Examination of Children's Height and Weight According to Standard NCHS Growth Curve: A Cross-sectional Study

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Abstract

Introduction: Measuring children's and adolescents' height and weight are among the most important information sources and the best index for the assessment of individual growth status and community's nutrition and health status. Regular measurements of height and weight and recording the data on proper curves lead to the timely identification of growth disorders. The present study aimed at determining the average height, weight, and body mass index of 6-18-year-old boys and girls in Jiroft Town and comparing the results with the National Center for Health Statistics (NCHS).
Method: In this study, the values for height, weight, and body mass index of 5850 children aged between 6 and 18 were examined in a stratified random fashion. Growth percentile curves for height, weight, and body mass index were plotted by Microsoft Excel Software.
Results: In comparison to the NCHS height and weight percentiles, the data of the present study showed lower values for the studied children. The comparison of BMI percentiles of boys and girls with NCHS percentiles for each age proved that until the age of 8, the BMI percentiles are fit to NCHS percentiles. This is while in older ages, the calculated BMI percentiles of males and females were remarkably lower than NCHS percentiles.
Conclusion: Based on the results, it is generally concluded that using foreign criteria leads to a false diagnosis of underweight or shortness in some children and it is recommended to apply native and country-level percentiles for the examination of children's growth.

Keywords: Height, Weight, Body Mass Index, Growth Curve, Student.

Introduction

Growth is a continuous process from egg fertilization to development.[1] Growth in the most prominent children's health and nutrition in every country, particularly in developing communities. Growth characteristics in infancy, early childhood, and adolescence are more important than other ages.[2-4] One of the most common methods for the examination of children's and adolescents' growth is by measuring their height and weight in childhood and maturation periods.[5] Measurement of children's and adolescents' height and weight is among the most important information sources and the best index for the assessments of an individual's growth status, nutrition status, and community health. Noting that growth is constantly influenced by factors such as nutrition, inheritance, endocrine, and some other systemic factors.[4,6] Regular measurements of height and weight and recording the data on proper curves

leads to the timely identification of growth disorders and the beginning of preventive and curative measures. Therefore, the implementation of height and weight curves for discovering children's health status is increasingly insisted on.[7-10]

Currently, indices such as height and weight are globally used for assessing children's physical growth and health, since the assessment of these indices is simple, cost-effective, and non-invasive.[11] Growth curves are the main reference for growth assessment, most of which are adapted from the criteria of developed countries such as England, Sweden, and the USA.[12-15] More than 30 years has passed since the publication of growth curves.[16] Investigations indicate that humans' growth pattern has been changed over time so that it has increased through the last two centuries.[8] For example, the average adult height and weight have been increasing since the mid-19th century in Europe.[9] This value was about one

centimeter per decade for northern Europe,[10] while in eastern and southern Europe, it has increased up to three centimeters per decade.[11] These changes increasingly necessitates updates for growth curves and height and weight standards. Currently in the Netherlands, these changes are made every 15 years.[9]

Examination of children's growth patterns and comparing it with reference growth curves end in the identification of improper growth patterns. The first growth curves were introduced in the 18th century.[17] Since then, several studies have been conducted to reach reference values and nowadays, the World Health Organization (WHO) recommends the application of the National Center for Health Statistics (NCHS) growth curve, which is derived from investigations on northern American children. But exploiting other countries' reference curves is objectionable because of ethnic and lifestyle differences, different diets and economic and cultural conditions and leads in a false diagnosis of underweight and shortness in some children. These needs justify application on national standard growth curves based on regional ethnic diversity.[3,9,18,19] In the present study, the average height, weight, and body mass index of 6-18-year-old boys and girls of Jiroft Town were examined during 2018 to compare them with the NCHS indices. This was done so that a foundation of country-level and regional percentiles could be established.

Method

This cross-sectional study (descriptive-analytical type) was carried out on 5850 children between 6 and 18 years of age (equal ratio of boys to girls) in Jiroft Town by stratified sampling method from 179 of preschool, primary school, and high schools. An ethical approval for the study was obtained from the Ethics Committee of the Jiroft University of Medical Sciences (Approval number IR.JMU.REC.1397.428).

The inclusion criteria for this study included a personal consent and students' health and the exclusion criteria were discontents of study participation and children with chronic and musculoskeletal diseases.

The health instructors in schools conducted data gathering. Despite the health instructors' sufficient information about measuring students' height and weight, they were provided by required education in the field. The subjects' consent was considered and all sampling steps were performed in accordance with the education administration and with official permissions.

Students' weights were measured by SECA balance (Germany) with a measurement accuracy of 0.25 Kg and their heights were measured by a tapeline with a measurement accuracy of 1 centimeter. Data regarding students' height, weight and birth date, date of questionnaire filling, and students' age were recorded on specific forms. The student's age was calculated by subtracting birth date from the date of questionnaire filling.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS Inc., Chicago, III., USA) for Windows Version 16. Descriptive statistical indices (mean, standard deviation, minimum, and maximum) were used to describe the data. Inferential statistical methods were also used, such as Kolmogorov-Smirnov test for checking the normal distribution of data and pair-wise independent t-test for comparison of height, weight, and body mass index in males and females of each age group. Growth percentile curves for height, weight, and body mass index were plotted by Microsoft Excel Software.

Results

In this study, 2925 girls and 2925 boys aged between 6 and 18 were examined for their height, weight, and body mass index. There were 225 boys and 225 girls in each age group (6-18-year-old). The one-sample Kolmogorov-Smirnov test designated a normal distribution of data in all age groups of both sexes. Independent samples t-test was used as a parametric test to compare average variables in boys and girls. Statistical analysis showed that in age categories of 6, 14, 15, 16, 17, and 18, there was a significant difference in average height and weight between boys and girls ($p<0/05$). Generally, it could be stated that almost in all age groups, the average height and weight values were higher for boys. Only for the age category of 14-year-olds, higher average height and weight values were observed for girls. The results for body mass index showed that only in age categories of 6- and-17-year-olds, boys and girls had different average BMI scores ($p<0.05$). In the age category of 6-year-olds, average BMI scores were higher for boys, while in the age category of 17-year-olds, average BMI scores were higher for girls.

The values of height (in centimeters), weight (in kilograms), and BMI (kg/m2) percentiles were examined in studied boys and girls of each age group. Height, weight, and BMI percentiles of 5, 25, 50, 75, and 95 for studied boys and girls were compared with standard criteria of NCHS (Figure-1).

By comparing the height percentiles of boys with NCHS percentiles sorted by age, it is observable that in the age range of 6-8 years, the height percentiles for boys was compatible with NCHS percentiles. In the age range of 8-18 years, the height percentiles for boys was lower than NCHS percentiles. It is notable that in the percentile of 95, in the age range of 16-18 years, the height percentiles of girls was about 5 centimeters lower than NCHS percentiles.

The comparison of weight percentiles of males and females with NCHS percentiles revealed that in all age groups, weight percentiles were lower than NCHS percentiles and this difference was more significant in age groups above 9 years old.

The comparison of BMI percentiles of males and females with NCHS percentiles for each age proved that before the age of 8, the BMI percentiles were fit to the NCHS percentiles and in older ages, the calculated BMI percentiles of males and females were remarkably and non-negligibly lower than the NCHS percentiles.
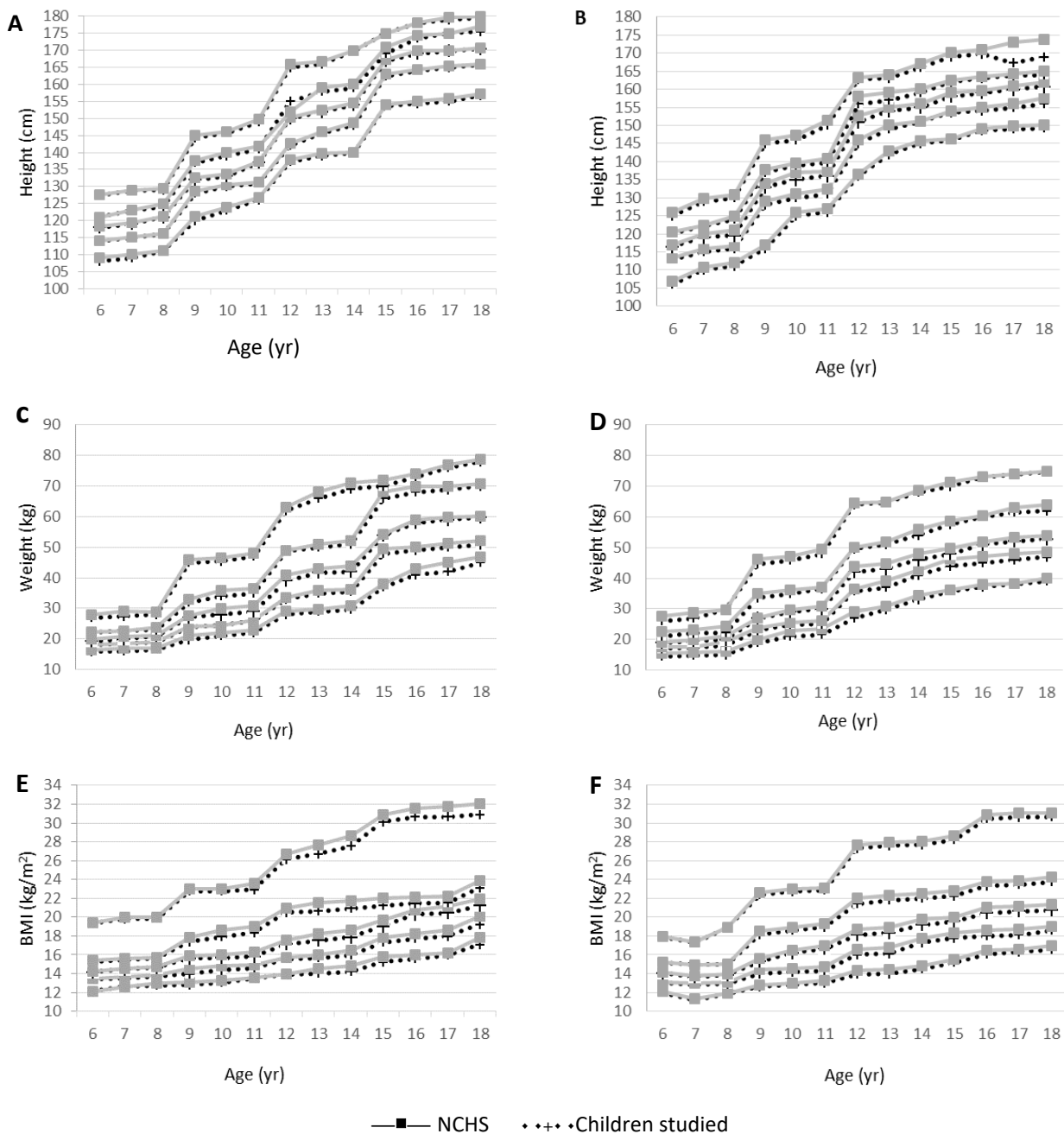

Figure-1. Values of height, weight, and BMI percentiles of 5, 25, 50, 75, and 95 in the studied subjects sorted by age and sex based on NCHS criteria; A: height percentiles in boys, B: height percentiles in girls, C: weight percentiles in boys, D: weight percentiles in girls, E: BMI percentiles in boys, F: BMI percentiles in girls.

Discussion

For several reasons such as considering lifestyle quality and individual and community health levels along with country-level plans for improving the community's public health, assessing the process of growth changes is of great importance. One of the prevalent methods for assessing the growth of children and the youth is measuring their height and weight in childhood and puberty ages, which is because of the importance of this growth period. As a result, the present investigation aimed at determining the average height, weight, and body mass index values of boys and girls in Jiroft Town during 2018 and comparing them with the NCHS standard criteria.

Regarding the results gained in this investigation, the average height and weight values in both groups of boys and girls, sorted by different age categories of 6-18 years showed that in groups of 6, 15, 16, 17, and 18-years-old, average values of height and weight were higher in girls. Only in the age group of 14-years-old, the average height and weight values were higher for girls. Since the growth spurt of girls begins earlier, many females of 10-14 years old have higher height and weight values than boys.[20] This finding reflects our study's accuracy.

The comparison of the average BMI values in boys and girls specified that the average BMI values in the age group of 6-year-olds were higher for boys, while in the age group of 17-year-olds, these were higher for girls. Based on the curve slope of height, weight, and BMI percentiles, it could be stated that boys have the highest increases in height, weight, and BMI growth in ages between 8 and 15. In girls, this occurs in ages between 8 to 12 (the highest growth rate is related to ages 8 to 9 and 11 to 12 for both sexes and 15 to 15 for boys). In the NCHS percentiles, this increase in height, weight, and BMI growth rates also fit each other and is observable in the mentioned age ranges. It was also determined that compared to the NCHS percentiles, particularly in ages above 8, height, weight, and BMI percentiles of studied individuals were significantly lower.

It is notable that in the percentile of 95, the height percentiles of girls in ages 16 to 18 were lower than the NCHS percentiles by five centimeters and it can be hypothesized that puberty has started earlier in Jiroft girls and that growth plate closure occurs earlier. This leads to a lower final height compared to American counterparts.

The data related to the BMI of children are only available in developed countries such as Northern America,[10,21] France,[13] England,[14] Sweden,[15] Italy,[16] and Germany.[22] The main criteria used for evaluating Iranian children and youth are from America or England. This is because the growth criteria for Iranian children has not been investigated yet. A few limited studies in some regions, such as the examination of height and weight in the children and youth of Shiraz,[23]

Jahrom,[11] Babol,[24,25] Kerman,[26] and Tehran[27] have been conducted, most of which showed non-negligible differences with foreign criteria and this was in accordance with the results of the present study. In a study in Shiraz, all growth curves for children were lower than relevant NCHS curves.[23] Examination of infants' growth curves in Jahrom also showed that height and weight values were generally lower than the NCHS criteria.[11] Growth percentiles gained from data analysis for the children of Isfahan during 1990-1992 were completely below NCHS and were parallel with growth patterns.[28] The results of the BMI curve analysis for 23730 boys and girls aged from 25 to 60 months in Northeastern Iran reflected some differences with the standard criteria.[29] These differences are not only reported in studies based on the Iranian population, but similar results have also been observed in some other populations. Examination of Indian children also showed lower BMI values compared to English age-mates.[30] A meta-analysis exploring alteration rates of height in children and youth aged 7-18 with proper health status among 53 African, European, and Asian population groups established that all of them supported linear growth. The average heights before puberty differed by three to five centimeters and height values of most non-European populations were lower than reference curves by five centimeters. This difference was more significant for northern European countries.[31]

Although standard curves such as NCHS are proper criteria of growth status in children and can be used for risk evaluation, they cannot be reliably applied for other populations such as the Iranian population. Due to the discrepancies with Iranian children's growth patterns, these criteria can even be misleading. Therefore, it seems that adjusting local and native curves in public health policies for children's care are of high priority.

Among the limitations of this study, the unavailability of data related to public health and diets can be mentioned. However, curves plotted according to sample size and health status of studied children are reliable strong suits.

Conclusion

To conclude, periodic measurements of height, weight, and BMI and the determination of regional percentiles for long-term alterations of these indices for the same community and comparing it with other communities are important and helpful. The comparison of our growth curves with NCHS showed some differences between the growth patterns of Iranian children and other communities. In Iran, several reports are in agreement with the findings of this study. Adjustments of native curves for measuring growth patterns in pediatric clinics can be much more efficient than using international criteria or curves gained from other populations.

Conflicts of Interest Disclosures

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Authors' Contribution

Conflict of Interests

Funding/Support

References

1. Chowdhury M, Malik M, Hoque M, Das D, Kabir MH, Chowdhury F. Comparison of Growth Pattern of School Children in Sylhet, Bangladesh Using the 2000 CDC Standards and 2007 WHO Standards. BIRDEM Medical Journal. 2019;9(1):35-43. doi:10.3329/birdem.v9i1.39722

2. Schneider EB. Children's growth in an adaptive framework: explaining the growth patterns of American slaves and other historical populations. The Economic History Review. 2017;70(1):3-29. doi:10.1111/ehr.12484

3. Kullman L, Martinsson T, Zimmerman M, Welander U. Computerized measurements of the lower third molar related to chronologic age in young adults. Acta odontologica Scandinavica. 1995;53(4):211-6. doi:10.3109/00016359509005974

4. Hsieh CW, Jong TL, Chou YH, Tiu CM. Computerized geometric features of carpal bone for bone age estimation. Chinese medical journal. 2007;120(9):767-70. doi:10.1097/00029330-200705010-00006

5. 5. Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF. NCHS growth curves for children birth-18 years. United States. Vital and health statistics Series 11, Data from the National Health Survey. 1977(165):i-iv, 1-74.

6. Štefan L, Baić M, Pekas D. Validity of Measured vs. Self-Reported Height, Weight and Body-Mass Index in Urban Croatian Adolescents. Int J Sport Stud Hlth. 2019;2(1):e89627. doi:10.5812/intjssh.89627

7. Mora S, Boechat MI, Pietka E, Huang HK, Gilsanz V. Skeletal age determinations in children of European and African descent: applicability of the Greulich and Pyle standards. Pediatric research. 2001;50(5):624-8. doi:10.1203/00006450-200111000-00015

8. Cole TJ. The development of growth references and growth charts. Annals of human biology. 2012;39(5):382-94. doi:10.3109/03014460.2012.694475

9. Ulukanligil M, Seyrek A. Demographic and socio-economic factors affecting the physical development, haemoglobin and parasitic infection status of schoolchildren in Sanliurfa province,

10. Turkey. Public health. 2004;118(2):151-8. doi:10.1016/j.puhe.2003.06.003

10. Hammer LD, Kraemer HC, Wilson DM, Ritter PL, Dornbusch SM. Standardized percentile curves of body-mass index for children and adolescents. American journal of diseases of children (1960). 1991;145(3):259-63. doi:10.1001/archpedi.1991.02160030027015

11. Heydari ST, Emamghoreishi F, Amini M. A comparative Study on Growth State of Children Less Than Two-Years Old in Jahrom, Southeastern Iran with NCHS Measurements. Quarterly of Horizon of Medical Sciences. 2005;11(3):42-8.

12. Hosseini SM, Afshari Safavi A, Esmaeilzadeh A, Beig Rezaei S. Comparison of Anthropometric Indices of the Children Aged 5-18 Years in Isfahan with Nchs Values. IRANIAN JOURNAL OF EPIDEMIOLOGY. 2017;13(2):119-27.

13. Rolland-Cachera MF, Cole TJ, Sempe M, Tichet J, Rossignol C, Charraud A. Body Mass Index variations: centiles from birth to 87 years. European journal of clinical nutrition. 1991;45(1):13-21.

14. Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. Archives of disease in childhood. 1995;73(1):25-9. doi:10.1136/adc.73.1.25

15. Lindgren G, Strandell A, Cole T, Healy M, Tanner J. Swedish population reference standards for height, weight and body mass index attained at 6 to 16 years (girls) or 19 years (boys). Acta paediatrica (Oslo, Norway: 1992). 1995;84(9):1019-28. doi:10.1111/j.1651-2227.1995.tb13819.x

16. Luciano A, Bressan F, Zoppi G. Body mass index reference curves for children aged 3-19 years from Verona, Italy. European journal of clinical nutrition. 1997;51(1):6-10. doi:10.1038/sj.ejcn.1600326

17. Hedayati Z, Golabinejad M, Shahidi S. Evaluation of Degree of Agreement between Cervical Vertebrae Maturation Indicators in lateral Cephalometry and Hand Wrist Radiographs. Journal of Dentistry. 2005;6(3,4):151-62.

18. Ball K, Mishra GD, Crawford D. Social factors and obesity: an investigation of the role of health behaviours. International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity. 2003;27(3):394-403. doi:10.1038/sj.ijo.0802237

19. Chinn S, Hughes JM, Rona RJ. Trends in growth and obesity in ethnic groups in Britain. Archives of disease in childhood. 1998;78(6):513-7. doi:10.1136/adc.78.6.513

20. Ahmadi A, AA V. A Survey of Height and Weight of Children and Adolescents in Kerman, Iran, in 1997. Journal of Kerman University of Medical Sciences. 1999;6(1):8-16.

21. Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht2) and triceps skinfold thickness. The American journal of clinical nutrition. 1991;53(4):839-46. doi:10.1093/ajcn/53.4.839

22. Schaefer F, Georgi M, Wuhl E, Scharer K. Body mass index and percentage fat mass in healthy German schoolchildren and adolescents. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 1998;22(5):461-9. oi:10.1038/sj.ijo.0800608

23. Ayatollahi SM, Ahmadi K. Infants' growth charts for southern Iran. Annals of human biology. 2001;28(3):337-45. doi:10.1080/030144601300119142

24. Hajian KO, Sajadi P, Rezvani A. Prevalence of Overweight and Underweight among Primary School Children Aged 7-12 Years (Babol; 2006) Journal of Babol University of Medical Sciences. 2008;10(3):83-91.

25. Khazaei S, Mohammadian-Hafshejani A, Nooraliey P, Keshvari-Delavar M, Ghafari M, Pourmoghaddas A, et al. The prevalence

of obesity among school-aged children and youth aged 6-18 years in Iran: A systematic review and meta-analysis study. ARYA Atheroscler. 2017;13(1):35-43.

26. Ahmadi A, Vahidi AA. A survey of height and weight of children and adolescents iI Kerman ,Iran, in 1997. Journal of Kerman University of Medical Sciences. 1997;5(1):8-16.

27. Razzaghi Azar M, Moghimi A, Montazer M, Mohammad Sadeghi H, Golnari P, Sedigh N, et al. Evaluation of Height, Weight and BMI(Body Mass Index) in Healthy 6-17-year-old Schoolgirls and 6-15-year-old Schoolboys, Tehran. Razi Journal of Medical Sciences. 2006;13(51):115-30.

28. Aminorroaya A, Amini M, Naghdi H, Zadeh AH. Growth charts of heights and weights of male children and adolescents of Isfahan, Iran. Journal of health, population, and nutrition. 2003;21(4):341-6.

29. Emdadi M, Safarian M, Doosti H. Standardized percentile curves of body mass index of northeast Iranian children aged 25 to 60 months. Iran J Pediatr. 2011;21(1):88-94.

30. Kelly AM, Shaw NJ, Thomas AM, Pynsent PB, Baker DJ. Growth of Pakistani children in relation to the 1990 growth standards. Archives of disease in childhood. 1997;77(5):401-5. doi:10.1136/adc.77.5.401

31. Haas JD, Campirano F. Interpopulation variation in height among children 7 to 18 years of age. Food and nutrition bulletin. 2006;27(4 Suppl Growth Standard):S212-23. doi:10.1177/15648265060274S505