Published in final edited form as:

JAMA Pediatr. 2022 April 01; 176(4): 424–425. doi:10.1001/jamapediatrics.2021.6366.

Interpreting Weight, Height, and Body Mass Index Percentiles in the US Centers for Disease Control and Prevention Growth Charts

David S. Freedman, PhD[1]

[1]Division of Nutrition, Physical Activity, and Obesity, US Centers for Disease Control and Prevention, Atlanta, Georgia

To the Editor:

Hendrickson and Pitt1 expressed concern that a child whose height and weight are both at the US Centers for Disease Control and Prevention (CDC)–defined 97th percentile would have a body mass index (BMI) above the 85th percentile of the CDC growth charts2 rather than in the normal weight range. Although the authors suggested that this seemingly counterintuitive observation may be the result of different data sets in the growth charts or a weakness of the BMI formula, the association of BMI z score with to z scores for weight and height was addressed by Cole3 in 2002. I further examined the associations between these sex- and age-standardized z scores for weight, height, and BMI and compared the association of body fat with both BMI z score and a metric based on the weight percentile minus height percentile difference (WHD).

I used data from National Health and Nutrition Examination Survey 2011 to 2012 through 2017 to 20184 for the analyses, which included 13 042 individuals aged 2 to 19 years with weight and height data. Body fat was calculated from dual-energy radiography absorptiometry for 6923 male individuals and nonpregnant female individuals who were 8 years and older.5

Multiple regression was used to predict BMI z score from weight z score and height z score. Percentiles and z scores are easily converted through the standard normal cumulative distribution function. A z score of 0 is the median, and the 97th percentile is 1.88 SDs above the median. Each SD increase in weight z score was associated with an increase in BMI z score by 1.15 SDs, whereas each SD increase in height z score was associated with a reduction in BMI z score of 0.54 SDs. Based on this model, which fit the data well ($R2 = 0.94$), a child at the CDC-defined 97th percentile for weight and height would have a predicted BMI z score of $0.01 + (1.15 \times 1.88) - (0.54 \times 1.88) = 1.16$ SDs, the 88th percentile.

Corresponding Author: David S. Freedman, PhD, Division of Nutrition, Physical Activity, and Obesity, US Centers for Disease Control and Prevention, 4770 Buford Hwy, Mailstop F107-5, 4770, Atlanta, GA 30341-3717 (dxf1@cdc.gov).

Conflict of Interest Disclosures: None reported.

I also examined the amount of variability in body fat that BMI z score and WHD could explain among individuals aged 8 to 19 years. A combination of sex, age, and BMI z score yielded multiple R2 values of 0.88 (fat mass) and 0.76 (percent body fat), whereas the comparable R2 scores with WHD were 0.40 and 0.52, respectively.

A tall child whose weight is at the 97th percentile has a BMI above the 85th percentile because BMI is a height-adjusted weight index that is more strongly related to weight than height. In contrast, WHD assigns equal importance to weight and height. Despite its limitations, BMI z score predicts body fat more accurately than WHD.

References

1. Hendrickson MA, Pitt MB. Three areas where our growth chart conversations fall short-room to grow. JAMA Pediatr. Published online November 1, 2021. doi:10.1001/jamapediatrics.2021.4330
2. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. Vital Health Stat 11. 2002;11(246):1–190. https://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12043359
3. Cole TJ. A chart to link child centiles of body mass index, weight and height. Eur J Clin Nutr. 2002;56(12):1194–1199. doi:10.1038/sj.ejcn.1601473 [PubMed: 12494304]
4. CDC National Center for Health Statistics. National Health and Nutrition Examination Survey. NHANES Questionnaires, Datasets, and Related Documentation. Accessed June 23, 2020. https://wwwn.cdc.gov/nchs/nhanes/Default.aspx
5. National Health and Nutrition Examination Survey. 2011–2012 Data Documentation, Codebook, and Frequencies Dual-Energy X-ray Absorptiometry - Whole Body (DXX_G) Data File. Published 2020. Accessed January 26, 2021. https://wwwn.cdc.gov/Nchs/Nhanes/2011-2012/DXX_G.htm