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Original Article

Using the National Indonesian Growth Chart to assess short stature and obesity in urban schoolchildren in Surakarta, Indonesia: comparisons to the WHO 2007 and CDC 2000 Growth Charts

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Abstract

Background The National Indonesian Growth Chart (NIGC) is a new growth chart based on Indonesian population data. To date, the CDC 2000 or WHO 2007 charts have been widely used in Indonesia to assess the growth of 5 to 18-year-old children. Use of these reference charts may lead to inaccurate conclusions about children's nutritional status, particularly when diagnosing short stature or obesity.

Objective To compare assessments of short stature and obesity in Indonesian urban schoolchildren and adolescents based on CDC, WHO, and NIGC reference charts.

Methods Pooled anthropometric data [height, weight, and body mass index (BMI)] were collected cross-sectionally from healthy schoolchildren aged 6 to 18 years in Surakarta in 2013, 2016, 2018, and 2019. We created scatterplots for height, weight, and BMI and analyzed differences in height-for-age (HAZ) and BMI (BAZ) z-scores according to the CDC, WHO, and NIGC growth charts, then calculated differences in proportions of children identified as having short stature or obesity.

Results We included 2,582 subjects; 63% were girls. Subjects' mean age was 13.1 (SD 3.4) years. Mean differences in HAZ between the NIGC vs. CDC chart and NIGC vs. WHO chart were 1.44 (SD 0.01) and 1.39 (SD 0.00), respectively. Mean differences in BAZ between the NIGC vs. CDC chart and NIGC vs. WHO chart were 0.18 (SD 0.01) and 0.06 (SD 0.01), respectively. The prevalence of short stature was 9.91%, 11.62%, and 0.39% according to the WHO, CDC, and NIGC charts, respectively. The prevalence of obesity was 10.15%, 5.07%, and 11.77% according to the WHO, CDC, and NIGC charts, respectively. The prevalence of obesity according to the WHO, CDC, and NIGC was 7.44%, 2.95%, and 10.08%, respectively in girls and 14.76%, 8.69%, and 14.66%, respectively in boys.

Conclusion The use of the NIGC resulted in a lower prevalence of short stature compared to the CDC or WHO charts. Compared to the WHO charts, the NIGC gave a similar prevalence of obesity overall and in boys, but a higher prevalence of obesity in girls. Compared to the CDC charts, the NIGC gave a higher prevalence of obesity both in boys and girls. **[Paediatr Indones. 2022;62:180-5 DOI: 10.14238/pi62.3.2022.180-5]**.

Keywords: *short stature; obesity; urban; growth chart*

Anthropometric measurements are an essential component of pediatric growth and nutritional assessments.[1] A growth chart is one such tool for assessing children's nutritional status and growth.[2] Abnormal growth patterns may suggest the need for further investigation to detect underlying conditions. In Indonesia, many medical practitioners use the *WHO 2006 Child Growth Standards* to assess children under five and the *CDC 2000* reference chart to assess children aged 5 to 18 years.[3] In 2007, the WHO published a growth reference chart for children and adolescents aged 5 to 19 years.[4] In 2019, the *National Indonesian Growth Chart* (NIGC) for children was developed based on the *2013 Indonesian Basic Health Research*.[5] National growth reference charts for each country are considered to be more appropriate than worldwide averages, as national charts reflect unique conditions in a country's population.[6] There are concerns that use of international charts in Indonesia, such as the CDC and WHO charts, could lead to incorrect growth assessments, particularly when assessing short stature or obesity. Hence, we aimed

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to compare the prevalence of short stature and obesity in urban schoolchildren from Surakarta, Indonesia, as assessed by the CDC, WHO, and NIGC reference charts.

Methods

This study used pooled data for anthropometric measurements (height, weight, and BMI) collected from 2,582 healthy schoolchildren in Surakarta, comprising 1,627 (63.01%) girls and 955 (36.99%) boys. Data were collected cross-sectionally in 2013, 2016, 2018, and 2019 with different subjects in each survey. There was an overlap between surveys in the age of subjects included. Physically healthy children aged 6 to 18 years were included; written informed consent was obtained from the parents of all participants. Children with a history of chronic disease, physical trauma (determined via interview), or physical disability (determined by physical examination) were excluded. Anthropometric measurements were done using a method described in our previous study.7 Short stature was defined as a height-for-age *z*-score (HAZ) of less than -2 standard deviations (SD). Overweight and obesity were defined as a BMI *z*-score (BAZ) over 1 and 2 SD, respectively. Underweight was defined as a BAZ of -2 SD.

This study used three growth curve reference charts: the *WHO Growth Chart* for children aged 5-19 years,[4] the *CDC 2000 Growth Chart*,[8] and the NIGC.[5] In 2007, the *WHO* developed a new reference chart by reconstructing the *National Center for Health Statistics (NCHS)/WHO* growth reference data from 1977, supplemented with data from the *2006 WHO Child Growth Standards Study*.[9] The *CDC 2000 Growth Charts* are revised versions of the growth charts developed by the *NCHS* for the US population in 1977, with the addition of BMI-for-age charts.[10] The NIGC for children was developed in 2019 based on the *Indonesia Basic Health Research of 2013*. To develop this chart, samples were taken from all Indonesian provinces, thus, the chart is considered to be representative of Indonesian children.[5]

The scatterplots for participants' height, weight, and BMI were created, and a LOWESS command in the *Stata software* was used to determine the means for height, weight, and BMI. The differences in height-for-age, weight-for-age, and BMI *z*-scores according to the three growth charts were analyzed using one-way ANOVA. We also performed comparisons between the *NIGC vs. WHO* and *NIGC vs. CDC Growth Charts* using the paired T-test. The proportions of individuals with short stature and with obesity according to the NIGC, WHO, and CDC charts were calculated and compared using the chi-square test. Statistical analyses were conducted using *Stata/MP 14.0 software*. The *z*-scores were calculated using the *ZANTHRO* command in *Stata/MP 14.0*.

Results

Of the 2,582 subjects, 1,627 were girls with a mean age of 13.4 (SD 3.2) years and 955 were boys with a mean age of 12.6 (SD 3.6) years (**Table 1**). **Figure 1** shows scatterplots for height (1A), weight (1B), and BMI (1C). Mean height at 18 years of age (18-<19 years of age) was 166.1 (SD 4.7) cm for boys and 156.3 (SD 11.9) cm for girls; mean height difference between boys and girls was 9.8 cm (**Table 2**). Girls reached their final adult height earlier than boys. Mean weight at 18 to <19 years of age was 55.7 (SD 11.5) kg in boys and 49.5 (SD 7.9) kg in girls. Mean BMI at 18 to <19 years of age was 20.2 (SD 4.4) kg/m^2 in boys and 20.6 (SD 4.5) kg/m^2 in girls (**Table 2**). During puberty, according to the NIGC, height-for-age increased by +1.5 HAZ in boys and +1 HAZ in girls, followed by a decline (**Figure 2A**). The BAZ of children and adolescents were similar across all three growth charts, ranging from -0.5 to +0.5 SD (**Figure 2B**).

The HAZ and BAZ for all subjects and proportions of subjects with short stature and obesity are shown in **Table 3**. Mean differences in HAZ between the *NIGC vs. CDC* and *NIGC vs. WHO Grow Charts* were 1.44 (SD 0.01) and 1.39 (SD 0.00), respectively (P<0.05).

Table 1. Subjects' characteristics

Characteristics	Total (n=2,582)	Girls (n=1,627)	Boys (n=955)
Year of data source			
2013	394	228	166
2016	698	571	126
2018	972	516	456
2019	518	311	207
Age, years			
Mean (SD)	13.1 (3.4)	13.4 (3.2)	12.6 (3.6)
Range	6.0-18.5	6.0-18.5	6.0-18.3

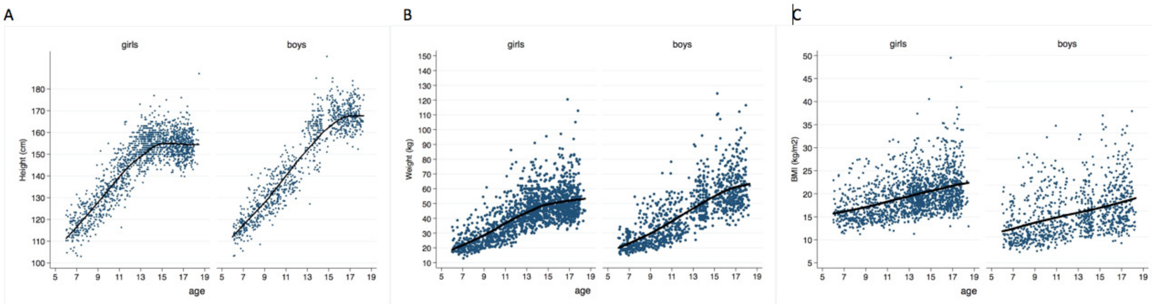

Figure 1. Scatterplots for height (A), weight (B), and BMI (C)

Table 2. Mean height, weight, and BMI for boys and girls by age

Age (years)	Boys				Girls			
	n	Height, cm	Weight, kg	BMI, kg/m^2	n	Height, cm	Weight, kg	BMI, kg/m^2
6	63	115.4	22.5	16.8	55	116.0	21.9	16.2
7	64	120.1	23.7	16.3	73	119.3	23.8	16.5
8	69	124.7	27.8	17.6	72	123.4	24.9	16.2
9	85	130.6	31.4	18.2	98	130.3	30.4	17.7
10	86	135.6	35.5	19.0	90	136.8	32.8	17.3
11	67	139.7	37.3	18.9	118	142.7	39.0	18.9
12	26	148.3	40.7	18.3	117	150.8	44.3	19.3
13	91	159.0	51.3	20.1	238	154.7	48.0	20.0
14	74	163.4	52.7	19.7	180	156.1	49.3	20.2
15	89	168.5	60.7	21.3	147	155.6	49.8	20.6
16	108	166.6	57.9	20.9	220	154.6	51.4	21.5
17	120	168.3	63.8	22.5	209	154.4	52.7	22.1
18	13	166.1	55.7	20.2	10	156.3	49.5	20.6

The NIGC BAZ scores differed from the CDC and WHO charts by 0.18 (SD 0.01) and 0.06 (SD 0.01), respectively ($P<0.05$). The overall prevalence of short stature was 9.91%, 11.62%, and 0.39% according to the WHO, CDC, and NIGC charts, respectively ($P<0.05$). Short stature was found in 7.54% of boys and 11.31% of girls according to the *WHO*, 8.80% of boys and 13.28% of girls according to the *CDC*, and 0.31% of boys and 0.43% of girls according to the *NIGC* ($P<0.05$).

The overall prevalence of obesity was 10.15%, 5.07%, and 11.77% according to the *WHO*, *CDC*, and *NIGC*, respectively. The difference in obesity prevalence differed significantly between the *CDC* and *NIGC* charts ($P<0.05$), and but not between the *WHO* and the *NIGC* charts ($P>0.05$). The prevalence of obesity according to the *NIGC vs. WHO* charts differed significantly in girls, but not in boys, while the *NIGC vs. CDC* charts did not give significantly different prevalence rates of obesity (**Table 3**).

Discussion

The choice of growth reference chart can influence anthropometric measures and the assessment of short stature. Our study showed that subjects aged 6-18 years in an urban area had significantly different HAZ scores depending on which chart was used; *NIGC* assessments differed by more than 1 SD from both *WHO* and *CDC* chart assessments. BAZ also differed depending on which chart was used, but this difference was less than 1 SD. Our findings suggest that these charts differ more in body height measurements than in BMI measurements. As a result, using the *WHO* or *CDC* growth charts to assess height leads to different conclusions than using the *NIGC*.

The determination of short stature differed significantly depending on which growth chart was used. The use of the *WHO* and *CDC* charts could lead to a higher prevalence of short stature in Indonesia than

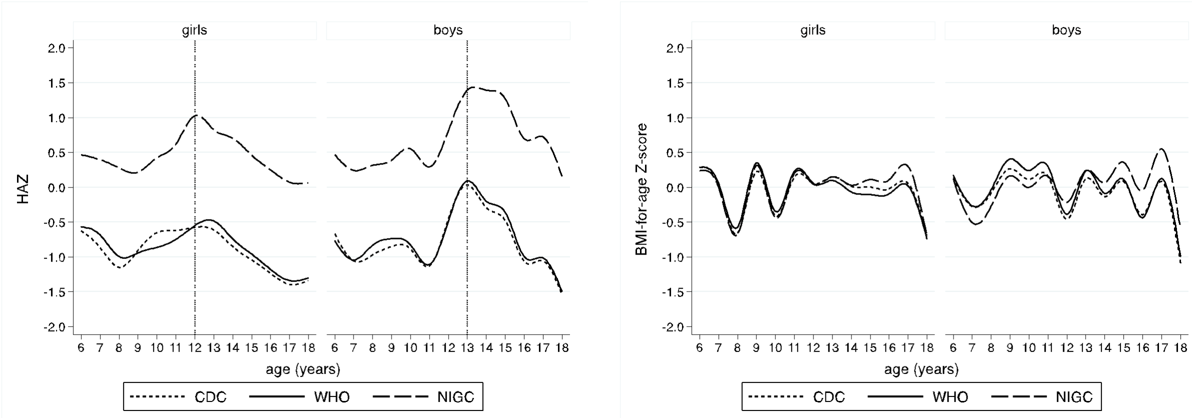

Figure 2. Comparison graphs of HAZ (A) and BAZ (B) across age using CDC, WHO, and NIGC

the use of the *NIGC*. In our assessment, 9.52% more participants had short stature based on the *WHO* chart than the *NIGC* chart, while the *CDC Growth Chart* had 11.23% more subjects with short stature than the *NIGC* chart.

Previous studies have compared national or local growth reference charts to *WHO Growth Standards*. A study in Bandung, Indonesia, found that more than 50% of children under five years old were considered to have stunted growth based on the *WHO* charts. However, using the NIGC, only 13.3% were stunted.[11] Similarly, the prevalence of stunting in children under five years in the Musi sub-district, Indonesia, was higher based on the *WHO* chart (53.9%) than based on the national reference (10.7%).[12] A study in Malaysia, another Southeast Asian country, found that 6.1% more children under six years were assessed with short stature when using the *WHO* charts than when using a national/local chart.[13] A Thai study revealed discrepancies in the prevalence of short stature or stunted growth in girls (but not in boys) at 24 months, depending on which growth chart was used.[6] All these studies revealed differences in the diagnosis of short stature based on whether an international or local growth chart was used for assessment. In contrast, however, Yang *et al.*[14] found a significantly higher prevalence of stunted growth when using a Chinese growth reference chart rather than the *WHO* chart (17.2% *vs.* 16.1%, respectively).

In our study of 6 to 18-year-old subjects, the *NIGC* resulted in a prevalence of short stature of less than 1% in our subjects, compared to 9% and 11% based on the *WHO* and *CDC* charts, respectively. However, this low prevalence of short stature might have been impacted by factors unique to an urban area. Children who live in urban areas are often from wealthier families and have better health than children in rural areas, making them likely to be taller. Furthermore, the prevalence of short stature in girls differed significantly from that in boys when assessed according to the *WHO* or *CDC* charts. According to these charts, less than 10% of boys were assessed as short, compared to more than 10% of girls. However, according to the *NIGC*, the prevalence of short stature among boys and girls was comparable (0.31% and 0.43%, respectively). It is unclear why girls were more likely than boys to be assessed as short according to the *WHO* and *CDC* charts. The population of girls studied to construct the *WHO* and *CDC* charts were taller than those studied to develop the *NIGC*.

Our findings indicate that clinicians in Indonesia should be cautious in diagnosing short stature based on the *WHO* and *CDC* growth charts. It is essential to differentiate pathological causes from normal variations, such as familial short stature. The differences in height assessments based on the *NIGC* compared to the *WHO* or *CDC* charts may stem from differences in the average height of the overall population used to create the growth charts. The *NIGC* offers several advantages for Indonesian children, as using it can reduce bias based on genetic or familial factors, sociodemographic variables, and secular trends. Since the *NIGC* was created using samples from all Indonesian provinces, it is considered representative of Indonesian children.[5]

Our study revealed that, during puberty, linear growth increased rapidly to more than +1SD HAZ; at the end of puberty, it declined to the previous HAZ. This suggests that the onset of puberty occurred earlier

Table 3. Mean HAZ and BAZ and percentages of subjects, short stature, and obesity using CDC, WHO, and NIGC

Variables	Overall			Girls			Boys		
	CDC	WHO	NIGC	CDC	WHO	NIGC	CDC	WHO	NIGC
Mean HAZ (SD)	-0.85 (0.97)	-0.80 (0.97)	0.59 (0.98)[a]	-0.91 (0.98)	-0.86 (0.97)	0.51 (0.96)[a]	-0.75 (0.95)	-0.69 (0.97)	0.74 (1.00)[a]
Mean HAZ difference from NIGC (SD)	1.44 (0.01)**	1.39 (0.00)**	- (ref)	1.41 (0.01)**	1.36 (0.01)**	- (ref)	1.50 (0.01)**	1.44 (0.01)**	- (ref)
Mean BAZ (SD)	-0.06 (1.29)	0.06 (1.43)	0.11 (1.51)[a]	-0.06 (1.19)	0.01 (1.31)	0.08 (1.47)[a]	-0.06 (1.44)	0.14 (1.61)	0.17 (1.57)[a]
Mean BAZ difference from NIGC (SD)	0.18 (0.01)**	0.06 (0.01)**	- (ref)	0.16 (0.01)**	0.08 (0.01)**	- (ref)	0.23 (0.01)**	0.03 (0.01)**	- (ref)
Short stature (HAZ <-2), %	11.62**	9.91**	0.39 (ref)	13.28**,[b]	11.31**,[b]	0.43 (ref)c	8.80**,[b]	7.54**,[b]	0.31 (ref)[c]
Obese (BMI-Z >2), %	5.07**	10.15*	11.77 (ref)	2.95**,[b]	7.44**,[b]	10.08 (ref)[b]	8.69**,[b]	14.76*,[b]	14.66 (ref)[b]
Overweight (BMI >1-≤2), %	17.23*	15.14*	15.96 (ref)	16.90*,[c]	15.30*,[c]	16.04 (ref)[c]	17.80*,[c]	14.87*,[c]	15.81 (ref)[c]
Underweight (BMI <-2), %	7.24*	6.62*	7.09 (ref)	5.78*,[b]	7.44*,[c]	6.76 (ref)c	9.74**,[b]	8.59*,[c]	7.64 (ref)[c]

HAZ=height-for-age z-score; BAZ=BMI-for-age z-score; normal HAZ (-2 SD<HAZ<2 SD); normal BAZ (-2 SD<HAZ<2SD); ref = reference, *P>0.05; **P<0.05; [a]=one-way ANOVA, all results were significant (P<0.05); [b]=Chi-square test between girls and boys (P<0.05); [c]=Chi-square test between girls and boys (P>0.05)

in our subjects than in the population used to create the *NIGC*. The tempo of puberty and pubertal timing impacts the timing of physical maturation in both boys and girls, but this timing does not always affect an individual's final adult height. Children who were taller than average at a given age often matured earlier than their peers, but there were usually no significant differences in their adult heights.[15]

Assessments of BMI were rather similar using all three charts. A similar overall proportion of subjects was assessed as obese using the *NIGC* or *WHO* chart, while more were assessed as obese using the *NIGC* than the *CDC* chart or the *WHO* (P<0.05). Compared to the *WHO* chart, using the *NIGC* resulted significantly in a higher proportion of obese girls (an increase of 2.6%) and a similar proportion of obese boys. More detailed data are needed to explain this discrepancy and to establish that using the NIGC will not result in an inappropriately increased assessment of obesity rates. This finding differs from a previous study that found lower BMIs when using the NIGC.[4] However, the use of urban subjects in our study may explain this difference, because individuals in urban areas are more likely to be obese than those in rural areas.[16] Therefore, assessments of obesity, especially in girls, should also be considered in light of the growth chart used.

This study had some limitations. All subjects were urban children. We used cross-sectional data collected in different years and did not follow the growth of subjects longitudinally. We conducted surveys in different time points with overlap of subjects' ages. The distribution of subjects' nutritional status may be different for the different time points. Further research is needed to determine the cause of short stature as assessed using the three charts, whether these differences indicate normal variants or pathology. More data on secular trends and parental height are also needed to determine the impact of genetics on height.

In conclusion, use of the *NIGC* rather than the *CDC* or the *WHO* chart to assess the growth of Indonesian children results in a lower prevalence of short stature. The use of the *NIGC* rather than the *WHO* chart results in a similar prevalence of obesity in all subjects and in boys, despite a higher prevalence of obesity in girls. The use of the *NIGC* compared to the *CDC* results in higher prevalence of obesity in all subjects, boys and girls. Clinicians must be cautious when using the *CDC* or *WHO* growth charts to diagnose short stature or obesity in Indonesian children.

Conflict of interest

None declared.

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