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Letter to the Editor

Rejoinder-Response To: Human Linear Growth Trajectory Defined

Dear Editor,

Dr. T J Cole is unconvinced by the claims he feels we made in our recent paper titled "Human Linear Growth Trajectory Defined." Here, we will show that his concerns are based on some misunderstandings of our model and on misinterpretations of the presented material.

Dr. Cole questions the accuracy of our measures by interpreting the data presented in Figure 1. The figure depicts data from a subset of 32 children with a total of 395 measurement points; the cases were selected based on having a large number of measurement points across a wide age range. The discrepancies between predicted and observed heights range from -3.6 to $+4.3$ cm over an age range of 0–21 years; the mean discrepancy of the signed values is 0.18 ± 1.40 (SD) cm, whereas the mean absolute discrepancy is 0.93 ± 1.07 cm. The signed mean, which is close to 0, suggests very little bias, whereas the absolute mean suggests an accuracy of about 1 cm. When calculated across all 137 children, the mean absolute discrepancy is 0.80 ± 1.76 cm, which we stated in the abstract. Given our measurement error of 0.5 cm, we consider the height predictions obtained with our formula rather accurate. We also clearly state in the paper that this is an average measure; not unexpectedly therefore, such accuracy is not obtained for all children.

Dr. Cole expects that the prediction error increase with age, and he is concerned that the representative data given in the figures do not reflect his expectations. We do not agree completely with Dr. Cole's assertion or his conclusion drawn. If the two input data points are representative of the growth trajectory throughout a given growth segment, the error of prediction does not increase with age. If, however, the growth is nonuniform (as it is when transitioning from one growth segment to the other or in the case of conditions that affect growth), the prediction error may be related to age, but not simply in a uniform fashion. An age or condition-related effect, but not necessarily a systematic dependence on age, can likely be appreciated in the example presented in Figure 3 and in the cases of the three children with scoliosis or obesity mentioned in the paper.

Figure 1 shows mostly positive discrepancies between age 16 and 21. These prediction errors are not a function of age *per se*. They are overestimations of actual heights that are expected, because most of the heights after age 16 were calculated from curves extrapolated from measurements obtained during childhood (because measurements after 16 years were sparse in most cases). As the growth rate during the childhood segment is different from that during adolescence, these greater positive discrepancies in adolescence are a function of the nonuniformity of growth across segments.

Dr. Cole expects that any fit with the Mon's formula should be perfect for the first two measurements, that is, the fit should pass through the centers of the first two points displayed. He notes that this is not true for the data presented in Figure 4, and he is puzzled by this. We should have used greater clarity in describing the procedures used for generating the material presented in the different figures. But as stated in the paper, it is not that the first two measurement points need to be used to generate the growth curves, but one could use "any two initial measurements that were separated by at least 4 months and at most 12 months". Therefore, it should not be expected that every curve pass through the centroids of the first two measurement points. All the same, a few plots in Figures 2 and 3 show cases in which the first two measurement points were used to calculate the growth curves plotted and in which the scale of the figure allows appreciating the fact that the fitted curves do indeed go through the centroids of these two measurement points. However, as noted by Dr. Cole, the growth trajectory drawn in Figure 4a did not use the first two measurement points to calculate the curve; instead, all 10 data points were modeled using our formula and two other published models. Modeling the data in such a way, the RMSE of the fits were numerically lowest for our formula over uniform segments of growth. Figure 4 is used for illustrative purposes; model fits to other uniform growth data from the entire data set showed similar patterns (as stated), leading us to conclude that "our formula gave better data fits for ranges of uniform individual growth data than the (other) models (tested)." We did not mean to make a general statement about how the fits from our formula compare to fits from other models across the entire age range from early childhood to adults, as we had little such data available. When comparing fits to a larger age range, other models may fit better than our model, but this was not tested. Acknowledging this limitation of our model comparisons, we explicitly stated in our paper that "a direct comparison of our formula with the existing models using the same sample is needed for a definitive conclusion" about which models best fit the entire growth trajectories from birth to adult.

Finally, Dr. Cole is concerned that selective reporting could have introduced bias into the interpretation of our results. The data presented in all the Figures and Table 2 were meant to be illustrative, as stated. Data analyses were conducted on all 137 children of the data set, and data is reported from all 137 children (mean discrepancies of 0.8 cm, intraclass correlation coefficient of 0.98, paired t-tests with $P > 0.97$). Importantly, our overall conclusions are based on the analyses of the entire sample, not selected data sets used for illustrative purposes.

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We appreciate the opportunity given us to clarify our analyses and we hope that these clarifications alleviate Dr. Cole's concerns. Only further practical applications of our simple formula by Dr. Cole and colleagues in his field will prove its usefulness and accuracy compared to existing growth formulae.

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