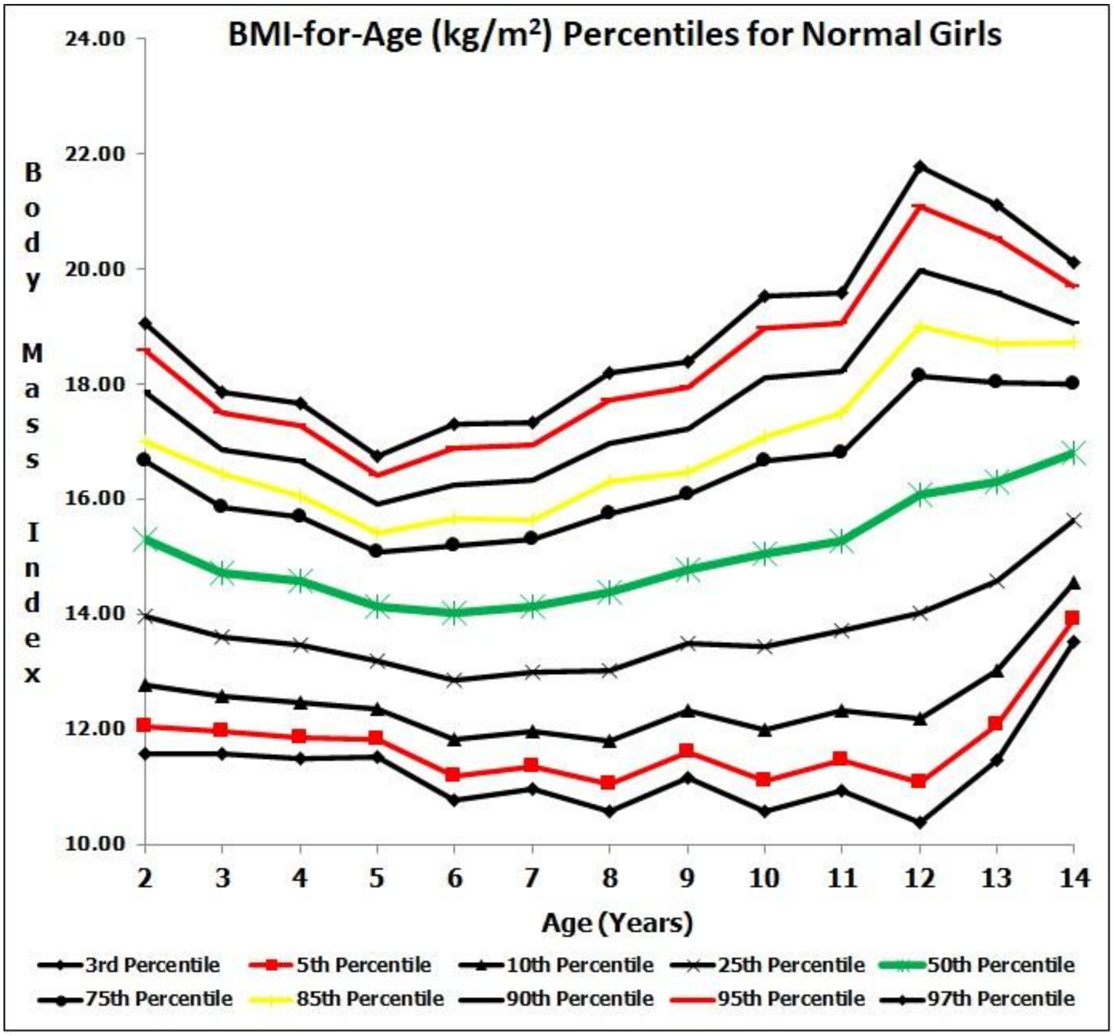

Fig 2: BMI-for-Age (kg/m^2) Percentiles for Normal Girls