Author's response to reviews

Title: Using height-for-age difference (HAD) instead of height-for-age z-scores (HAZ) for the meaningful measurement of population-level catch-up in linear growth in children less than 5 years of age

Authors:

   Jef L Leroy (j.leroy@cgiar.org)
   Marie Ruel (m.ruel@cgiar.org)
   Jean-Pierre Habicht (jh48@cgiar.org)
   Edward A Frongillo (EFRONGILLO@sc.edu)

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Author's response to reviews: see over
Review: Using height-for-age difference (HAD) instead of height-for-age z-scores (HAZ) for the meaningful measurement of population-level catch-up in linear growth in children less than 5 years of age

1. Is the question posed by the authors well defined?
2. Are the methods appropriate and well described?

The main objective of this paper was to assess whether there is evidence of population-level catch-up growth in children. The authors reason that the mean height-for-age difference is a more appropriate measurement than using findings with the HAZ measurement.

On page 7 line 133 onwards they reason that if HAD is negative but remains constant with age (they imply that there is no catch-up growth), the z-score will increase with age, because the SD increases, indicating catch-up growth. But this actually implies catch-up growth, because, relative to the population, this (a constant HAD) is actually an improvement. An increased standard deviation implies an increase in HAD.

*** An improvement in the context of our study, which is about catch-up growth, requires that children grow at a faster rate than would be expected between two points in time. This faster growth allows them to make up for the lost growth in height.

The table below shows what happens with a group of children with a constant HAD of -5 cm between 24 and 60 months. As can be seen, this group of children grows exactly at the expected velocity for their age, but they do not grow faster than the expected velocity for their age. This means that there is no improvement, i.e., children do not make up for the height deficit accumulated in the past. Said differently, there is no improvement or catch-up growth in length/height.

We added text in the methods to clarify what “improvement” means in the context of catch-up growth (e.g., faster than expected growth velocity) and added growth velocity (compared to standards) in Table 2 (analyses of Young Lives data sets). We show that even in the group labeled as catching up based on the HAZ criterion, velocity in height is below the expected velocity in all four countries. This confirms our conclusion that there is no catch-up growth. We also added a sentence in the methods and discussion on what linear growth retardation means, i.e. the deficient environment to which children are exposed.

Table: Population of children tracking along HAD of -5 cm (“actual”), compared to the growth standard (“expected”) from 24 to 60 mo of age

<table>
<thead>
<tr>
<th>Age (m)</th>
<th>Expected (standard median)</th>
<th>Actual</th>
<th>HAD</th>
<th>Age range</th>
<th>Expected (standard median)</th>
<th>Actual</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m)</td>
<td>(cm)</td>
<td>(cm)</td>
<td></td>
<td></td>
<td>(cm/y)</td>
<td>(cm/y)</td>
<td>(cm/y)</td>
</tr>
<tr>
<td>24</td>
<td>87.8</td>
<td>82.8</td>
<td>-5.0</td>
<td>24 to 36</td>
<td>8.26</td>
<td>8.27</td>
<td>0.0</td>
</tr>
<tr>
<td>36</td>
<td>96.07</td>
<td>91.1</td>
<td>-5.0</td>
<td>36 to 48</td>
<td>7.24</td>
<td>7.24</td>
<td>0.0</td>
</tr>
<tr>
<td>48</td>
<td>103.31</td>
<td>98.3</td>
<td>-5.0</td>
<td>48 to 60</td>
<td>6.63</td>
<td>6.63</td>
<td>0.0</td>
</tr>
<tr>
<td>60</td>
<td>109.94</td>
<td>104.9</td>
<td>-5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Page 8 line 161 the authors mention that the z-score criterion is different from the absolute difference criterion. According to the z-score criterion, \( \Delta \text{HAD} > (\text{negative number}) \) for catch-up growth; whereas the absolute difference criterion states that \( \Delta \text{HAD} > 0 \), for catch-up growth. The z-score criterion cannot be different from the absolute difference criterion – it is less restrictive, and includes the absolute difference criterion.

*** We are not sure we understand the reviewer’s comment. In this section of the paper, we show that the two criteria are different and hence lead to a different conclusion regarding catch-up growth. More specifically, we show that the Z-score criterion is less restrictive than the absolute difference criterion. Since we also show that Z-scores should not be used to assess catch-up growth (because of the cross-sectional SDs used to calculate them, see response to the comment above), we conclude that the Z-score criterion will lead to the erroneous conclusion of catch-up growth when in reality there is no catch-up growth.

Page 10 line 198 a reference of where the WHO 2006 growth standards median heights can be obtained from is missing.

*** The reference to the WHO website was added to the text.

Also, motivate why 5SD’s were used to drop records, as opposed to 4SD’s in line 207.

*** Records with a HAZ below -5SD or above 5SD at any point in time were dropped. We also dropped records with a change in HAZ between baseline and follow-up larger than 4SD.

The purpose of this article can be merely to describe the relation between HAD and z-scores. I refer to “Issues in the assessment of nutritional status using anthropometry”, Gorstein, Sullivan, Yip, de Onis, Trowbridge, Fajans and Clugston, in Bulletin of the WHO, 1994, 72(2): 273-283. They reason that “the percent-of-median is simpler to calculate than a z score or percentile. Unfortunately, because the calculation of the percent-of-median ignores the distribution of the reference population around the median, the interpretation of the fixed percent-of-median value varies across age and height groups.” They continue to reason that “the z-score and percent–of-median curve would be approximately the same only if the coefficient of variation were to remain constant throughout childhood. But it changes, especially during the first two years.

In summary, if the HAD value of a person remains constant over time (age), it actually indicates an improvement for that person relevant to the population, because for the rest of the population the differences or HAD values increased because the standard deviation increased. One cannot view the HAD only when considering catch-up growth, because it is not relative to the population.

*** We carefully read the article by Gorstein et al., but we did not find any discussion of the use of HAD, the metric we use in our analyses.

We do not agree with the reviewer’s statement that “if the HAD value of a person remains constant over time (age), it actually indicates an improvement for that person relevant to the population”. As emphasized in the text, our manuscript focuses on groups of children, not on individual children, and therefore the assessment of catch-up growth in individual children is outside the scope of our study. More importantly, we do not agree with the point made by the reviewer that a constant HAD implies an improvement. As discussed above, an improvement in the context of our study, which is about catch-up growth, would mean that children grow at a faster rate than would be expected between two points in time, in order to make up for the lost growth in height. The table above shows that a group of children with a constant HAD do not improve, i.e., they do not make up for the height deficit accumulated in the past. Said differently, they do not experience catch-up growth.
As mentioned above, we added text to the manuscript on what “improvement” means in the context of catch-up growth (e.g. faster than expected growth velocity) and added growth velocity results.

3. Are the data sound? Yes, secondary data used.
4. Do the figures appear to be genuine, i.e. without evidence of manipulation? Yes
5. Does the manuscript adhere to the relevant standards for reporting and data deposition? Yes
6. Are the discussion and conclusions well balanced and adequately supported by the data? I do not agree with the conclusion that the HAD is a better measurement for describing catch-up growth than using the z-score comparisons.
   *** We refer the reviewer to our responses above.

8. Do the authors clearly acknowledge any work upon which they are building, both published and unpublished? YES
9. Do the title and abstract accurately convey what has been found? YES
10. Is the writing acceptable? YES

In conclusion, although the article is well written, I do not agree with the conclusions. I will therefore feel that it cannot be published as is.

*** We refer the reviewer to our responses above.
Reviewer 2

Leroy, et al. submit a manuscript describing the comparison of population catch up growth when calculated using height for age Z-scores (HAZ) vs. height for age discrepancy (HAD) from the median. They particularly focus on several resource-limited countries in which adequate height data already exist. They first discuss the calculation of the two measures, emphasizing that because height SD increases with increasing age, the HAZ may improve over time even though the absolute height discrepancy may not. This is important, because recent publications appear to demonstrate an improvement of height limitations over time using the HAZ approach, whereas older papers using HAD assessments have not demonstrated such improvements. Analyzing the data using both approaches illustrates the pitfalls of the HAZ approach, confirming that additional height loss can occur over time even when the HAZ is getting better. The authors present a reasoned argument in favor of the HAD approach. However, the paper seems overly long and repetitious. Additionally, there are some clarifications that are needed to improve the article.

Major compulsory revisions:
1. Abstract: In the Background section, define the settings in which catch up growth is examined, such as assessments of growth as a measure of nutritional deprivation in resource-limited countries.

   *** We changed the first sentence of the abstract to:
   “Evidence from studies conducted in nutritionally deprived children in low- and middle-income countries (LMIC) in past decades showed little or no population-level catch-up in linear growth (mostly defined as reductions in the absolute height deficit) after 2 years of age.”

2. Methods: The Study Scope, Theoretical Background, and Mathematical Background sections are overly long and repetitive and should be shortened. I have highlighted some of the repetitive areas below. Although the equations listed make sense, they don’t really add anything. The concept being illustrated is not complicated, and the authors do a nice job laying them out verbally in the text.

   *** We agree with the reviewer that the equations are not complicated. Based on the many comments and questions we have received when we have presented this work, however, we are convinced that they will help the reader understand the study’s rationale. We would therefore prefer to keep them in the text.

   a. Lines 103-103 are repeated from lines 76-80.

      *** Lines 76-80 explain the difference between earlier studies (using absolute deficit) and more recent studies (using HAZ).

      Lines 103-... explain the different age groups that have been studied in the literature (childhood to adulthood vs. infancy to childhood) in order for us to define the scope of our study (infancy to childhood).

   b. Lines 128-130 are repeated from lines 122-125.

      *** We agree with the reviewer. We dropped the text lines 128-130.

   c. Lines 144-150 are repeated from lines 132-136.

      *** We agree that these sections are similar, though not exact repetitions. Again, the inclusion of these are based on questions and comments we received when we presented this work previously.

   d. Lines 292-296 are unnecessarily repetitive.

      *** We agree with the reviewer. We dropped some of the text.

   e. Lines 316-319 are repeated from lines 303-307.

      *** We do not see the repetition to which the reviewer refers.
3. Datasets: Give more detail about the Demographic and Health Surveys. Table 1 lists the survey years for different countries, but only lists one year for each. Are the DHS data cross-sectional? If so, changes over time cannot be adequately assessed.

*** We added the following information about the DHS surveys to the text: “DHS, funded by the U.S. Agency for International Development, are nationally-representative household surveys that collect data on a wide range of population, health, and nutrition indicators.” The DHS are cross-sectional, which strictly speaking does not allow one to make assessments over time. Differences seen in attained growth in groups of children from different ages could therefore be due to differences in the growth environment to which children from different ages have been exposed. It is unlikely, however, that environments could have changed drastically over a 5 five-year period across the 6 nations we study. Furthermore, environmental influences would affect both HAZ and HAD in the same way and therefore would not alter our results related to the comparison between HAZ and HAD. The reason for using the DHS surveys is that they have been used in the past (see Prentice et al.) to make claims about catch-up growth.

Minor essential revisions:
1. Line 40: change “pregnancy” to “conception.”
   *** We changed the text.
2. Line 86: I believe two words are inverted. Should read “…compare with findings using mean…”
   *** We changed the text.