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

Annang Giri Moelyo, Dewinda Candrarukmi, Ulfa Puspita Rachmat

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. 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, the CDC 2000 Growth Chart, and the NIGC. 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. 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. 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.

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/m² in boys and 20.6 (SD 4.5) kg/m² 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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n=2,582)</th>
<th>Girls (n=1,627)</th>
<th>Boys (n=955)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of data source</td>
<td>2013</td>
<td>394</td>
<td>228</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>698</td>
<td>516</td>
</tr>
<tr>
<td></td>
<td>2018</td>
<td>972</td>
<td>516</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>518</td>
<td>311</td>
</tr>
<tr>
<td>Age, years</td>
<td>Mean (SD)</td>
<td>13.1 (3.4)</td>
<td>13.4 (3.2)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>6.0-18.5</td>
<td>6.0-18.5</td>
</tr>
</tbody>
</table>
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

In assessing short stature and obesity, 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. 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%). 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. 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. 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. 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.

In our study of 6 to 18-year-old subjects, 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

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall</th>
<th>Girls</th>
<th>Boys</th>
</tr>
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<tbody>
<tr>
<td>Mean HAZ (SD)</td>
<td>-0.85 (0.97)</td>
<td>0.59 (0.98)*</td>
<td>-0.86 (0.97)</td>
</tr>
<tr>
<td>Mean HAZ difference from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIGC (SD)</td>
<td>1.44 (0.01)**</td>
<td>- (ref)</td>
<td>1.36 (0.01)**</td>
</tr>
<tr>
<td>Mean BAZ (SD)</td>
<td>-0.06 (1.29)</td>
<td>0.11 (1.51)*</td>
<td>-0.06 (1.19)</td>
</tr>
<tr>
<td>Mean BAZ difference from</td>
<td>0.18 (0.01)**</td>
<td>- (ref)</td>
<td>0.08 (0.01)**</td>
</tr>
<tr>
<td>NIGC (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short stature (HAZ &lt;-2), %</td>
<td>11.62**</td>
<td>9.91**</td>
<td>0.39 (ref)</td>
</tr>
<tr>
<td>Obese (BMI-Z &gt;2), %</td>
<td>5.07**</td>
<td>10.15*</td>
<td>11.77 (ref)</td>
</tr>
<tr>
<td>Overweight (BMI 1-≤2), %</td>
<td>9.27*</td>
<td>15.14*</td>
<td>16.90 (ref)</td>
</tr>
<tr>
<td>Underweight (BMI &lt;2), %</td>
<td>7.24*</td>
<td>6.62*</td>
<td>7.09 (ref)</td>
</tr>
</tbody>
</table>

HAZ=height-for-age z-score; BAZ=body mass index z-score; normal HAZ (SD=HAZ<2 SD); normal BAZ (SD=HAZ<2SD); ref=reference. *P<0.05; **P<0.01; *one-way ANOVA, all results were significant (P<0.05); *Chi-square test between girls and boys (P<0.05)

In conclusion, use of the CDC chart results in a similar prevalence of obesity compared to the WHO chart in all subjects, boys and girls. Clinicians must be cautious when using the CDC or WHO growth charts to avoid misclassifying subjects. The CDC charts may be more suitable for assessing growth in boys, while the WHO charts may be more appropriate for girls. The NIGC charts may be used as a reference, but clinicians should use other data to determine the cause of short stature and obesity.

In our subjects, the prevalence of obesity was higher in urban areas compared to rural areas. This finding is consistent with previous studies that have reported an increase in obesity rates in urban areas. However, we did not find a significant difference in the prevalence of obesity between boys and girls in our study, which is consistent with other studies. Therefore, the use of BMI to assess obesity in Indonesian children results in a lower prevalence of obesity compared to other charts.

More data on secular trends and parental height are also needed to determine the impact of genetics on height. More detailed data are needed to explain these discrepancies and to establish that using the NIGC chart results in a similar prevalence of obesity compared to the WHO chart or the NIGC chart. More detailed data are needed to explain this discrepancy and to establish that using the NIGC chart results in a similar prevalence of obesity compared to the WHO chart or the NIGC chart.
to diagnose short stature or obesity in Indonesian children.

Conflict of interest

None declared.

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References