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## ORIGINAL ARTICLE

# Body mass index reference curves for the population with Down syndrome between 2 and 18 years of age<sup>☆,☆☆</sup>

Q1 Fabio Bertapelli<sup>a,\*</sup>, Maira R. Machado<sup>a</sup>, Raísa do Val Roso<sup>a</sup>, Gil Guerra-Júnior<sup>b</sup>

<sup>a</sup> Faculdade de Ciências Médicas, Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil

<sup>b</sup> Department of Pediatrics, Faculdade de Ciências Médicas, Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil

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### KEYWORDS

Trisomy 21;  
Body mass index;  
Weight;  
Height;  
Growth charts;  
Nutritional status

### Abstract

**Objective:** To develop specific charts for body mass index (BMI-for-age) for Brazilian individuals with Down syndrome (DS). The secondary objective was to compare the BMI-for-age values with the standards set forth by the Centers for Disease Control and Prevention (CDC).

**Methods:** A retrospective and cross-sectional growth study of 706 youth with DS (56.7% males) was performed in 51 centers in São Paulo state, Brazil. Data on weight and height were used to calculate the BMI (kg/m<sup>2</sup>). The LMS method was applied to construct the growth charts. Z-scores were based on the CDC 2000 growth standards.

**Results:** The BMI-for-age reference charts showed excellent adjustment statistical for boys and girls with DS aged 2–18 years. At 2 years of age, the mean BMI Z-scores of boys and girls with DS were lower compared to those of the CDC (Z-score = -0.2). In contrast, children with DS had higher mean Z-scores for BMI-for-age from 3 to 18 years when compared to those of the CDC (Z-scores = +0.2 to +1.3).

**Conclusions:** Young Brazilian individuals with DS have different development standards for BMI when compared to those of the CDC. These are the first Brazilian BMI-for-age charts for young individuals with DS and will hopefully guide clinicians and parents in the evaluation and management of the nutritional status in children and adolescents with DS in Brazil.

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☆☆ Study carried out at Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil.

\* Corresponding author.

E-mail: [fbertapelli@gmail.com](mailto:fbertapelli@gmail.com) (F. Bertapelli).

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**PALAVRAS-CHAVE**

Trissomia 21;  
Índice de massa  
corporal;  
Peso;  
Estatura;  
Curvas de  
crescimento;  
Estado nutricional

## Curvas de referência de Índice de Massa Corporal para população brasileira com síndrome de Down entre 2 e 18 anos de idade

**Resumo**

**Objetivo:** Desenvolver curvas específicas de Índice de Massa Corporal (IMC-para-idade) para população brasileira com síndrome de Down (SD). O objetivo secundário foi comparar os valores de IMC-para-idade com os valores normativos do Centro para o Controle de Doenças dos Estados Unidos (CDC).

**Método:** Trata-se de estudo do tipo retrospectivo e transversal. A amostra foi constituída de 706 jovens com SD (56,7%, meninos) recrutados em 51 instituições no estado de São Paulo, Brasil. Peso e estatura foram obtidos e empregados para o cálculo de IMC (Kg/m<sup>2</sup>). O método LMS foi usado para a construção das curvas. Escores Z foram calculados com base na referência do CDC 2000.

**Resultados:** As curvas de referência de IMC-para-idade para meninos e meninas com SD na faixa etária entre 2-18 anos apresentaram excelente ajuste estatístico. Aos dois anos de idade, o escore Z médio IMC de crianças com SD apresentou-se menor quando comparado ao CDC (escore Z = -0,2). Em contraste, os escores Z médios de IMC de jovens com SD foram superiores nas idades entre 3-18 anos (escores Z = +0,2 a +1,3).

**Conclusões:** A população brasileira com SD apresentou diferentes padrões de IMC quando comparada às referências do CDC. As curvas desenvolvidas nesse estudo representam a primeira referência nacional de IMC-para-idade para jovens com SD. Espera-se, portanto, que essas curvas possam guiar pais e profissionais na avaliação do estado nutricional de crianças e adolescentes com SD no território brasileiro.

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**Introduction**

Down syndrome (DS) is a chromosomal disorder with an approximate incidence between 3.05 and 14 cases per 10,000 live births in countries such as the United States and China.<sup>1,2</sup> In relation to the most recent population prevalence, studies have shown a variation between 6.1 and 13.1 per 10,000 individuals.<sup>3,4</sup> The life expectancy of individuals with DS has increased considerably in recent decades. A study suggests that 94.4% of children with DS born in 2000 will survive up to 2020, 90.8% up to 2030, and 76.3% up to 2050.<sup>3</sup> The increase in life expectancy is related to the development of research and services provided to this population.<sup>5</sup> Despite these advances, children with DS have health conditions that affect their quality of life, including congenital heart disease, hypothyroidism, gastrointestinal disorders, and obstructive sleep apnea.<sup>6</sup> According to the guidelines of the American Academy of Pediatrics and of the Brazilian Ministry of Health, individuals with DS also have growth restriction and overweight.<sup>7,8</sup>

The adequate monitoring of the nutritional status of young individuals with DS helps to prevent and identify overall health problems. The body mass index (BMI) is a health indicator that is commonly used to classify the nutritional status of children, adults, and the elderly. The United States Centers for the Disease Control and Prevention (CDC) has recommended the use of BMI to assess the health status of children older than 2 years. However, young individuals with DS have different weight, height, and BMI standards when compared to children in the general population.<sup>9</sup>

When compared to the CDC charts, young individuals with DS aged between 2 and 20 years had shorter stature and higher BMI values after 2 years of age, suggesting the need for specific growth curves for young individuals with DS.<sup>10</sup> In Brazil, the Ministry of Health recommends the use of the weight-for-age curves by Cronk et al.<sup>11</sup> for monitoring the nutritional status of young Brazilian individuals with DS aged between 2 and 18 years.<sup>7</sup> These curves combine cross-sectional and longitudinal data including 730 young American individuals with DS aged between 1 month and 18 years.<sup>11</sup> The clinical and practical use of these curves, however, had been disputed by the American Academy of Pediatrics.<sup>8</sup>

Due to the limitations of the existing curves and the absence of normative values of BMI-for-age for young Brazilian individuals with DS, this study aimed to develop specific BMI-for-age curves for the Brazilian population with DS aged between 2 and 18 years. The secondary objective was to compare the values of BMI-for-age of the study participants with the normative values established by the CDC in 2000.

**Methods**

Children and adolescents with DS aged between 2 and 18 years were recruited from a retrospective and cross-sectional study carried out between 2012 and 2015. The study was conducted at Universidade Estadual de Campinas, 48 specialized centers that provide care to individuals with intellectual disabilities, and two specialized centers for individuals with DS, all located in the state of São Paulo. The

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