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Growth Trends and Growth References: A Study on Children and Adolescents of a North Indian City

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ABSTRACT

The present study aims to construct anthropometric references of height, weight and body mass index (BMI) for the girls aged 8–16 years residing in Prayagraj, a city, of north India. A cross-sectional study was carried out on 460 girls aged 8–16 years of Prayagraj city. Anthropometric data was collected during school visits on healthy girls of the middle income group. Box-Cox power exponential distribution was used to construct percentile reference charts and tables for girls through the GALMASS package in R software. Further, we have compared our results with available growth references including Indian Paediatric Association (IPA), World Health Organization (WHO) and Centre for Disease Control and Prevention (CDC). Findings show lower median values for height, weight and BMI across all ages for girls of Prayagraj city as compared to WHO, CDC and IPA median values with few exceptions. It is observed that peak velocity emerges at the age between 8–10 years and 10–12 years for height and weight respectively. An anthropometric reference chart was prepared for the girls of age 8–16 years of Prayagraj for height, weight and BMI. These growth references will be valuable for policy makers and health practitioners.

Key words: *anthropology, growth, anthropometric reference, height, weight, BMI*

Introduction

Anthropometric measurements are globally used to assess health status of populations in general and their nutritional status in particular[1,2]. These measurements are utilized in developing the growth references of a population. Growth references are also called anthropometric references, which universally act as a diagnostic tool to screen and monitor physical growth of children and adolescents[3]. They are used in health clinics to assess growth of an individual or the whole population in the field studies[4].

Several international and national health organizations including International Union of Nutritional Science (1971), Maternal and Child Health Program of the Bureau of Community Health Services, U.S. (1971), the Food and Nutrition Board (1974), National Institute of Child Health and Human Development, National Institutes of Health Academy of Sciences (1975) and the World Health Organisation (1995) have emphasized the relevance of growth references[5]. It is recommended to establish and consistently update growth references for each country[6]. Because growth is a dynamic phenomenon, its pattern varies over time, hence growth references must be updated on a regular basis[7].

Several growth references have been developed globally for anthropometric indices including height for age, weight for age, body mass index (BMI) for age, mid upper arm circumference (MUAC) for age etc. Growth references for children and adolescents often used at international and national levels include the National Center for Health Statistics (NCHS, 1975) and Center for Disease Control and Prevention[5] growth reference charts based on American population, World Health Organization[7,8] growth standard and reference charts are based on populations from India, America, Norway, Ghana, Oman, and other few countries while the references of the Indian Council of Medical Research and the Indian Paediatric Association are based on the Indian population[9]. Nonetheless several nations have used WHO or CDC growth charts in the absence of their own growth references, although nutritional, genetic, economic, ethnic, and geographical circumstances significantly influence growth references[10]. Worldwide, new growth references at the population, region, and country levels are essential.

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India is known for its diversity in terms of geography, climate, nutrition, economic condition, ethnicity and culture[11]. Several studies on growth of children and adolescents have been conducted in different regions of India on different population groups to understand the growth patterns. In most of the studies, scholars have reported ethnic variation in growth[12–15]. For instance, a study by Agarwal and Agrawal[6] reported that Punjabis were the tallest when compared to other ethnic groups at regional level. Kumarvel et al.[15] in their study on Madurai children in south India emphasized the need for representative growth references by comparing with the Indian standard given by Agarwal and International Obesity Task Force (IOTF).

Though the cross-sectional measurements of height and weights are considered to be the gold standards for height and growth references, longitudinal measurements are considered to be the gold standard for the velocity of height and weight growth reference[16]. Growth monitoring guidelines for Indian children recommend the use of the WHO growth charts until five years of age and local (country specific) references from 5 to 18 years of age[17].

The existing body of literature indicates scarcity of data on growth references related to northern states of India. The present study is an effort to address the existing research gap. It was conducted in Prayagraj, a north Indian city to construct an anthropometric reference chart of height for age, weight for age and body mass index for age of 8 to 16 years old girls. The other objective was to evaluate differences between the obtained median values of height, weight and BMI values with those provided by the World Health Organization[8], Centers for Disease Control and Prevention[18] and the Indian Paediatric Association[17].

Materials and Methods

Study area

Prayagraj (erstwhile Allahabad) is a famous holy city situated at the confluence of the rivers Ganga, Yamuna and Saraswati in Uttar Pradesh, India. It is a regional centre of education, government organizations, industries, and judiciary. Consequently, people from different corners of Prayagraj district have settled in the city for several generations. The city can thus be considered as a blend representative sample of Prayagraj district suitable for setting anthropometric reference chart and anthropometric reference values for the children. As reported by Prayagraj municipal cooperation, the city is comprised of 80 wards. Purposively city was divided into four Zones i.e. North, East, West and South each with 20 wards. Ten schools were randomly selected from each zone. Written permission was sought from school authorities. A total of 22 schools granted permission for data collection, 6 schools from the north zone, 5 schools from the south zone, 5 from the east zone and 6 from the west zone.

Study design and sampling

A cross-sectional study was carried out on 481 girls aged 8 to 16 years. Simple random sampling was used for selecting schools (zone-wise)**.** The participants of study consist of Hindi speaking native girls of Prayagraj district of Uttar Pradesh. Only healthy girls belonging to the middle income group were included in the study. Healthy refers to physical well being and absence of any growth disorder or deformities and other chronic diseases[19]. Pretested interview schedule was used to obtain data on socio-demographic characteristics and occurrence of morbidities during last six months. The participants who reported to suffer from any illness during last six months were excluded from the study.

Anthropometric measurements were taken on each participant on their birthday with a window of one month (*i.e.* birth ±1month) during April 2017 to July 2019. Age of the child was confirmed thrice by asking the child, their parents and from the school register. Ethical clearance was obtained from the Institutional Ethical Review Board (IERB) of the University of Allahabad. Informed consent was obtained from the parents of study participants by signing a consent form by participants or their parents.

Anthropometric measurements

Anthropometric measurements included three variables i.e. height (stature), weight and BMI. All the measurements were taken by a trained female researcher following guidelines laid down by Farkas[20]. The measurements were made on the participant in minimum clothes by denoting landmarks on the body with a lip liner while the head was held in eye ear plain, and the palms were touching thighs on lateral sides. Every measurement was obtained on the right side of the body. Stature was measured using the anthropometer manufactured by Holtain Ltd. UK, with the nearest value of 1mm. Weight was calculated with accuracy of 0.5 kg through manual weighing scale (MCP deluxe personal manual analog). Body Mass Index of the participant was calculated by dividing weight in kilogram to square of height in meter[5]. As for children and teenagers BMI is age and sex specific so it is often called as BMI for age.

Information quality control: All data collection was done by the same instrument and by the same researcher to minimize errors. To remove outliers and to conform to normal distribution 21 data points were dropped ($\pm$3SD from median) and anthropometric reference charts were made on 460 data points (Table 1).

Statistical analysis

One sample Wilcoxon-signed rank test was employed to compare the medians of existing growth references (WHO, CDC, and IPA) with the current study based on

TABLE 1

DISTRIBUTION OF STUDY PARTICIPANTS FOR AGE AFTER REMOVING OUTLIERS

Age (in years)	8	9	10	11	12	13	14	15	16	Total
Frequency	54	52	43	63	71	50	44	61	22	460

age group[21]. To minimize skewness and kurtosis substantially in the data, Box-Cox power exponential (BCPE) method was used[7,22]. BCPE distribution is flexible to model dependent variable Y (height, weight, BMI) on independent variable X (age), which is required for construction of growth reference. BCPE has a set of parameters (mu, sigma, nu and tau); these represent parameters for location (median), scale (coefficient of variation), skewness and kurtosis respectively. Generalized Additive Linear Model for Location Scale and Shape (GALMSS) in R package was used, which gives maximum penalized likelihood with a good fitted curve based on BCPE distribution[23].

Results

Height, weight and BMI for age

Tables 2, 3 and 4 represent 1st, 3rd, 5th,15th, 25th, 50th, 75th, 85th, 95th, 97th, 99th percentile values for height, weight and BMI by age group (8–16 years) for girls of Prayagraj city i.e. anthropometric reference values. Equivalent reference chart for height, weight and BMI by age is shown in Figures 1, 2 and 3 respectively. The 50th percentile (median) value of height for age 8–16 year old girls ranges from 124.7 to 153.2 cm (Table 2). The growth in height based on median value indicates more noticeable increase between 8 to 10 years i.e. 5.3 cm. From 14 to 16 years gradual slow down occurs in height i.e. from 2.5cm to 0.8cm. The growth in height median reference chart among girls of 8 to 16 years follows a sigmoid pattern (Figure 1).

Weight for age 50th percentile rises linearly up to 12 years and gradually level off from 14 years onward. This jump is more pronounced for age 10 to 12 years i.e. 3.3 kg (Figure 2, Table 3). The total growth increment in median value of weight across all ages is about 22 kg. Median weight value of girls (8–16 years) ranges from about 22 kg to 45 kg. The smoothed weight curve (reference chart) shows curvilinear rise in the growth of 8 to 16-year -old girls.

TABLE 2

PERCENTILE VALUE FOR HEIGHT (IN CM) OF THE PARTICIPANT GIRLS

Age	L	M	S	1st	3rd	5th	15th	25th	50th	75th	85th	95th	97th	99th
8	-0.67	124.7	0.04	114.4	115.8	116.6	118.9	120.7	124.7	129.0	131.0	133.9	134.9	136.7
9	0.06	130.0	0.04	118.9	120.5	121.5	124.2	126.1	130.0	134.0	136.0	139.0	140.1	142.1
10	0.80	135.3	0.04	123.3	125.4	126.5	129.6	131.5	135.3	139.1	141.0	144.2	145.3	147.5
11	1.54	140.2	0.04	127.4	129.9	131.2	134.6	136.6	140.2	143.8	145.7	148.9	150.1	152.4
12	2.28	144.7	0.04	131.3	134.1	135.5	139.1	141.1	144.7	148.1	150.0	153.1	154.4	156.7
13	3.02	148.5	0.04	134.8	137.8	139.3	143.0	145.0	148.5	151.9	153.7	156.8	157.9	160.1
14	3.75	151.2	0.03	137.5	140.4	141.9	145.6	147.6	151.2	154.5	156.3	159.1	160.2	162.1
15	4.49	152.6	0.03	139.0	142.0	143.4	147.0	149.0	152.6	155.8	157.5	160.1	161.1	162.9
16	5.23	153.2	0.03	140.0	142.8	144.3	147.8	149.7	153.2	156.4	158.0	160.4	161.3	162.9

TABLE 3

PERCENTILE VALUE FOR WEIGHT (IN KG) OF THE PARTICIPANT GIRLS

Age	L	M	S	1st	3rd	5th	15th	25th	50th	75th	85th	95th	97th	99th
8	-0.67	22.2	0.14	16.5	17.3	17.9	19.3	20.2	22.2	24.5	25.9	28.6	29.8	32.2
9	-0.58	25.3	0.16	18.0	19.1	19.7	21.6	22.8	25.3	28.3	30.2	33.8	35.4	38.8
10	-0.49	28.5	0.18	19.3	20.7	21.5	23.8	25.3	28.5	32.4	34.9	39.6	41.7	46.1
11	-0.40	31.8	0.19	20.8	22.4	23.4	26.1	27.9	31.8	36.6	39.5	45.2	47.8	53.1
12	0.30	35.1	0.20	22.7	24.6	25.7	28.7	30.8	35.1	40.4	43.6	49.8	52.5	58.1
13	-0.20	38.2	0.19	25.1	27.2	28.3	31.6	33.7	38.2	43.5	46.7	52.7	55.3	60.6
14	-0.12	41.1	0.17	27.8	30.0	31.2	34.5	36.6	41.1	46.1	49.1	54.7	57.0	61.7
15	-0.02	43.3	0.15	30.3	32.4	33.6	36.9	39.1	43.3	48.1	50.9	56.0	58.0	62.2
16	-0.07	44.7	0.14	32.1	34.2	35.4	38.6	40.6	44.7	49.1	51.7	56.2	58.1	61.8

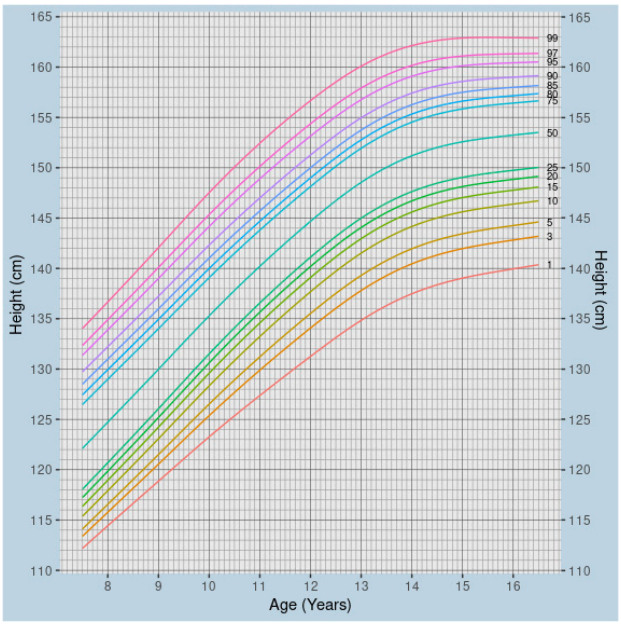

Fig. 1. Height for age (in cm): Percentile reference chart of the study participants.

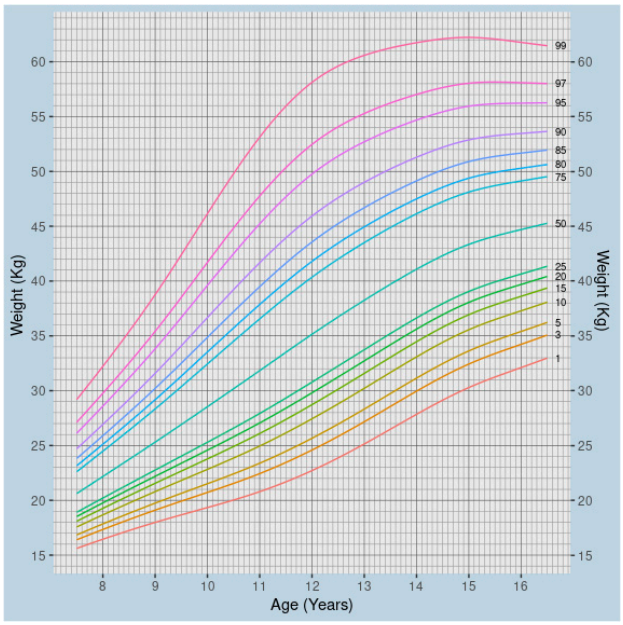

Fig. 2. Weight for age: Percentile reference chart of the study participants.

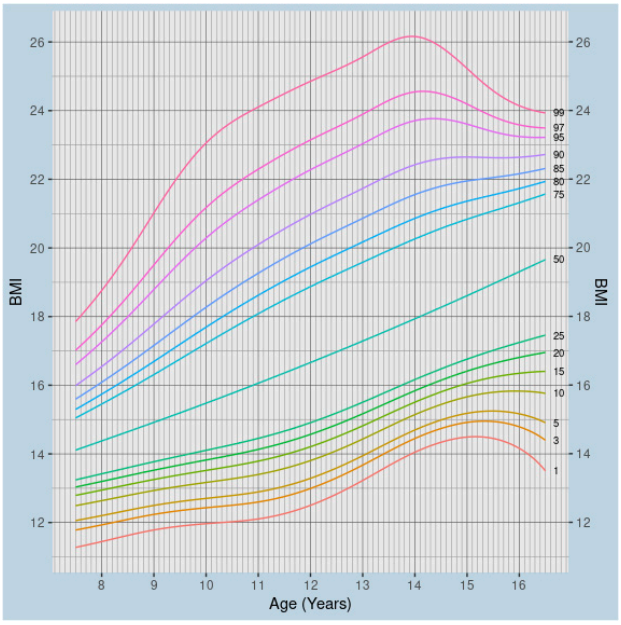

Fig. 3. BMI for age (in kg/m2): Percentile reference chart of the study participants.

The BMI median value rises from age 8 years onwards. However, after 10 years, the increase in median BMI remains steady until 14 years, at which point it begins to rise again across age. After 14 years, the median increase in BMI per year is 0.7 kg/m^2 (Table 4 and Figure 3). The 50th percentile of BMI is between 14.4 and 19.3 kg/m^2. In Prayagraj, the overall growth increment in the 50th percentile of BMI among 8 to 16-year-old girls is 4.9 kg/m^2.

Comparison with IPA, CDC and WHO reference values

Tables 5, 6 and 7 illustrate the comparison of mean and median reference values of height, weight and BMI of the present study with IPA[17] growth reference, CDC growth reference[24] and WHO[8]) growth reference values. It can be observed that the values of average height, weight and BMI of the current study are lower across all age groups than IPA, CDC and WHO reference values (Tables 5–7). In general, the results of one sample Wilcoxon-signed rank test demonstrate that median height, weight and BMI values of our participants were significantly lower as compared to IPA, CDC and WHO values. However, for height the differences were not statistically significant in 8 year age group with respect to WHO and IPA references and in 13 year age group with respect to IPA references. Overall, median height of the current study is closer to national data, i.e. IPA as compared to CDC and WHO values (Table 5).

Girls in the present study are significantly lighter in weight when compared with reference values of WHO, IPA and CDC using one sample Wilcoxon signed rank test, except, for 10 year age group where results were not significant only for reference values IPA (Table 6). The difference between median values of the present study and the IPA values shows an increasing trend with age: 1.8 kg for 8 years and 5kg for 16 years. It is pertinent to note that the median weight of the WHO growth reference study is on an average 3kg higher as compared to the median weight of our participants in the age group 8 to 10 years (Table 6).

It can be observed that the 50th percentile of IPA, CDC and WHO for BMI is significantly higher for 8 to 16 year old as compared to the participants in our study (Table 7). The difference in median BMI varies from 2.4 kg/m^2 to

TABLE 4

PERCENTILE VALUE FOR BMI (IN KG/M2) OF THE PARTICIPANT GIRLS

Age	L	M	S	1st	3rd	5th	15th	25th	50th	75th	85th	95th	97th	99th
8	-0.62	14.4	0.10	11.4	11.9	12.2	12.9	13.4	14.4	15.5	16.1	17.3	17.8	18.8
9	-1.30	14.9	0.12	11.8	12.2	12.5	13.3	13.8	14.9	16.3	17.2	18.8	19.5	21.0
10	-1.36	15.5	0.13	12.0	12.4	12.7	13.5	14.1	15.5	17.2	18.3	20.3	21.2	23.1
11	-1.06	16.1	0.15	12.1	12.6	12.9	13.8	14.5	16.1	18.1	19.3	21.4	22.3	24.1
12	-0.97	16.7	0.16	12.5	13.0	13.3	14.2	14.9	16.7	18.9	20.1	22.3	23.2	24.9
13	-1.16	17.3	0.15	13.2	13.7	14.0	14.8	15.5	17.3	19.6	20.9	23.0	23.9	25.6
14	-1.42	17.9	0.14	14.1	14.5	14.7	15.5	16.2	17.9	20.3	21.6	23.7	24.6	26.2
15	-0.71	18.6	0.14	14.5	14.9	15.2	16.1	16.8	18.6	20.8	22.0	23.6	24.2	25.2
16	1.24	19.3	0.13	14.2	14.8	15.2	16.4	17.3	19.3	21.3	22.2	23.3	23.6	24.1

TABLE 5

GIRLS' HEIGHT COMPARED TO VALUES OF OTHER STUDIES USING ONE SAMPLE WILCOXON-SIGNED RANK TEST

Age	Present Study		IPA (2015)		CDC (2012)			WHO (2007)	
	Mean	Median	Median	p-value	Mean	Median	p-value	Median	p-value
8	125	124.72	125.4	0.991	131.3	130.7	0.000	126.6	0.173
9	130	129.98	131.4	0.019	137.0	136.7	0.000	132.5	0.001
10	136	135.28	137.4	0.049	144.5	144.5	0.000	138.6	0.003
11	140	140.20	143.3	0.000	150.4	150.7	0.000	145.0	0.000
12	144	144.67	148.4	0.000	156.1	156.7	0.000	151.2	0.000
13	149	148.54	152.2	0.177	160.0	159.5	0.000	156.4	0.000
14	151	151.18	154.7	0.000	161.6	161.9	0.000	159.8	0.000
15	152	152.57	156.1	0.004	162.9	161.7	0.000	161.7	0.000
16	152	153.23	156.9	0.016	162.2	161.4	0.000	162.5	0.000

TABLE 6

GIRLS' WEIGHT COMPARED TO VALUES OF OTHER STUDIES USING ONE SAMPLE WILCOXON-SIGNED RANK TEST

Age	Present Study		IPA (2015)		CDC (2012)			WHO (2007)	
	Mean	Median	Median	p-value	Mean	Median	p-value	Median	p-value
8	22.4	22.2	24	0.005	31.9	29.2	0.000	25.0	0.000
9	26.1	25.3	27.2	0.011	35.5	31.9	0.000	28.2	0.001
10	29.5	28.5	31.0	0.103	41.1	39	0.000	31.9	0.026
11	32.0	31.8	35.4	0.000	47.5	43.3	0.000	–	
12	37.1	35.1	39.8	0.001	52.3	51.4	0.000	–	
13	38.2	38.2	43.6	0.001	58.9	52.3	0.000	–	
14	41.2	41.1	46.4	0.000	61.6	59.0	0.000	–	
15	45.1	43.3	48.4	0.001	63.3	59.5	0.000	–	
16	43.4	44.7	49.7	0.000	62.4	58.7	0.000	–	

4.5kg/m^2 between our results and CDC values, 1.2kg/m^2 to 1.7kg/m^2 for WHO values, and from 0.2kg/m^2 to 1.8kg/m^2 with respect to IPA. It is therefore evident that the median BMI of our participants is closer to IPA reference values than those of WHO and CDC.

Discussion

It has been demonstrated that local reference charts indicate different growth patterns and health conditions among populations even when the same inclusion criteria

are used to produce them[25]. Therefore, one sample Wilcoxon-signed rank was used to compare the values of growth measures of the present study with the reference values of IPA, CDC, and WHO. It shows statistically significant differences in median values of height, weight, and BMI for age with respect to IPA, CDC, and WHO except for few age groups (Tables 2, 3 and 4). The 50th percentiles of height, weight and BMI of the present study are closer to national data[17] than to international references[8,18] which suggests that some population attributes of genetic and proximal environment may be responsible for differences and variations in the growth indicators[10,26].

Girls of Prayagraj city have shorter height, lighter weight in all age groups with respect to girls in the USA[18]. Similar results were observed for Saudi and Turkish populations when compared with USA population[27,28]. Indian studies[6,17] have yielded similar findings when compared with WHO and CDC growth references. These variations in height and weight may be the reflection of factors such as nutritional, geographical, regional, environmental, hormonal, and genetic as reported by earlier studies[10,26,29]. In our study, all age groups have lower median BMI than WHO, CDC, and IPA data. Studies on Portuguese, British, Iranian, Danish and Saudi children have shown similar results[27,28]. Several studies have concluded that variations in growth measures like weight and BMI may be attributed to the variations in genetic makeup of the populations and related genetic factors[26,30–32,].

Median height velocity of the present study has increased to its peak of 5.3 cm at the age between 8–10 years. Khadilkar et al.[33] reported peak height velocity in the girls at the age of 10.5 years. Qamra et al.[34] observed that Panjabi girls showed peak height velocity in the age between 11–13 years. Several international and national studies also documented variations in age to attain peak height velocity such as 13.8 years in Gambian Girls[35], 12.2 years in Swedish girls[36], 12.2 years in Norwegian girls[37], 12.2 years in Swiss girls[38], 12.1 in rural Indian girls[39] and 12.5 years in semi urban Bengali girls[40]. Environmental variables, including nutrition and food intake might provide a plausible explanation for differences in the onset of puberty between populations[33,39]. However, Swedish cohort study on twins[41] and study on Javanese compared with urban and rural Cape Coloured schoolchildren indicated that puberty appearance was strictly genetically regulated[42].

The present study has illustrated the anthropometric reference values of height, weight and BMI among the girls (8 to 16 years) of the north Indian city of Prayagraj. It is an unexplored population i.e., Prayagraj city, where local health workers, doctors or policy makers will have an opportunity to use this local reference chart to screen and monitor the girls' health at the local level. Body Mass Index is preferred to assess nutritional status in Indian children to prevent stunting caused by consistent energy inadequacy. Many stunted children generally have appropriate weight but to attain normal height their energy intake may increase which may consequently cause over nutrition and late childhood or adolescent obesity[43]. Speedy economic and social transition in India has influenced growth patterns of children especially in the cities. Thus a local growth reference chart and regular growth monitoring will help developing healthier community and devising intervention strategies and programs. Trends have been observed for increase in the prevalence of obesity and related morbidities in both the genders[33].

Our study was conducted on a comparatively unexplored population with a modest sample size, using BCPE method for robust estimates[30–32]. However, the results of the study should be viewed under certain limitations such as using limited components in the investigation and not considering factors that can cause variations in individual or population growth path.

Conclusion

A significant difference is visible in all three anthropometric parameters (height, weight and BMI) at the local level when compared with national and international references. However, reference values are closer to national data than to WHO and CDC values. India in general, and north India in particular, is in a phase of nutritional transition therefore updating growth references regularly is required[44]. The obtained reference chart will aid clinical practitioners and nutritionists in monitoring the growth of girls aged 8 to 16 years in urban areas of northern India. This research could also provide useful local growth references for future research on height, weight and BMI.

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REFERENCES

1. KAHN J, CHATTOPADHYAY A, SHAW S, Scientific Reports. 13 (2023) 13015. — 2. SANCHEZ-GRACIA S, GRACIA-PENA C, DUQUE-LOPEZ MX, JUAREZ-CEDILLO T, CORTEZ-NUNEZ AR, REYES-BEAMAN S, 7 (2007) 2. doi:10.1186/1471-2458-7-2. — 3. WRIGHT CM, BOOTH IW, BUCKLER JMH, CAMERON N, COLE TJ, HEALY MJR, HULSE JA, PREECE MA, REILLY JJ, WILLIAMS AF, Archives of Disease in Childhood, 86 (2002) 11. doi: 10.1136/adc.86.1.11. — 4. TANNER JM, Growth at Adolescence. (Blackwell, Oxford, 1962). — 5. KUCZMARSKI RJ, OGDEN CL, GUO SS, GRUMMER-STRAWN LM, FLEGAL KM, MEI Z, WEI R, CURTIN LR, ROCHE AF, JOHNSON CL, 2000 CDC Growth Charts for the United States: methods and development. Vital Health Statistics, 11/246 (Centers for Disease Control and Prevention, National Center for Health Statistics, Hyattsville, Maryland, 2002). — 6. AGARWAL DK, AGARWAL KN, UPADHYAY SK, MITTAL R, PRAKASH R, RAI S, Indian Pediatrics, 29 (1992) 1203. — 7. BUCKLER JMH, Growth Disorders in Children (BMJ Publishing Group, London, 1994). — 8. WHO, Child Growth Standards (2007). https://www.who.int/tools/child-growth-standards/standards. — 9. INDIAN COUNCIL OF MEDICAL RESEARCH, Growth and physical development of Indian infants and children (Division of Publication, Indian Council of

Medical Research, New Delhi, 1972). — 10. MALINA RM, BOUCHARD C, BAR-OR ODED, Growth, Maturation and Physical activity (Human Kinetics, Champaign, 2004). doi:10.5040/9781492596837. — 11. BHARATI S, MUKHERJI D, PAL M, SOM S, ADAK D, VASULU TS, BHARTI P, Collegium Antropologicum, 34 (2010) 1207. — 12. REDDY PYB, RAO AP, Annals of Human Biology, 27 (2000) 67. — 13. BANERJEE SR, CHAKRABARTY S, VASULU TS, BHARATI S, SINHA D, BANERJEE P, BHARATI P, Indian Journal of Pediatrics, 76 (2009) 391. doi: 10.1007/s12098-009-0015-3. — 14. KUITI BK, DASH I, JANA M, PRATIHAR S, BOSE K, Journal of Life Sciences, 9 (2017) 18. doi:10.1080/09751270.2017.1343706. — 15. KUMARVEL V, SHRIRAAM V, ANITHARANI M, MAHADEVAN S, BALAMURUGAN A, SATHIYASEKARAN BWC, Indian Journal of Endocrinology and Metabolism, 18 (2014) 56. doi:10.4103/2230-8210.126541. — 16. FALKNER F, TANNER JM, Human growth (Plenum Press, New York, 1986). — 17. KHADILKAR V, YADAV S, AGRAWAL KK, TAMBOLI S, BANERJEE M, CHERIAN A, GOYAL JP, KHADILKAR A, KUMARAVEL V, MOHAN V, NARAYANAPPA D, RAY I, YEWALE V, Indian Pediatrics, 52 (2015) 47. doi:10.1007/s13312-015-0566-5. — 18. GRUMMER-STRAWN LM, REINOLD C, KREBS NF, CDC, MMWR Recomm Rep, 59 (2010) 1. https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5909a1.htm. — 19. RAZZAGHY-AZAR M, MOGHIMI A, SADIGH N, MONTAZER M, GOLNARI P, ZAHEDI-SHOOLAMI L, VAN BUUREN S, MOHAMMAD-SADEGHI H, ZANGENEH-KAZEMI A, FERESHTEHNEJAD SM, Annals of Human Biology, 33 (2006) 628. doi:10.1080/03014460600909372. — 20. FARKAS LG, Anthropometry of head and face. (Raven press, New York 1994). — 21. CONOVER WJ, Practical Nonparametric Statistics (3rd ed.) (John Wiley & Sons, New Delhi, 1999). — 22. Rigby RA, Stasinopoulos DM, Statistics in Medicine, 23 (2004) 3053. — 23. STASINOPOULOS DM, RIGBY RA, LANE PW, Journal of the Royal Statistical Society, 54 (2005) 507. doi:10.1111/j.1467-9876.2005.00510.x. — 24. FRYAR CD, GU Q, OGDEN CL, Vital Health Stat 11 (2012) 1. — 25. JÚLÍUSSON PB, ROELANTS M, HOPPENBROUWERS K, HAUSPIE R, BJERKNES R, Arch Dis Child, 96 (2011) 916. doi:10.1136/adc.2009.166157. — 26. YANG W, KELLY T, HE J, Epidemiol Rev, 29 (2007) 49. doi:10.1093/epirev/mxm004. — 27. AL-SEKAIT MA, AL-NASSER AN, BAMGBOYE EA, Saudi Medical Journal, 13 (1992) 141. — 28. NEYZI O, BUNDAK R, GÖKÇAY G, GÜNÖZ H, FURMAN A, DARENDELILER F, BAŞ F, Journal of Clinical Research in Pediatric Endocrinology, 7 (2015) 280. doi:10.4274/jcrpe.2183. — 29. EVELETH P, TANNER J, Worldwide Variation in Human Growth (Cambridge University Press, London, 1991). doi:10.1017/CBO9780511629105. — 30. KATZMARZYK PT, MALINA RM, PÉRUSSE L, RICE T, PROVINCE MA, RAO DC, BOUCHARD C, Am J Hum Biol, 12 (2000) 395. doi:10.1002/(sici)1520-6300(200005/06)12:3<395::aid-ajhb10>3.0.co;2-j. — 31. RICE T, DAW EW, GAGNON J, BOUCHARD C, LEON AS, SKINNER JS, WILMORE JH, RAO DC, Obes Res, 5 (1997) 557. — 32. WU DM, HONG Y, SUN CA, SUNG PK, RAO DC, CHU NF, Eur J Epidemiol, 18 (2003) 221. doi:10.1023/A:1023337917377. — 33. KHADILKAR V, KHADILKAR AV, KAJALE N, Indian J Endocrinol Metab, 23 (2019) 635. doi:10.4103/ijem.IJEM-555-19. — 34. QAMRA SR, MEHTA S, DEODHAR SD, Indian Pediatr, 27 (1990) 925. — 35. BILLEWICZ WZ, MCGREGOR IA, Ann Hum Biol, 9 (1982) 309. doi:10.1080/03014468200005811. — 36. TARANGER J, HÄGG U, Acta Odontologica Scandinavica, 38 (1980) 57. doi:10.3109/00016358008997719. — 37. WAALER PE, (1983). Anthropometric studies in Norwegian children. Acta Paediatrica Scandinavica, 308 Suppl (1983) 1. — 38. LARGO RH, PRADER A, Helvetica paediatrica acta, 38 (1983) 229. — 39. RAO S, JOSHI S, KANADE A, Ann Hum Biol, 27 (2000) 127. doi:10.1080/030144600282244. — 40. HAUSPIE RC, DAS SR, PREECE MA, TANNER JM, Ann Hum Biol, 7 (1980) 429. doi:10.1080/03014468000004541. — 41. WIKLAND KA, LUO ZC, NIKLASSON A, KARLBERG J, Acta Paediatrica, 91 (2002) 739. doi:10.1080/08035250213216. — 42. ARTARIA MD, The adolescent growth spur: a study of the growth of Javanese and Cape Coloured 6-18 year olds and several populations from published literature, PhD Thesis (University of Adelaide, 2003). https://hdl.handle.net/2440/21973. — 43. RAMACHANDRAN P, GOPALAN HS, Indian Journal of Medical Research, 134 (2011) 47. 44. KHADILKAR V, KHADILKAR A, Indian Journal of Endocrinology and Metabolism. 15 (2011) 166.

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TRENDOVI I REFERENTNE VRIJEDNOSTI RASTA U DJECE I ADOLESCENTA JEDNOG SJEVERNOINDIJSKOG GRADA

S A Ž E T A K

Cilj ovog istraživanja je bila izrada referentnih antropometrijskih vrijednosti visine, težine i indeksa tjelesne mase (BMI) za djevojčice u dobi od 8 do 16 godina koje žive u Prayagraju, gradu u sjevernoj Indiji. Presječna studija provedena je prikupljanjem antropometrijskih podataka u školama Prayagraja na 460 djevojčica iz srednje imućnih obitelji u dobi od 8 do 16 godina. Box-Coxova eksponencijalna distribucija snage korištena je za izradu referentnih grafikona percentila i tablica za djevojčice putem paketa GALMASS u R softveru. Dobiveni rezultati zatim su uspoređeni s dostupnim referentnim vrijednostima rasta uključujući one Indijskog pedijatrijskog udruženja (IPA), Svjetske zdravstvene organizacije (WHO) i američkog Centra za kontrolu i prevenciju bolesti (CDC). Analiza je pokazala niže srednje vrijednosti za visinu, težinu i BMI u svim dobnim skupinama djevojčica iz Prayagraja u usporedbi s postojećim srednjim vrijednostima uz nekoliko iznimaka. Uočeno je da se najveća brzina rasta javlja u dobi između 8–10 godina za visinu i 10–12 godina za težinu. Za djevojčice u dobi od 8 do 16 godina iz Prayagraja izrađena je tablica antropometrijskih referentnih vrijednosti za visinu, težinu i BMI. koja će biti korisna kreatorima politika i zdravstvenim djelatnicima.