New Growth Standards for the 21st Century: A Prescriptive Approach
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Breast-fed babies have been shown to grow at a substantially different rate from the current international reference curves, with greater growth rates in height but with smaller body weight increases and substantially less variability in the growth patterns of a group. On this basis, the World Health Organization concluded that there was a need to undertake new studies to establish on a global basis the appropriate growth curves for exclusively breast-fed babies, their growth curves then being potentially seen as optimum standard curves rather than an arbitrary set of reference charts. The Multi-Country Growth Reference Study was therefore carried out from July 1997 to December 2003 as a population-based study covering the cities of Davis, California, USA; Muscat, Oman; Oslo, Norway; and Pelotas, Brazil, together with selected affluent neighborhoods of Accra, Ghana and South Delhi, India. These centers were considered conducive to a study of babies and children under optimum breast-feeding and weaning and early feeding conditions. These studies, to be reported shortly, confirm previous observations on breast-fed children, but also show that the greatest differences are within each population group rather than being international differences.

Key words: breast-feeding, growth rates

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doi: 10.1301/nr.2006.may.S000–S000

The Multi-Country Growth Reference Study (MGRS) was designed to develop new tools for the assessment of infant and young child growth. This study had its origins almost 15 years ago, when the World Health Organization (WHO) initiated a comprehensive review of the uses and interpretation of anthropometric references. Among the products of that early beginning was a comprehensive review of the current international growth reference for infants and a systematic evaluation of the growth performance of breast-fed infants whose growth was evaluated under relatively controlled conditions. This review’s outcomes included three findings particularly relevant to the MGRS. The first was that the growth of highly selected, relatively privileged infants from northern Europe and North America (i.e., the WHO-pooled breast-fed data set/group) deviated negatively from the current international reference. The deviation’s magnitude was sufficiently large to interfere with nutritional management (Figure 1).

The second salient finding emerged from the review group’s assessment of the growth of healthy breast-fed infants in studies conducted in Chile, Egypt, Hungary, Kenya, and Thailand by the WHO Human Reproduction Program (HRP). These infants’ growth was assessed on the basis of the current international growth reference and of the WHO-pooled breast-fed group. The HRP infants’ growth was assessed on the basis of the current international growth reference and of the WHO-pooled breast-fed group. The HRP group’s weight-for-age (the only measurement available) Z-scores decreased progressively from approximately 3 to 11 or 12 months relative to the current international reference. The HRP infants’ Z-scores, however, were sustained or increased during the same interval if their growth was compared with the WHO-pooled breast-fed data set (Figure 2).

The third salient finding was that the variability of growth in the WHO-pooled breast-fed data set was significantly less than that of the present international reference. It was unclear whether the reduced variability reflected the ethnic/genetic/geographic “homogeneity” of the WHO-pooled breast-fed group. Alternatively, the current international growth reference’s greater variability could reflect the broad definition of health used to select its sample: for example, the absence of observable illness. The majority of infants included in the current international reference were fed artificial milks that are no longer on the market. It is possible, therefore, that the current international reference’s greater variability reflects responses to “non-optimal” formulas that have been replaced by more advanced formulations based on

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newer knowledge of the nutritional needs of infancy (Figure 3).

The review group concluded from these and other related findings that new references were necessary because of the likelihood that the current international reference interfered with the sound nutritional management of infants and may lead to faulty estimates of malnutrition. It also recommended that the new tools to assess growth should approximate standards (i.e., enable value judgments), rather than be limited to the less-expansive goal of providing a basis for comparisons, to the degree possible. Thus, the MGRS undertook to describe how children should grow independently of time or place, rather than the more limited aim of describing the growth of children at a particular time and place.

The MGRS was carried out from July 1997 to December 2003. It was designed as a population-based study covering the cities of Davis, California; Muscat, Oman; Oslo, Norway; and Pelotas, Brazil, and selected affluent neighborhoods of Accra, Ghana and South Delhi, India. The MGRS protocol and a description of its implementation in the six sites was described in detail elsewhere.3-9 The MGRS combined a longitudinal study from birth to 24 months with a cross-sectional study of


children 18 to 71 months of age. In the longitudinal study, mothers and newborns were screened and enrolled at birth and visited at home a total of 21 times on weeks 1, 2, 4, and 6; monthly from 2 to 12 months; and bimonthly in the second year. Data were collected on anthropometry and motor development; feeding practices; morbidity; perinatal factors; and socioeconomic, demographic, and environmental characteristics.

Motor development assessments also were performed longitudinally beginning at 4 months of age on all subjects enrolled in the longitudinal subsample in five of the six sites. Motor development assessments were not performed in Brazil because most of that site’s longitudinal sample was older than 4 months when motor development was added to the MGRS protocol. Six distinct gross motor milestones were assessed: sitting without support, hands-and-knees crawling, standing with assistance, walking with assistance, standing alone, and walking alone. These were selected because they are considered universal, fundamental to the acquisition of self-sufficient locomotion, and simple to test and evaluate. All milestones were assessed using standardized testing procedures and criteria, and were performed by study staff monthly until 12 months of age and bimonthly thereafter until 24 months or until all milestones were achieved. No fixed milestone sequence was assumed and all milestones were assessed at each visit. Training and standardization procedures and data collection protocols were similar among sites. These protocols were also described in detail elsewhere.10

The study populations lived below altitudes of 1500 m under socioeconomic conditions favorable to growth, experienced low mobility, were characterized by ≥20% of mothers likely to follow feeding recommenda-
tions, and had access to breast-feeding support. Individual inclusion criteria were: the absence of health or environmental constraints on growth, mothers willing to follow MGRS feeding recommendations: exclusive or predominant breast-feeding for at least 4 months, introduction of complementary foods by the age of 6 months, partial breast-feeding to be continued for at least 12 months, no maternal smoking before or after delivery, single term birth, and absence of significant morbidity. Eligibility criteria for the cross-developed in consultation with neonatologists and pediatricians that excluded infants from participating were local socioeconomic characteristics that could be used to select groups whose growth was not environmentally constrained. Local criteria for screening newborns, based on parental education and/or income levels, were developed from those surveys. Preexisting survey data were available from Brazil, Norway, and the United States for this purpose. Site-specific lists of clinical diagnoses that excluded infants from participating were developed in consultation with neonatologists and pediatricians at each site. Eligibility criteria for the cross-sectional study were the same as those for the longitudinal study, with the exception of infant feeding practices. A minimum of 3 months of any breast-feeding was the requirement for participants in the study’s cross-sectional component.

In adopting this design, the MGRS made operational the goal of selecting a population that reflects optimal nutrition, care, and environments to the best degree possible within the limitations of a community-based effort. The study recruited approximately 8400 children; approximately 1700 were followed longitudinally for 2 years and the remainder were enrolled in the MGRS cross-sectional component. The target was to obtain the equivalent of 400 children (200 girls and 200 boys) in the longitudinal and cross-sectional components.

Preliminary analyses supported expectations related to the similarity in growth of children less than 5 years of age across the diverse cultures and environments in which the MGRS protocol was implemented. Not unexpectedly, these preliminary analyses suggest that the bulk of the variability in length growth resides within populations, not between them. Thus, the MGRS will provide international standards for attained length-for-age, weight-for-age, and weight-for-length/height. The present international standards incorporate these indicators of physical growth. The new WHO standards, however, will provide a number of additional tools for assessing attained growth: BMI-for-age, head circumference-for-age, mid-arm circumference-for-age, triceps skin-fold thickness-for-age, and subscapular skin-fold thickness-for-age. International velocity standards also will be available for the first time for length, weight, length/weight, and body-mass index (BMI).

The anticipated WHO growth standards for infants and young children will incorporate several innovative aspects. They will reflect a prescriptive approach as the basis for selecting the population on which the new standards are based, thus explicitly recognizing the need for standards rather than only references. They rely on the breast-fed infant as the normative model. The sample will reflect a truly international sample, and its design enables the development of both attained and velocity curves. By relying on a prescriptive model, the new standards will provide the most accurate population description available of the normal range and distribution of various anthropometric measures in healthy children, and offer the potential for velocity standards. These features are expected to provide more accurate estimates of over- and undernutrition and improve the ability to identify children in the “process” of becoming under- or overnourished rather than waiting until a predetermined statistical cutoff is exceeded to make the diagnosis of either condition. Lastly, its design will link physical growth with motor development, and thus underscores that although normal physical growth is essential to normal development, it is not sufficient. It is hoped that this feature will continue to “raise the bar” in terms of the world’s expectations of itself in the treatment of children.

This effort’s longer-term aims are to provide sound international standards to assess growth. This effort also includes the development of training and other ancillary materials to promote their appropriate use, and thus contribute to the development, implementation, and monitoring of effective interventions designed to improve child health and evaluate our progress in achieving international goals related to improving the human condition.

REFERENCES