fortune Journals

Research Article

JOURNAL OF RADIOLOGY AND CLINICAL IMAGING

ISSN: 2644-2809

Radius-Stage-Adjusted Height-for-Age and Weight-for-Age Percentile Charts for Chinese Children and Adolescents

Shao-yan Zhang[1*] and Miao Zhang[2]

Abstract

Background: Height-for-age and weight-for-age charts are commonly used in child health screening and paediatric clinical examinations. However, for children at different levels of maturity, the use of such charts may produce different degrees of bias. Therefore, height and weight percentile distributions were calculated for children of different chronological ages with the same bone maturity and were superimposed on height-for-age and weight-for-age charts. Radius-stage-adjusted height-for-age and weight-for-age charts were generated for children with "advanced" and "delayed" bone development.

Methods: A sample of 15598 healthy children (7733 boys, 7865 girls) aged 3-19 years was obtained from the "The Skeletal Development Standards of Hand and Wrist for Chinese Children-China 05" study. The radius stage (RS) was evaluated by the Rating System of the TW3 . The correlation coefficients between height and weight and the RS, as well as between chronological age and height and weight in the RS groups, were calculated. The Box–Cox power exponential distribution model in GAMLSS was used to calculate the radius-stage-adjusted (RSA) height-for-age and weight-for-age percentile curves. The RSA height-for-age and weight-for-age percentile curves were superimposed on the height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years.

Results: During the growth period, the height and weight of the children were significantly correlated with the developmental stage of the radius (RS). Within the RS groups, the chronological age of the children was significantly correlated with their height and weight, but the correlation coefficient decreased with increasing RS. Twenty-eight RSA height-for-age and weight-for-age growth charts were obtained by calculating the percentile curves of height and weight within the radius stage groups. The adjustments for height and weight were smaller for the RSA charts during childhood and larger for the RSA charts during adolescence.

Conclusion: RSA height-for-age and weight-for-age growth charts provide useful tools for adjusting the results of assessments indicating "advanced" and "delayed" bone development in children and adolescents.

Keywords: Child; Adolescent; Height; Weight; Radius Stage; Chart

Abbreviations

RS: Radius Stage

RSA: Radius Stage Adjusted

Affiliation:

[1]Hebei Research Institute of Sports Sciences, 372 Zhongshan East Road, Shijiazhuang, Hebei 050011, China

[2]Gold Bone Age Technology Co. LTD, 52 Yucai Road, Shijiazhuang, China.

Corresponding author:
Shao-yan Zhang, Hebei Research Institute of Sports Sciences, 372 Zhongshan East Road, Shijiazhuang, China.

Citation: Shao-yan Zhang, Miao Zhang. Radius-Stage-Adjusted Height-for-Age and Weight-for-Age Percentile Charts for Chinese Children and Adolescents. Journal of Radiology and Clinical Imaging. 7 (2024): 36-43

Received: August 16, 2024
Accepted: August 26, 2024
Published: September 10, 2024

Zhang SYand Zhang M., J Radiol Clin Imaging 2024 DOI:10.26502/jrci.2809095

Introduction

Growth charts are an important tool for child health screening and paediatric clinical examination. Traditionally, children have been grouped by chronological age, and the percentiles of the distribution of height and weight values have been calculated to develop growth charts, called height-for-age and weight-for-age charts. However, the application of such charts to individual children with different levels of maturity produces different degrees of bias. Therefore, in 1959, Bayley [1] developed the 50th percentile height-for-age and weight-for-age growth charts for children with advanced, appropriate and delayed development, respectively. Between 1965 and 1985, Tanner et al. [2,3,4] developed height-for-age and weight-for-age growth charts for children in the United Kingdom and North America, respectively, classified by advanced, moderate, and delayed development. Height and weight growth charts of children with advanced, appropriate, and delayed development are classified by the age of peak pubertal height

According to the analysis of the research data of the Brush Child Growth and Development Fund in the United States, Himes[5] reported that due to differences in body maturity (the average bone age of six parts of the body), the maturity-associated deviation in height for male and female children can reach 11 cm and 9 cm, respectively, and the maturity-associated deviation in weight can reach 12 kg and 10.5 kg, respectively. At the height velocity peak, the misclassification of height by maturity is 2.3 and 1.3 times more likely for boys than girls, respectively, at the age of 5 years, while the misclassification of weight is 4.9 and 3.1 times more likely. Recently, Gillison et al. [6] examined the effect of maturity adjustment on weight classification in a cross-sectional sample of 9 to 11-year-old children in the United Kingdom. After adjustment for maturity, 32% of overweight girls and 15% of overweight boys classified by chronological age were reclassified as normal- weight girls and boys, 11% and 8% of obese children were reclassified as overweight children, respectively, and overweight children with early maturity were 4.9 times more likely to be reclassified as normal- weight children than children who matured 'on-time'. Using data on the height and Tanner stages of secondary sexual characteristics of a cross-sectional sample of adolescents aged 8-18 years in the United States, Addo et al. [7] reported that the onset of puberty in children of different -races and ethnicities had a significant impact on the prevalence of shortness and tallness via chronological height-for-age z scores. The curves adjusted for puberty status avoid the misclassification of children with early and late puberty. Therefore, using population-based Tanner staging and anthropometric data for 13358 children aged 8 to 18 years from 3 large US national surveys: including the National Health Examination Surveys (NHES cycle III), the Hispanic Health and Nutrition Examination Surveys (HHANES) and the third National Health and Nutrition Examination Surveys (NHANES III), Miller et al. [8] developed the Tanner stage-age adjusted CDC height curves. In Sweden, Albertsson-Wikland et al. [9,10] proposed a new type of pubertal height and weight reference constructed from individual curves according to age at onset of pubertal growth fitted by the quadratic-exponential-puberty-stop (QEPS) model.

The indications of specific bone maturity in the hand and wrist are closely related to pubertal growth [11], especially the growth and development of the radius are throughout childhood and adolescence. Therefore, our aim was to develop radius- stage- adjusted (RAS) height-for-age and weight-for-age growth charts, to reduce the misclassification of children with advanced or delayed development based only on height or weight and age.

Subjects and Methods

Study population

The subjects were 15,598 healthy Han children aged 3-19 years (7733 males and 7865 females) from Shanghai, Guangzhou, Wenzhou, Dalian and Shijiazhuang included in the "The Standards of Skeletal Age in Hand and Wrist for Chinese-China 05" study [12] . Representative primary and secondary schools, kindergartens and maternal and child health stations were selected as sampling points in each urban area, and stratified cluster sampling was carried out according to age. Subjects with organic and endocrine diseases, abnormal physical development, or who participated in amateur art and amateur sports training were excluded. The boys and girls aged 3~5 years the boys aged 11~16 years and the girls aged 9~14 years were grouped by 0.5 years of age, and the rest were grouped by 1.0 years. The subjects were investigated and included based on their birth date (within 15 days before and after birth), and posterior and anterior X-ray images of the left hand and wrist were taken, at the same time, their height and weight were measured. Informed consent was obtained from the participants (parents/guardians for minors), information about the risk of radiation due to hand and wrist X-rays was provided) and all data collection was approved by the local ethics review board [12].

Methods

Evaluation of bone maturity

The radius, which has the longest growth period, was selected as the representative bone among the hand and wrist bones. The radius stage (RS) was assigned according to the definition of TW3 [13] stage E-I, and add stage J (fusion of the epiphysis and metaphysis is at least 50% completed) and stage K (fusion of the epiphysis and metaphysis is completed) were added. The age distribution range and number of subjects of each radius stage group are shown in Table 1.

Zhang SYand Zhang M., J Radiol Clin Imaging 2024 DOI:10.26502/jrci.2809095

Correlations among height, weight and radius stages

Pearson correlations among height, weight and radius stage during different age periods, and among height, weight and chronological age within each radius stage group were calculated to determine the influence of chronological age and radius developmental stage on height and weight.

The radius-stage-adjusted (RSA) percentile curves

The radius-stage- adjusted (RSA) height-for-age and weight-for-age percentile curves were calculated. Within each radius stage group, smoothed RSA height and weight percentile curves were calculated by sex and age. In R 3.6.0. software, the Box–-Cox power exponential distribution in generalized additive model for location, scale and shape (GAMLSS) [14] was used to calculate the function and to select the degrees of freedom of the explanatory variables. This allowed us to adjust the skewness and kurtosis of the distribution of height and weight data. The 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentile curves of height and weight within each radius stage group were smoothed by a cubic spline function. The goodness of fit is shown as the percentage of the number of participants under the fitted percentile curve.

To facilitate clinical application, MATLAB (R2017b) was used to superimpose the RSA height and weight percentile curves on the height-for-age and weight-for-age standardized growth charts for Chinese children and adolescents aged 0-18 years [15].

Results

Correlations of height, and weight with chronological age and radius stage

Table 2 shows that height and weight were significantly correlated with radius stage (RS) in both boys and girls during growth, and height was more strongly correlated with radius stage than weight. However, the correlation between height and radius stage also differed among the children in different growth stages. The correlation was greater in childhood (boys aged 3-<10 years and girls aged 3-<9 years) and early adolescence (boys aged 10-<13 years and girls aged 9-<12 years), while the correlation was still statistically significant in late adolescence (boys aged 13-16 years and girls aged 12-15 years); however, the correlation coefficient was lower.

Table 3 shows that within the radius stage groups, that is, children at the same bone maturity level, the correlation

Table 1: Number of subjects and age range for each radius stage (RS) group

Sex	Age range	Radius Stage						
		RS-E	**RS-F**	**RS-G**	**RS-H**	**RS-I**	**RS-J**	RS-K
male	n	582	1757	1493	1278	1190	664	769
	age range (years)	3~8	4.5~12	8~14.5	11~16	13~18	14.5~18	15.5~18
female	n	499	1454	1346	1306	1110	1190	960
	age range (years)	3~7	4~10.5	7~12.5	9.5~14	11~16	13~18	14~18

Table 2: Correlation coefficients of height, weight and radius stage (RS) among male and female children at different ages

		3~16 years		3~<10 years		10~<13 years		13~16 years	
Male		n	r	n	r	n	r	n	r
	Height and RS	6504	0.79**	2021	0.70**	1836	0.65**	2647	0.21**
	Weight and RS	6504	0.21**	2021	0.56**	1836	0.51**	2647	0.08**
Female		3~15 year		3~<9 year		9~<12 year		12~15 year	
		n	r	n	r	n	r	n	r
	Height and RS	6387	0.64**	1796	0.71**	2635	0.76**	1956	0.05*
	Weight and RS	6387	0.46**	1796	0.51**	2635	0.44**	1956	0.10**
*P<0.05, **P<0.01									

Table 3: Correlation coefficients of height, weight and chronological age within the radius stage (RS) groups

		RS-E	RS-F	RS-G	RS-H	RS-I	RS-J	RS-K
male	Height and age	0.75**	0.80**	0.22**	0.40**	0.20**	0.16**	0.03
	Weight and age	0.46**	0.30**	0.11**	0.40**	-0.08**	-0.05	-0.09*
female	Height and age	0.75**	0.83**	0.55**	0.41**	0.21**	0.14**	0.13**
	Weight and age	-0.49**	0.58**	0.24**	0	-0.05	-0.08*	-0.09*
*P<0.05, **P<0.01								

coefficient between height and chronological age was greater than that between height and weight for both male and female children. From the appearance of the articular surface of the carpus to the radius epiphysis covering the metaphysis (RS-E~RS-H), the correlation coefficients of height, weight and chronological age for male and female children were high, while the radius epiphysis and metaphysis ranged from the beginning of fusion to complete fusion. The correlation coefficients from the beginning of fusion to complete fusion between the radius and metaphysis (RS-I~RS-K) were low, and the individual correlation coefficients were very low and not statistically significant.

RSA height-for -age, and weight-for-age percentile curves

The BCPE model was used to calculate the height-for-age and weight-for-age percentile curves for boys and girls in each radius stage group and total of 28 RSA-height-for-age and weight-for-age growth charts (the charts for RSA EK percentile for both sexes) were obtained. For example the RSA-G height-for-age and RSA-G weight-for-age charts for females are shown in Fig. 1, Fig. 2, respectively, and the remaining charts are shown in Appendix Figures 1-28.

Classification by radius stage (RS) was used to observe the distribution of height and weight at different chronological ages under the same degree of development. The percentile curve of this distribution reflects the influence of growth and development degree on height and weight. Moving from the middle of each percentile curve to the left indicates early maturity (the age at which maturity is reached decreases), and moving from the middle of the curve to the right indicates delayed development (the age at which maturity is reached increases). Because of the added factor of maturity, this percentile curve was referred to as the radius-stage-adjusted (RSA) growth chart. The RSA growth chart is equivalent to the overall clockwise rotation of the height-for-age and weight-for-age percentile curves for Chinese children and adolescents aged 0-18 years within the radius stage groups. The greater the rotation angle was, the greater the impact of maturity was (Figs. 1 and 2).

Figure 3 and Figure 4 show the comparison of height-for-age and weight-for-age RSA-50th percentile curves with the 50th percentile curves of height and weight standards for children and adolescents aged 0-18 years in China. In general, at different growth stages there were have different degrees of the angle between the RSA height-for-age and weight-for-age 50th percentile curves and the Chinese children's growth standards height-for-age and weight-for-age 50th percentile curves, reflecting different degrees of influence of maturity. In childhood (RSA-4 and RSA-5 curves), the angle was small (fewer adjustments). However, in adolescence (RSA-6 and RSA-7 curves), the angle was larger (many adjustments). However, the RSA curve had different effects on height and weight in late adolescence. With respect to height, the influence of the RSA-8, RSA-9, and RSA-10 curves gradually decreased, and the final RSA-10 curve was almost parallel to the 50th percentile curve of height-for-age. However, in terms of weight, the RSA-9 and RSA-10 curves still had some influence in late adolescence.

Table 4 shows that for children with advanced and delayed development, the absolute value of height adjusted by the RSA chart reaches ~10. 8 cm for boys and ~9. 2 cm for girls, and the absolute value of weight adjusted by the chart reaches ~12. 9 kg for boys and ~11.3 kg for girls.

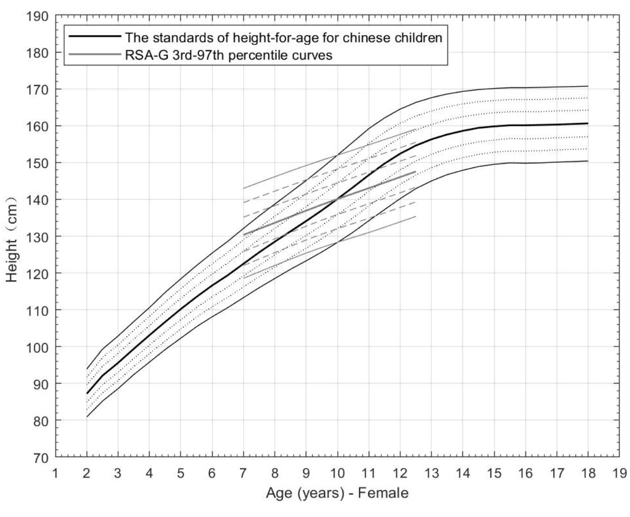

Figure 1: RSA-G height-for-age percentile curves for females. The curves are the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles (from bottom to top) of the height-for-age standards for Chinese children and adolescents aged 0-18 years; The grey curve is the RSA-G height-for-age percentile curve, which is the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentile curve from bottom to top.

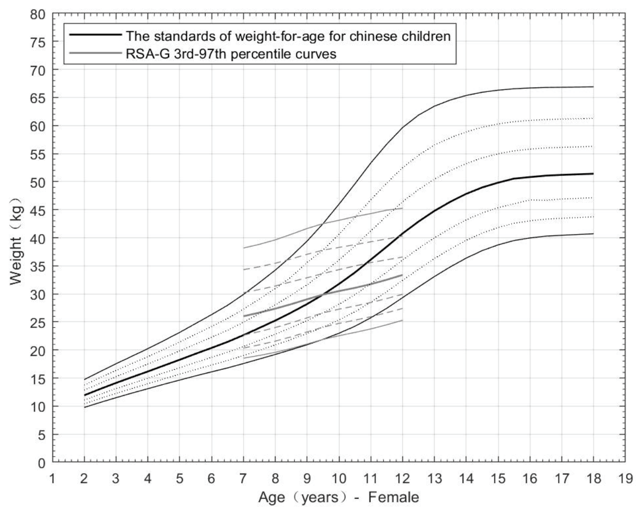

Figure 2: RSA-G weight-for-age percentile curves for females. The black curve is the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles (from bottom to top) of the weight-for-age standard for Chinese children and adolescents aged 0-18 years. The grey curve is the RSA-G weight-for-age percentile curve, which is the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentile curve from bottom to top.

fortune Journals

Zhang SYand Zhang M., J Radiol Clin Imaging 2024 DOI:10.26502/jrci.2809095

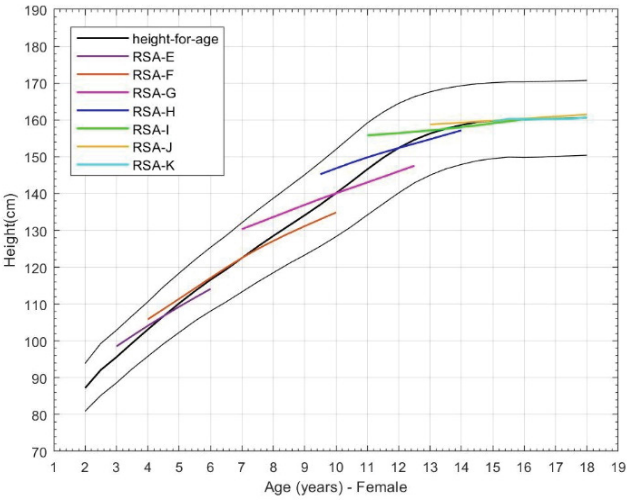

Figure 3: Comparison of the 50th percentile curve between RSA height-for-age E-K and the height standard for Chinese female children and adolescents aged 0-18 years -The black curve is the height-for-age standard for Chinese children and adolescents aged 0-18 years, which is the 3rd, 50th, and 97th percentile curve from bottom to top

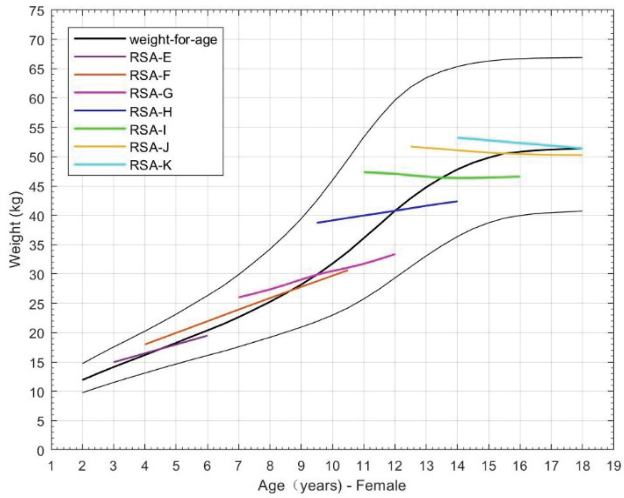

Figure 4: Comparison of the 50th percentile curve between RSA weight-for-age E-K and the weight standard for Chinese female children and adolescents aged 0-18 years -. The black curve is of the weight-for-age standard for Chinese children and adolescents aged 0-18 years, which is the 3rd, 50th, and 97th percentile curve from bottom to top.

	RSA-E	RSA-F	RSA-G	RSA-H	RSA-I	RSA-J	RSA-K
Male							
height（cm）	+3.5~－3.1	+3.7~－5.5	+5.7~－10.8	+10.7~－3.0	+7.8~－0.1	+2.7~0.0	0
weight（kg）	+1.2~－1.4	+1.8~－4.1	+5.1~－11.3	+12.9~－7.6	+12.0~－4.0	+5.9~－2.5	+3.7~0
Female							
height（cm）	+2.9~－2.5	+2.8~－4.0	+7.8~－7.0	+8.2~－1.4	+9.2~－0.9	+2.5~0.0	0
weight（kg）	+0.8~－0.9	+1.8~－3.2	+3.3~－7.4	+8.8~－5.4	+11.3~－4.2	+8.8~－1.1	+5.4~0

Appendix Table 1 shows the percentages of participants under the RSA height-for-age and weight-for-age percentile curves for both boys and girls. The greatest difference between the percentage of the sample and the percentile value under the percentile curves was less than 1%, the difference between the 15% percentile curves was between 1% and 1.5%, the difference between the 3% percentile curves was between 1.5 and 2%, and only one percentile curve had a difference >2%. Therefore, the fitted RSA height-for-age and weight-for-age percentile curves reflected the overall distribution of the actual data.

Application of RSA -height-for-age and weight-for-age charts

When using -height-for-age and weight-for-age RSA charts, X-ray images of children's left hands and wrists should be taken to determine the developmental stage (RS) of the radius byvia the China-05 method or TW3 method. The corresponding height-for-age or weight-for-age RSA charts should be selected according to the RS and child sex. The position of a child on the overlapping charts was determined based on their chronological age and height, and from the each distribution of the two charts, , the height-for-age (or weight-for-age) percentile and its RSA- percentile (adjusted for developmental stage) were derived. This adjustment is of particular clinical importance for the evaluation of height or weight in children with advanced or delayed development.

For example, (Appendix Figure 29), a girl in China who is 12 years old and 138 cm tall, which is lower than the 3rd percentile according to the height-for-age standard for children and adolescents aged 0-18 years, as determined to have delayed development according to the height-for-age RSA-G chart and is in the 13th percentile. Another girl is 8 years old and 139 cm tall, which is higher than the 97th percentile according to the height-for-age of standard for children and adolescents aged 0-18 years in China, is in the 79th percentile according to the height-for-age RSA-G chart.

Discussion

There are great differences in the degree of growth and development of children of the same chronological age, and this biological variation significantly affects the accuracy of growth charts based on chronological age. Therefore, it is important to consider developmental status when evaluating the growth and development of children. For this purpose, we developed -height-for-age and -weight-for-age RSA growth charts as an auxiliary and supplement to height and weight standardized growth curves of for Chinese children and adolescents aged 0-18 years.

We constructed height-for-age, and weight-for-age RSA percentile growth charts based on modified TW3 radius stages, which were superimposed on height and weight standardized charts for Chinese children and adolescents aged 0-18 years. These charts could be used to simultaneously compare the relationships among chronological age, biological maturity and height or weight. The correlations shown in the growth charts are consistent with the correlation coefficients between the radius stage and height or weight (Table 2), and the correlation coefficients between the chronological age and height or weight within the same radius stage group (Table 3). The stage of radius development was significantly correlated with height and weight during children's growth periods. In the RSA-E and RSA-F stages (childhood), the correlation coefficients between age and height or weight were relatively high, while the rotation angle between the percentile curves of the RSA chart and the corresponding percentile curves of height and weight standards for Chinese children was relatively small. In the RSA-G to RSA-J stages (adolescence), the correlation coefficients between age and height and weight were low, but the rotation angle between their percentile curves was large, indicating that the influence of chronological age was reduced, while the influence of biological maturity was increased.

The use of the radius to evaluate the developmental status of children has several advantages: 1) Bone maturity is more closely related to pubertal growth. Granados et al. [16] used data from a longitudinal growth study on a contemporary sample of US youth to examine the relationship between peak height velocity (PHV) and Tanner stage. They observed a substantial variability in the timing of the PHV across Tanner stages. Recently, using prospective longitudinal populations of healthy children from two North American populations, Sanders et al. [17] reported a uniform pattern of growth and skeletal maturation during adolescence. 2) This sampling is convenient, because when evaluating the growth and development of children, hand and wrist X-ray images are usually also taken, and the stage of radius development is evaluated when evaluating bone maturity. 3) The definition of the TW radius stage is clear and definite, and the evaluation reliability is high. 4) The height-for-age, and weight-for-age RSA charts have a wide range of use, because when using the radius, it is possible to evaluate not only adolescent but also childhood development. In contrast, the use of secondary sex characteristics has several disadvantages: 1) There are ethical issues related to children's privacy, and sampling is difficult. 2) According to the definition of secondary sex characteristics, it is difficult to distinguish between different stages. 3) Visual evaluation of the breast development stage in girls may be biased, especially in obese girls. 4) Only height-for-age and weight-for-age growth charts can be adjusted during adolescence.

There are considerable differences in the onset time of puberty among children. Due to the growth spurt during puberty, "advanced" and "delayed" pubescent children have significantly different growth patterns, which require adjustment regarding development. Our RSA-G chart is similar to the Tanner stage 2 of secondary sexual characteristics reported by Miller et al.[8]. However, in the longer childhood period, although the growth is relatively slow, the growth patterns of children with different development levels increasingly differ with increasing age, so it is also necessary to adjust the height-for-age and weight-for-age percentile curves. Therefore, we selected the radius, which has with the longest growth and development period in the hand and wrist (excluding the RS-B to RS-D stages in infancy). However, the long duration of the RS-F stage (4 to 10 years of age for females and 5 to 12 years of age for males) may have led to the loss of some adjustment information. Therefore, appropriate staging of radius development in childhood, to determine the duration of the developmental stage, not only for RSA growth charts, but also for the evaluation of the bone maturity in the hand and wrist, is of important.

The height and weight standardized charts for Chinese children and adolescents [14] and the “Standards of Skeletal Age in Hand and Wrist for Chinese-China 05” study [12] are two studies, based on different, samples. Therefore, the overlapping of RSA growth charts with height-for-age and weight-for-age standards for Chinese children and adolescents may be the main limitation of this study. However, these two cross-sectional studies were both completed just before and after 2005, the large sample included children from the upper and middle socioeconomic classes in China, and the height and weight percentile distributions calculated by the same statistical model were basically the same [18]. Therefore, the RSA growth chart was superimposed on the height-for-age or weight-for-age standards for Chinese children should be reliable.

Conclusion

Using a sample of children from “The Standards of Skeletal Age in Hand and Wrist for Chinese-China 05” study, we developed 28 height-for-age and weight-for-age RSA growth charts, which were superimposed on the height-for-age and weight-for-age standardized growth charts for Chinese children and adolescents. These charts provides a useful tool for adjusting the evaluation results of height-for-age and weight-for-age standards for children and adolescents with "advanced" and "delayed" development.

Declarations

Ethical approval and consent to participate:

The study was performed in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Hebei Research Institute of Sports Sciences (No. 2022005). Informed consent was obtained from the parents and the guardians of the children who participated in the study because the children in the study were less than/ or equal to 16 years of age. Informed consent was obtained from participants older than 16 years.

Consent for publication:

Not applicable.

Availability of Data and Materials

All data generated or analysed during this study are included in this published article.

Competing interests:

The authors declare that they have no competing interests.

Funding: Not applicable

Authors' contributions:

Shao-yan Zhang: developed the research concept and design, contributed to writing the manuscript, and data interpretation and made critical revisions for intellectual content.

Miao Zhang: developed the research concept and design, performed the statistical analyses, wrote the manuscript performed the skeletal maturity ratings of hand radiographs using the TW3 method, and made substantial contributions to the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Acknowledgements

The authors would like to thank Professor Hui Li of the Capital Institute of Pediatrics, Beijing, China, for her support of our research.

References

1. Bayley N. Growth curves of height and weight by age for boys and girls, scaled according to physical maturity. J. Pediat. 48 (1956): 187-194.
2. Tanner JM, Whitehouse RH, Takaishi M. Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children, 1965 Parts I and II. Arch Dis Child 41 (1966): 613–635.
3. Tanner JM, Whitehouse RH. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and the stages of puberty. Arch Dis Child 51 (1976):170-179.
4. Tanner JM, Davies PSW. Clinical longitudinal standards for height and height velocity for North American children. Journal of Pediatrics 200 (1985): 317–329.
5. Himes JH. Maturation-related deviations and misclassification of stature and weight in adolescence. Am J Hum Biol 11 (1999):499-504.
6. Gillison F, Cumming S, Standage M, et al., Assessing the impact of adjusting for maturity in weight status classification in a cross-sectional sample of UK children. BMJ Open 7 (2017): e015769.
7. Addo OY, Sarafoglou K, Miller BS. Effect of Adjusting for Tanner Stage Age on Prevalence of Short and Tall Stature of Youths in the United States. J Pediatr 201 (2018): 93-99.
8. Miller BS, Sarafoglou K, Addo OY. Development of Tanner Stage-Age Adjusted CDC Height Curves for Research and Clinical Applications. J Endocr Soc 2020 Jul 17;4(9): bvaa098.
9. Albertsson-Wikland KG, Niklasson A, Holmgren A, Gelander L, Nierop AFM. A new type of pubertal height reference based on growth aligned for onset of pubertal growth. J Pediatr Endocrinol Metab 33 (2020):1173-1182.
10. Albertsson-WK, Niklasson A, Gelander L, et al., Novel type of references for weight aligned for onset of puberty - using the QEPS growth model. BMC Pediatr 21 (2021): 507.
11. Zhang Shao-yan, LIU Gang, Liu Li-juan, et al. The relationship of certain skeletal maturity indicators of hand and wrist with adolescent growth spurt. Natl Med J China 88 (2008): 2198-2200.
12. Zhang Shao-yan, Liu Li-juan, Wu Zhen-lie, et al. The Skeletal Development Standards of Hand and Wrist for Chinese Children-China 05 I.TW3-C RUS-TW3-C Carpal, and RUS-CHN Methods. Chin J Sports Med 25 (2006): 6-13.
13. Tanner JM, Healy MJR, Goldstein H, Cameron N. Assessment of skeletal maturity and prediction of adult height (TW3 method) Third Edition. London, W.B.SAUNDER (2001).
14. Rigby RA Stasinopoulos DM Smooth centile curves for skew and kurtotic data modeled using the Box-Cox power exponential distribution. Statist Med 23 (2004): 3053-3076.
15. Li Hui, Ji Cheng-ye, Zong Xin-nan, et al. Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years. Chin J Pediatr 47 (2009):487-492

16. Granados A, Gebremariam A, Lee JM. Relationship Between Timing of Peak Height Velocity and Pubertal Staging in Boys and Girls. J Clin Res Pediatr Endocrinol 7 (2015): 235-237.

17. Sanders JO, Qiu X, Lu X, Duren DL, Liu RW, Dang D, Menendez ME, Hans SD, Weber DR, Cooperman DR. The Uniform Pattern of Growth and Skeletal Maturation during the Human Adolescent Growth Spurt. Sci Rep 7 (2017):16705.

18. ZHANG Shao-yan, HAN Yi-san, SHEN Xun-zhang, et al. The Growth Charts of Height, Weight and Body Mass Index for Han Chinese Children and adolescent from Large and Middling Cities of China. CJCHC 16 (2008): 257-259.