A new international growth reference for young children$^{1,2}$

Cutberto Garza and Mercedes De Onis

**ABSTRACT** Growth references for children are among the most widely used instruments in public health and clinical medicine. A comprehensive review by the World Health Organization (WHO) of the use and interpretation of anthropometric data concluded that the present international growth reference for infants does not describe physiologic growth adequately; thus, a new anthropometric reference was recommended for young children from birth to 5 y. The approach taken by the WHO for development of a new reference is guided by the principle that anthropometric reference data must always reflect the functional context of their intended uses and an awareness of the consequences of their application. The new reference will be constructed from data to be collected in a longitudinal study of infants who will be exclusively or predominantly breast-fed for ≥4 mo with continued breast-feeding throughout the first year, and a cross-sectional study of infants and young children aged 18–71 mo. The sample will be drawn from ≥7 diverse geographic sites around the world. The adopted protocol is expected to provide a single international reference that represents the best standard possible of optimal growth for all children <5 y of age. Furthermore, documentation will be sufficient to allow for possible future revision of the reference as substantial new biological information on the growth of infants and young children becomes available. *Am J Clin Nutr* 1999;70(suppl):169S–72S.

**KEY WORDS** Infant growth, childhood growth, international growth reference, anthropometry, growth charts, growth curves, child health, child nutrition, public health, breast-feeding, breast-fed infants

**INTRODUCTION**

Anthropometric data provide health professionals and para-professionals with accessible, efficient, and reliable tools for a variety of purposes. The effort sponsored by the World Health Organization (WHO) to develop a new growth reference encompasses children from birth through 5 y of age (1). Although this discussion focuses on infants, much of it also applies to toddlers, young children, and even adults. Growth references for children are among the most widely used instruments in public health and clinical medicine. At the population level, growth references have diverse applications. For example, they are useful for predicting emergencies related to food and nutrition, assessing the equity of economic resources as distributed within and between communities, evaluating the suitability of weaning practices, and screening and following groups at risk for deficient or excessive growth. For individuals, growth references are the mainstay of growth monitoring and promotion; they help identify the optimal time to introduce complementary foods, are often used to assess lactation performance, and help in the diagnosis of growth faltering, failure to thrive, and excessive growth.

The group that initiated the activities that led to recommendations for a new anthropometric reference for young children, the Working Group on Infant Growth, was part of a larger WHO effort initiated to evaluate the interpretation and appropriate uses of anthropometric data in all age groups (2). The working group selected to assess references for infants was charged with developing recommendations for the appropriate use and interpretation of anthropometric data in this age group. This working group was also asked to select or develop new reference data for the most appropriate anthropometric indicators for specific uses, provide guidelines for the use of reference data, and identify crucial issues and gaps in knowledge.

**WHO 1994 WORKING GROUP ON INFANT GROWTH**

One principal issue emerged quickly from the working group’s review: despite an increased recognition of the health, nutritional, and fertility benefits of breast-feeding, the group found repeated documentation of negative deviations in growth patterns of healthy breast-fed infants relative to the current reference. The biological questions raised by the growth deviations were of obvious interest, yet practical concerns were more significant. The deviations in growth appeared to be so marked that they encouraged the premature introduction of complementary feeding. Thus, the growth deviations suggested that many women were unable to produce sufficient milk to sustain the physiologic growth of their infants through the recommended period of exclusive breast-feeding. Evidence of premature cessation of breast-feeding heightened the working group’s concerns about the adequacy of the current reference because premature introduction of complementary feeding often has adverse consequences on the health and nutritional well-being of infants, as well as for maternal fertility, particularly in the developing world. These considerations raised a more general issue that is highly relevant to the efforts undertaken by the International Obesity Task Force, ie, that the development

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$^1$From the Division of Nutritional Sciences, Cornell University, Ithaca, NY, and the Nutrition Programme, World Health Organization, Geneva.

$^2$Address reprint requests to C Garza, Division of Nutritional Sciences, Cornell University, Ithaca, NY 14853. E-mail: cg@cornell.edu.
of a growth reference must always reflect the functional context of its intended uses and an awareness of the consequences of its applications. The remainder of this article focuses elaborates on this important point.

The Working Group on Infant Growth elected to assess the growth patterns of breast-fed infants because in its judgement, breast-fed infants represent the most physiologic group and breast-feeding has many functional benefits. The working group gathered the best information available from the published scientific literature and other data of comparable quality that for various reasons remains unpublished. Conservative standards were applied in the selection of data to assure that growth was not constrained by environmental stresses, the nutritional status of the mother, the pregnancy and lactation, and the adequacy of the lactation support available to the mother. A sample that was adequate for the purposes of the working group emerged from published and unpublished data; 226 infants (109 males and 117 females) who were predominantly or exclusively breast-fed for 24–6 mo and breast-fed for the remainder of the year. However, the resulting sample consisted exclusively of northern European and North American infants.

COMPARISONS BETWEEN THE GROWTH OF BREAST-FED INFANTS AND THE CURRENT REFERENCE

The growth of these 226 infants was compared with the current reference. The results of these analyses are summarized in Figure 1. The growth of even this conservatively selected group of infants deviated negatively from the current reference. An ideal match between the growth patterns of the selected group and the current reference required a sustained \( z \) score of 0 throughout the period of interest. A match, however, was not observed. Weight-for-age \( z \) scores fell progressively from mo 2 through 12. \( z \) Scores for weight-for-length showed a similar pattern, and those for length-for-age fell through mo 8. Such comparisons force us to recognize the common practice of using anthropometric references as standards. References are often used not only as a basis for making comparisons but for making value judgments as well (4). Thus, on the basis of analyses such as those depicted in Figure 1, one could reach the conclusion that exclusive or predominant breast-feeding was inadequate after 2 mo of life and that additional energy, nutrients, or both were required after that time. Alternatively, given the other attributes of the breast-fed group and the benefits associated with breast-feeding, one also could conclude that the current reference was not adequate in its description of physiologically normal growth. Additional analyses were performed under the working group’s direction. The group concluded that these analyses provided satisfactory evidence that the current reference was inadequate and therefore no conclusions could be reached on the basis of the current reference regarding the adequacy of growth of breast-fed infants. Given the normative characteristics associated with breast-feeding, this also raises questions about inferences that may be reached regarding other infants. For additional details, the reader is encouraged to consult more complete descriptions of these analyses (5).

PROBLEMS WITH THE CURRENT REFERENCE

The reasons for the inadequacy of the current reference curves are probably both biological and technical.

Biological sources of error

The biological reasons for the curve’s inaccuracies stem from the fact that growth patterns are affected by feeding modes and patterns. The current reference is based on growth data collected from infants who were fed formulas available in the United States >30 y ago. These formulas are no longer available because of improvements in the composition of artificial milks. The current reference curve may also reflect feeding patterns that are no longer recommended. It was not uncommon to supplement infants with solid foods in the early months of life during the time period when the current reference data were collected.

Technical sources of error

Technical problems related to the frequency of measurements may have also influenced the current reference because growth data were available only at birth and ages 3, 6, 9, and 12 mo. These measurements were not frequent enough to describe the rapid changes in growth velocity that occur during the first year of life. Also, the curve-fitting or -smoothing techniques used to construct the current reference were criticized because they may not have accurately described the growth of infants during the period of interest. Advances in analytic capabilities and approaches have made the methods used to develop the current reference outdated. Considerations of this type emphasize that in the development of references, we must consider fully the biological and other determinants of the reference measurement or indicator, eg, weight, length, and weight:length, and the ability of the analytic approaches to construct references with the desired accuracy and precision.

RECONCEPTUALIZATION OF APPROACHES FOR DEVELOPING A NEW REFERENCE FOR INFANT GROWTH

Deliberations of this nature persuaded the working group that the fundamental approach to developing infant growth references should be reconceptualized. Until now, the predominant approach to the development of growth references has been based on the
identification and measurement of statistically representative, healthy groups. *Health*, for these purposes, has been defined as the absence of identifiable disease. The analyses done by the working group, however, showed that the growth of children free of overt disease varies significantly depending on other factors.

Among the better examples that may be used to illustrate this point are data obtained from an independent study conducted by the Human Reproductive Program (HRP; unpublished observations) at WHO and data that were collected from formula-fed infants and pooled by the WHO Working Group (5). Infants in the HRP study were more heterogeneous than the pool of breast-fed infants used by the working group in its analyses. The HRP group included 1273 children from 5 countries: Egypt, Hungary, Thailand, Kenya, and Chile. Of the 1273 infants, ~30% were fully breast-fed for 4 mo and then partially breast-fed to ≥12 mo of age. In Figure 2, we compare the subset of HRP infants who were predominantly or exclusively breast-fed (*n* = 382) with both the current National Center for Health Statistics–WHO reference and the pooled breast-fed data set compiled by the WHO Working Group. Compared with the current reference, the HRP infants’ *z* scores fell from about mo 3 to mo 11 or 12. However, when the growth of HRP infants was compared with that of the pooled North European and North American sample, their *z* scores became slightly but progressively more positive from mo 2 onwards.

These and other data supported the merits of expanding the definition of “healthy” beyond documenting the absence of clinically overt disease, to include the adoption of recommended health and feeding practices by the reference population. The working group concluded that this modification would provide a physiologic description of normal growth and help promote breast-feeding and other associated goals adopted by health professionals throughout the world.

**ISSUES RAISED BY THE PROPOSED APPROACH**

Because of the working group’s commitment to fully consider the biologic and other determinants of the reference measurements and indicators, and the diverse abilities of various analytic approaches to construct references of the desired accuracy and precision, several issues raised by members of the working group or others asked to review the group’s work are currently the focus of investigation. Concern has been expressed that most infants who are exclusively or predominantly breast-fed for ≥4–6 mo and continue to be breast-fed through the first year do not reach maximal length as depicted by the current reference. This is evident in the difference at 8 mo between the current reference length and the length attained by breast-fed infants, as shown in Figure 1. Another concern is that a prescriptive approach that results in the selection of groups that follow health recommendations constrains the variability in growth patterns inappropriately. The thinking is that such groups will be too homogeneous. This too is an important concern, because an accurate description of variability in growth is key to identifying children most at risk for growth failure or excessive growth. These and other issues require careful consideration as we shift from the predominantly descriptive approaches that have guided the development of references in the past to a prescriptive approach.

**SUMMARY AND CONCLUSIONS**

In summary, these analyses and other analyses referenced herein led to 3 major conclusions. First, a new growth reference is needed to improve the management of infant health. Second, the reference population should reflect current health recommendations, particularly in view of the frequent use of references as standards. Third, the reference population should be representative of the world’s children who are being fed according to health recommendations and whose mothers did not smoke during pregnancy nor plan to smoke during lactation.

The proposed approach for meeting these goals is a multicenter study that will involve ≥7 diverse geographic sites. These sites will represent North and South America, Europe, sub-Saharan Africa, and eastern, southern, and western Asia. The proposed study will combine a longitudinal design from birth to 24 mo of age with a cross-sectional study of children aged 18–71 mo. At each site, children born through 5 y of age will be enrolled in the cross-sectional study. For the longitudinal portion, newborns will be selected from populations with low mobility and socioeconomic conditions that should not constrain infant growth. Individual eligibility requirements for this component of the study include that the infants have term, single births, health status that does not constrain growth, and mothers willing to follow current WHO feeding recommendations.

This is clearly an ambitious undertaking. By prescribing the nature of the sample to the degree proposed in the protocol, the recommended approach represents a significant departure from those used in the past to construct growth references. This approach is being proposed because of the intent to create a reference that also approximates a standard. Thus, the proposed reference should be representative of children whose feeding and care reasonably approach recommended health practices. This approach lends itself to the development of a single international reference representing the best standard possible of optimal growth for all children <5 y of age, and it also lends itself to revision as substantial new biological information becomes available.

**REFERENCES**

2. World Health Organization. Physical status: the use and interpreta-

