Journal of Epidemiology xxx (2017) 1–9

Contents lists available at ScienceDirect

Journal of Epidemiology

journal homepage: http://www.journals.elsevier.com/journal-of-epidemiology/

Original Article

Growth charts for Brazilian children with Down syndrome: Birth to 20 years of age

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ARTICLE INFO

Article history:
Received 31 January 2016
Accepted 29 June 2016
Available online xxx

Keywords:
Trisomy 21
Weight
Height
Development

ABSTRACT

Background: The growth of youth with Down syndrome (DS) differs from that of youth without DS, and growth charts specific to DS have been developed. However, little is known about the growth of Brazilian youth with DS. The objective of this study was to construct growth charts for Brazilian youth with DS and compare the growth data with the Child Growth Standards of the World Health Organization (WHO) and charts for children with DS from other studies.

Methods: Mixed longitudinal and cross-sectional data were collected at University of Campinas, 48 specialized centers for people with intellectual disabilities, and two foundations for people with DS between 2012 and 2015. A total of 10,516 growth measurements from birth to 20 years of age were available from 938 youth with DS (53.7% boys) born between 1980 and 2013. The Lambda Mu Sigma method was applied to construct the curves using generalized additive models for location, scale, and shape.

Results: Length/height-for-age, weight-for-age, and head circumference-for-age percentile curves were generated for Brazilian boys and girls from birth to 20 years of age. Differences in growth of Brazilian youth ranged from −0.8 to −3.2 z-scores compared to WHO standards, and −1.9 to +1.3 compared to children with DS in other studies.

Conclusions: These specific growth charts may guide clinicians and families in monitoring the growth of Brazilian children and adolescents with DS.

Introduction

Down syndrome (DS) is a chromosomal disorder with prevalence estimates ranging from 6.1 to 13.1 per 10,000 people.[1,2] Children with DS have different growth patterns compared to children without DS.[3,4] Abnormal bone development is the most common feature and is hypothesized to be regulated by genetic factors.[5] A review showed that stature of children with DS was 0.4–4.0 standard deviations below that of children without DS.[6] This growth restriction has led to the development of specific growth charts for children with DS around the world.[6–9] Specific growth charts are essential for guiding clinicians and families in monitoring the growth of infants, children, and adolescents with DS from different racial and ethnic backgrounds.

The Brazilian Ministry of Health recommends using the growth charts by Mustacchi[10] for Brazilian children with DS aged 0–24 months.[11] These growth charts were developed in a sample of children with DS born before 2000. Studies around the world show a secular trend in growth, especially for weight status,[12,13] so updated growth charts may be needed. Furthermore, the previous charts for Brazilian children were developed with a relatively small sample using exclusively retrospective data from a single community. For Brazilian youth with DS older than 2 years and up to 18 years of age, the Brazilian Ministry of Health[11] recommends using

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Peer review under the responsibility of The Japan Epidemiological Association.

http://dx.doi.org/10.1016/j.je.2016.06.009

the growth charts by Cronk et al,[14] which were developed for American youth with DS; however, these charts may not represent the growth of Brazilian youth with DS. In addition, they date back to the 1980s, and their overall applicability has been questioned.[15] Importantly, there is a need to construct updated growth charts for Brazilian youth with DS employing newer and more accurate statistical methods for constructing growth curves. Taken together, these data suggest that new growth charts are necessary because previously developed references may not be representative of the present growth of infants, children, and adolescents with DS in Brazil.

Existing charts for children in the general population developed by the World Health Organization (WHO) and charts for children with DS in other countries may not be representative of the growth of Brazilian youth with DS. Past research has shown that the WHO growth standards may underestimate the growth of youth with DS,[9] but the extent to which this applies to Brazilian youth with DS is not known. Furthermore, Brazil is a large and developing multi-cultural country with a population differing from that of other countries in racial, ethnic, and economic backgrounds. Children from low- and middle-income countries are more likely to show higher prevalence of growth restriction and stunting.[16] Therefore, the growth of Brazilian youth with DS may differ from those of youth with DS in other countries; however, this has not been empirically examined. More research is needed to examine whether previously developed standards reflect the current growth of Brazilian youth with DS.

The objective of this study was to construct length/height-for-age, weight-for-age, and head circumference-for-age growth charts specifically for Brazilian youth with DS from birth to 20 years. We also compared the growth data with the WHO Child Growth Standards, and specific growth charts for youth with DS of other studies.

Materials and methods

Participants

We derived data from youth with DS using two approaches: (a) by actively recruiting participants; and (b) by retrospectively examining medical records. Active recruitment of youth with DS and examination of retrospective medical records occurred at several sites across the State of São Paulo, Brazil. Participating sites were the University of Campinas, 48 specialized centers for people with intellectual disabilities, and two foundations for people with DS. The State of São Paulo has an estimated population of 44,035,304 people, or 21.7% of the total population of Brazil. The sites were selected to represent distinct geographic regions of State of São Paulo, with population composition similar to that of the total Brazilian population in terms of racial and ethnic backgrounds. We included in the sample individuals who had complete data for weight, height, birthdate, and trisomy 21 karyotype. We excluded children who were born very prematurely (before 32 weeks of gestation).

Standard protocol approvals

The study protocol was approved by the research ethics committee of the University of Campinas. All parents or guardians of participants with DS provided written informed consent.

Data collection

A mixed longitudinal and cross-sectional study was carried out between 2012 and 2015. Retrospective data were collected at all sites mentioned above. We used existing medical records, which were supplemented in part with an interview with parents or guardians to confirm the following variables: birthdate, age, sex, skin color, gestational age, comorbidities, weight, length/height, and head circumference. All parents/guardians we interviewed maintained and confirmed the growth records of their children. In addition, we used medical records from the sites, which had permission to use the data for research; in those cases, we could not confirm the medical records from the parents/guardians. Prospective growth data were collected from the sites a total of three times in years 2012, 2013, and 2014. Anthropometric measurements were conducted by trained testers using standardized procedures.[17] Youth were measured without shoes and wearing light clothes. Measurements were taken at four sites used standard equipment. Height was measured with a stadiometer (E210; Wiso®, Santa Catarina, Brazil). Weight was measured with a digital scale (W801; Wiso®, Santa Catarina, Brazil). Head circumference was measured with a non-stretch tape.

Data screening and analyses

We used data points at monthly intervals for youth aged 0–36 months, and at annual intervals for youth aged 3–20 years. We performed data screening in several phases. First, we excluded duplicated data based on identification code, birthdate, and measurement date. Second, we removed data points when values were five standard deviations above or below the mean. Third, we excluded data points demonstrating loss of height over time. Fourth, we identified and corrected transcription errors by reexamination of personal source data or medical records. A total of 137 measurements (1.3%) were excluded from the data cleaning.

Growth charts were developed using the generalized additive models for location, scale, and shape package in R software (R Foundation for Statistical Computing, Vienna, Austria).[18] In constructing the growth charts for weight-for-age, length/height-for-age, and head circumference-for-age, we generated percentiles ranging from the 97th to the 3rd. Goodness of fit was checked using worm plots. The Lambda Mu Sigma (LMS) method was selected as the most appropriate to smooth the growth curves.[19] LMS is a transformation of skewness (L), median (M), and coefficient of variation (S).

We calculated z-scores to compare our growth data to the WHO standards[20,21] and to those previously developed for youth with DS of other countries, including the Netherlands, Portugal, United States, and United Arab Emirates,[7,9,22,23] for which data were available. We also compared our growth data with those of Brazilian youth with DS previously published by Mustacchi (2002).[10] When the L, M, and S values were available, we calculated z-scores as:

$$Z = \left[(X/M)^L - 1\right] \Big/ L*S,$$

where X is the observed measurement (weight, length/height or head circumference). When the L, M, and S values were not available, the following equation was used:

$$Z = (X - M)/SD,$$

where X is the observed measurement, M is the mean, and SD is the standard deviation; M and SD were obtained from age-specific growth standards. Multilevel regression models were performed to examine the effects of comorbidities, year of birth, gestational age, and data source (prospective vs. retrospective data) on the growth of individuals with DS.

Please cite this article in press as: Bertapelli F, et al., Growth charts for Brazilian children with Down syndrome: Birth to 20 years of age, Journal of Epidemiology (2017), http://dx.doi.org/10.1016/j.je.2016.06.009