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Roger Shrimpton, Cesar G. Victora, Mercedes de Onis, Rosângela Costa Lima, Monika Blössner and Graeme Clugston

Pediatrics 2001;107;e75
DOI: 10.1542/peds.107.5.e75

Worldwide Timing of Growth Faltering: Implications for Nutritional Interventions

Roger Shrimpton, MSc, PhD*; Cesar G. Victora, MD, PhD‡; Mercedes de Onis, MD, PhD§; Rosângela Costa Lima, MD, MSc‡; Monika Blössner, Dipl oec troph§; and Graeme Clugston, MD, PhD§

ABSTRACT. ***Objective.*** **It is widely assumed that growth faltering starts at around 3 months of age, but there has been no systematic assessment of its timing using representative national datasets from a variety of countries.**

Methodology. **The *World Health Organization Global Database on Child Growth and Malnutrition* includes the results of 39 nationally representative datasets from recent surveys in developing countries. Based on these data, mean *z* scores of weight for age, length/height for age, and weight for length/height were compared with the National Center for Health Statistics and Cambridge growth references, for children younger than 60 months.**

Results. **Mean weights start to falter at about 3 months of age and decline rapidly until about 12 months, with a markedly slower decline until about 18 to 19 months and a catch-up pattern after that. Growth faltering in weight for length/height is restricted to the first 15 months of life, followed by rapid improvement. For length/height for age, the global mean is surprisingly close to National Center for Health Statistics and Cambridge references at birth, but faltering starts immediately afterward, lasting well into the third year.**

Conclusions. **These findings highlight the need for prenatal and early life interventions to prevent growth failure. *Pediatrics* 2001;107(5). URL: http://www.pediatrics.org/cgi/content/full/107/5/e75; *growth, body height, body weight, infant nutrition disorders, child nutrition disorders.***

ABBREVIATIONS. UNICEF, United Nations Children's Fund; WHO, World Health Organization; NCHS, National Center for Health Statistics; SD, standard deviation; NHANES, National Health and Nutrition Examination Survey; IMCI, Integrated Management of Childhood Illnesses.

Stunting affects 182 million (33%) and being underweight affects 150 million (27%) of the world's children[1]; these are associated with over half of the 10 million annual deaths of children under 5 years.[2] Developing countries account for almost all of this burden, with 70% of all early child mortality and malnutrition concentrated in sub-Saharan Africa and South Asia. Despite setting a goal of reducing malnutrition by 50% at the World Summit for Children,[3] few countries in these 2 regions will have been successful in achieving this goal by the end of the decade. It is our contention that one of the reasons for failure is the lack of clear definition and common understanding of what the problem is. The purpose of this article is to try to bring more clarity to these issues.

Waterlow[4] proposed a functional classification for child malnutrition that separated children who had acute malnutrition from those with chronic malnutrition. The acutely malnourished children were those with adequate height for age but inadequate weight for height (wasted). The chronically malnourished children were those that had inadequate height for age (stunted). Chronically malnourished children could also be acutely malnourished, in which case they would be both stunted and wasted. The Waterlow Classification was called a functional classification, because it helped decide what interventions were needed by the children being surveyed. Stunted children need little attention, because stunting cannot be reversed and they are in no immediate danger of dying. On the other hand, wasted children need urgent medical attention to prevent death.

The Waterlow classification was extremely useful for guiding curative interventions, but it did not indicate how the processes of becoming either stunted and/or wasted could be prevented, because it does not indicate when, what, and how the stunting and/or wasting happens.[5] Neither does it facilitate understanding at what age actions might be taken to prevent child malnutrition from occurring.

The Child Survival and Development Revolution, promoted by the United Nations Children's Fund (UNICEF) during the 1980s, contributed to the monitoring of children's growth becoming an almost universal practice,[6,7] The objective of growth monitoring is the early detection of growth failure, to allow timely remedial interventions and prevention of further growth failure. Several authors have suggested that growth faltering starts at about 3 months of life in developing-country settings,[5,8,9,10] However, most such publications have looked only at weight growth, not height growth, and were not population-based studies of national scale. The present paper is the first attempt to investigate globally the patterns

From the *Nutrition Unit, UNICEF, New York, New York; the ‡Postgraduate Program in Epidemiology, Universidade Federal de Pelotas, Pelotas, RS, Brazil; and the §Department of Nutrition for Health and Development, World Health Organization, Geneva, Switzerland.

Dr Shrimpton's current affiliation is with the Centre of International Child Health, Institute of Child Health, University College London, London, United Kingdom.

Received for publication Aug 30, 2000; accepted Nov 21, 2000.

Reprint requests to (C.G.V.) Postgraduate Program in Epidemiology, Universidade Federal de Pelotas, CP 464, 96001-970, Pelotas, RS, Brazil. E-mail: cvictora@terra.com.br

and timing of growth faltering and to discuss implications for developing interventions for prevention of child malnutrition worldwide.

METHODOLOGY

The *World Health Organization (WHO) Global Database on Child Growth and Malnutrition*[11] collates data from cross-sectional anthropometric surveys worldwide; 39 national samples from less-developed countries, each with >500 children aged 0 to 23 months, were reanalyzed to provide information on mean z scores by month of age. Table 1 shows the datasets included in the analyses with the corresponding numbers of children, and the age ranges for which the data were available. All but 3 surveys provided data from birth onward; 13 provided data until age 35 or 36 months, 2 until 47 months, and the remaining 24 until 60 months. All surveys were conducted between 1987 and 1997.

For every age group in each national sample, the mean weight for age, length/height for age, and weight for length/height z scores were calculated using the National Center for Health Statistics (NCHS) reference.[12] Mean weight for age and length/height for age z scores were also calculated relative to the Cambridge reference,[13] resulting from criticisms of the NCHS growth curves.[5]

For each of 3 regions (Africa, the Americas, and Asia), the average value of the national means was calculated. The global average of all studies was also calculated.

RESULTS

The initial analysis consisted of plotting the mean z scores by age for each country dataset, against the NCHS growth reference. In general, the national curves had remarkably similar shapes within each of the regions of the world, although their relative positions showed some variation (data available on request).

Figure 1 shows the global mean z scores, calculated from the 39 national survey population samples. At birth, the average weight for age, length for age, and weight for length are quite close to the NCHS reference. Growth faltering occurs thereafter, so that by 18 months the mean values of weight for age and length for age are between 1 and 2 standard deviations (SD) below the reference median value, while the mean weight for length is about −0.6 SD. The way the 3 indices behave during the first 3 months of life is different. Although weight for age stays horizontal and parallel to the reference for the first 3 months, length for age decreases. Consequently, the weight for length z score increases in this period. This observation raises the question of

TABLE 1. Nationally Representative Samples Included in the Analyses*

Region	Countries	Dates of Survey	Age Range (Months)	Number of Children
Latin America and Caribbean	Bolivia	1993–94	0–35	2860
	Brazil	1996	0–59	3815
	Paraguay	1990	0–59	3389
	Peru	1996	0–59	13431
	Colombia	1995	0–59	4408
	Guatemala	1995	0–59	7768
	Haiti	1994–95	0–59	2794
	Dominican Republic	1991	0–59	2883
	Trinidad and Tobago	1987	3–36	840
Asia	Pakistan	1990–91	0–59	4056
	Nepal	1996	0–35	3705
	Sri Lanka	1987	3–36	1993
	India	1992–93	0–47	24421
	Bangladesh	1996	0–59	4787
	Turkey	1993	0–59	3152
	Thailand	1987	3–36	1857
Africa	Kenya	1993	0–59	4763
	Rwanda	1992	0–59	4386
	Tanzania	1996	0–59	5344
	Uganda	1995	0–47	4775
	Zambia	1996–97	0–59	5443
	Zimbabwe	1994	0–35	2014
	Comoros	1995–96	0–35	921
	Madagascar	1992	0–59	4240
	Malawi	1992	0–59	3233
	Namibia	1992	0–59	2430
	Benin	1996	0–35	2273
	Burkina Faso	1992–93	0–59	4278
	Côte d'Ivoire	1994	0–35	3341
	Niger	1992	0–59	4052
	Nigeria	1990	0–59	5606
	Mali	1995–96	0–35	4678
	Ghana	1993–94	0–35	1818
	Senegal	1992–93	0–59	3865
	Central African Republic	1994–95	0–35	2310
	Cameroon	1991	0–59	2380
	Egypt	1995–96	0–59	9766
	Morocco	1992	0–59	4532
	Tunisia	1988	3–36	1996

* Source: WHO Global Database on Child Growth and Malnutrition.

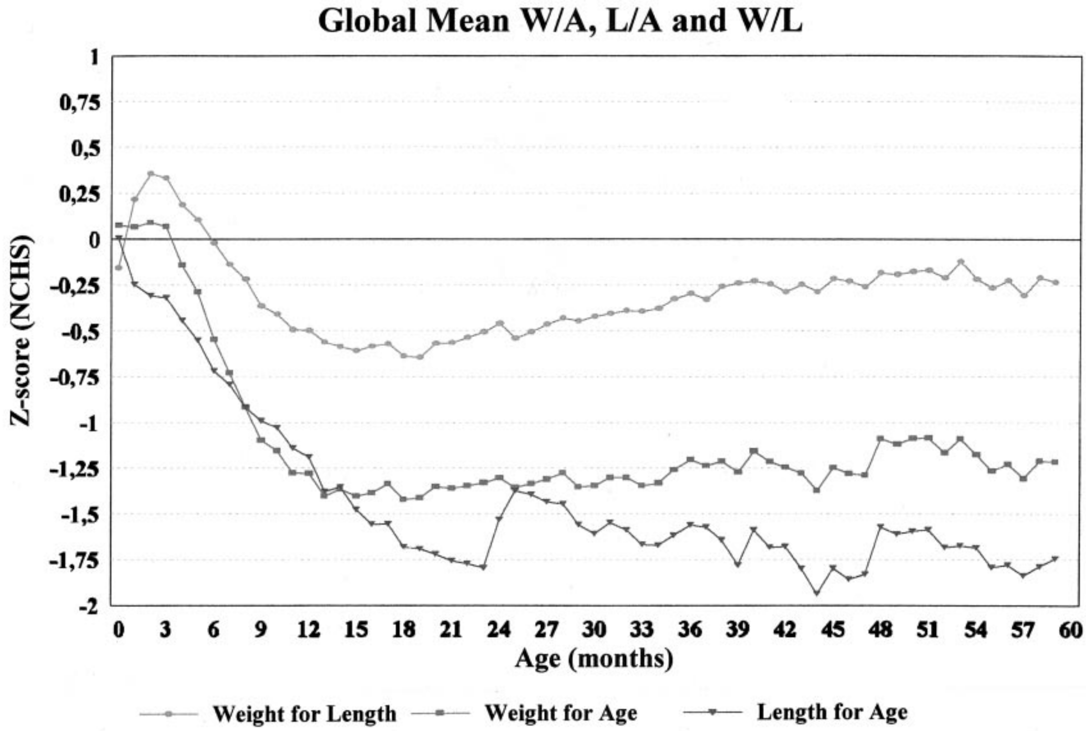

Fig 1. Mean anthropometric z scores by age for all 39 studies, relative to the NCHS reference (0–59 months).

why height growth is faltering when weight growth is apparently normal.

After the first 3 months, the falls in weight for age and length for age are similar until around 12 months of age, when weight for age stops decreasing, stabilizing at around −1.4 SD. Length for age continues to fall through until 24 months of age. The increase at 24 months is artificial and caused by the disjunction of the 2 datasets used for the NCHS reference (Fels and National Health and Nutrition Examination Survey [NHANES]).[5] Ignoring the disjunction, mean length/height for age continues to decrease until around 40 months. This finding was confirmed when the data were plotted against the Cambridge reference (see below). The weight-for-length profile declines after 3 months to about −0.7 z scores at about 18 months. Thereafter, it slowly increases to about −0.25 SD around 40 months of age, when it remains parallel to the reference profile. Data for 4- and 5-year-old children should be interpreted with caution because some of the datasets were restricted to children under 3 or 4 years.

The behaviors of these 3 growth profiles shows that the processes of becoming stunted and of becoming wasted are independent of each other. The process of stunting begins at birth and continues during the first 3 years of life. The process of wasting is concentrated in the period of 3 to 15 months. Thereafter, there is a process of gradual improvement in the wasting situation, so that by about 40 months there is little and the global mean is just 0.25 SD below the reference. However, the stunting that occurs in the first 3 years is not recovered thereafter.

In Fig 2, the weight-for-age means for Africa, Asia, and the Americas are compared. The 3 profiles have similar shapes but start and finish at different levels in relation to the reference. The lines are less steady after 36 months because they are based on fewer data points as some studies did not include 3- and 4-year-olds (Table 1). At 3 months, the Latin American and Caribbean mean z score is about 0.25 SD above the African mean, which is about 0.5 SD above the Asian mean. All means drop sharply until about 10 months, but run roughly parallel to the reference or even catch up slightly after 12 months. The differences between the 3 regions that were present at birth remain throughout the first 5 years of life.

In Fig 3, the length/height-for-age profiles of the three regions are compared. Unlike weight, the mean length z scores at birth are very similar in all 3 regions and the same as the growth reference. In all 3 regions, the mean z score of length for age falls sharply from birth to about 24 months. The magnitude of the drop in Latin America and the Caribbean is about −1.25 SD, whereas in Africa and Asia the drop is −2 SD. Again, interpretation of the profiles is affected by the 24-month disjunction in the NCHS reference, but after the 24th month the process of stunting seems to continue, albeit at a much slower rate.

The process of wasting in the 3 regions is shown in Fig 4. At birth, Asian children are on average 0.4 SD below African children, who are in turn 0.4 SD below Latin American children. In each region the mean z score rises about 0.5 SD, reflecting the maintenance of weight growth (Fig 2) in the face of length faltering (Fig 3). From about 3 months of age, the mean z scores for weight for length fall in all regions—about −1 SD—until about 9 to 15 months of age. At some time during the second year, mean length for age starts to improve in all regions, but regional differences persist. By 36 months of age the African child

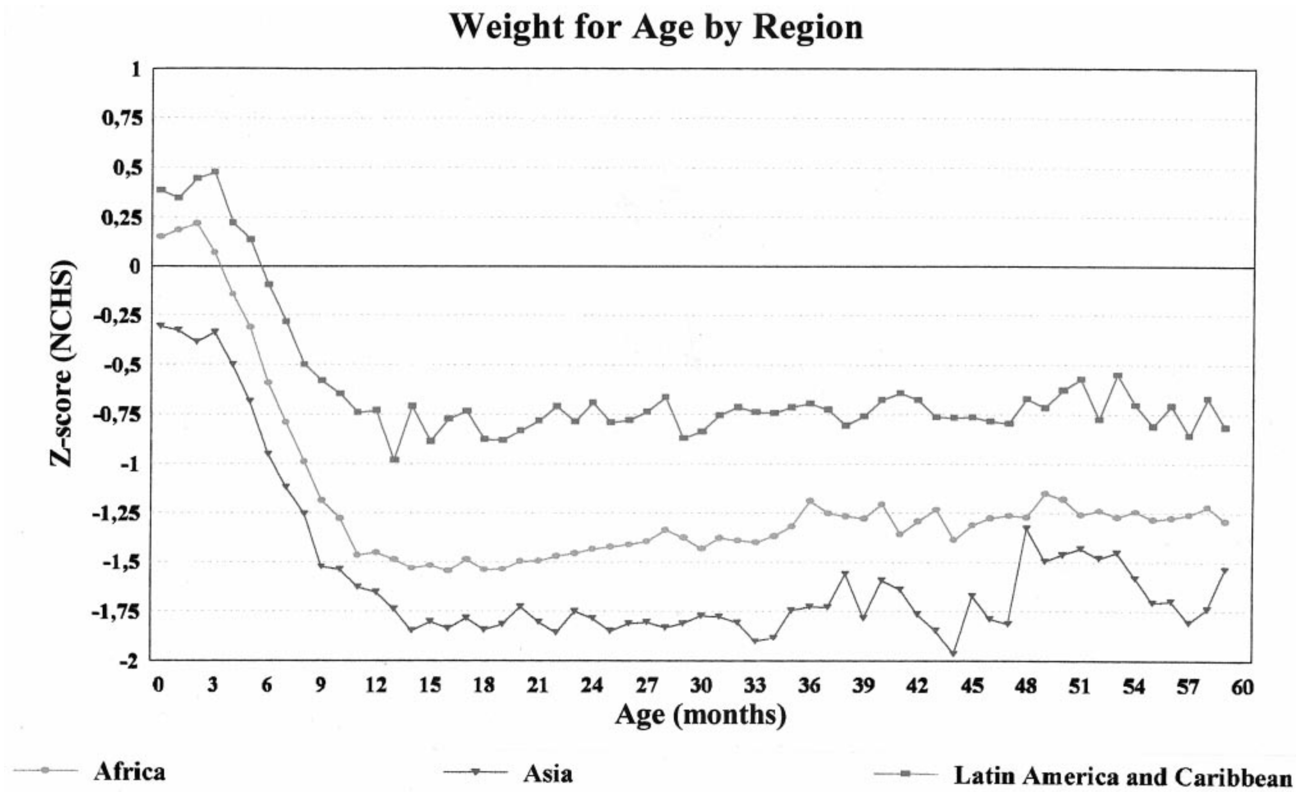

Fig 2. Mean weight-for-age *z* scores by age, relative to the NCHS reference, by region (0–59 months).

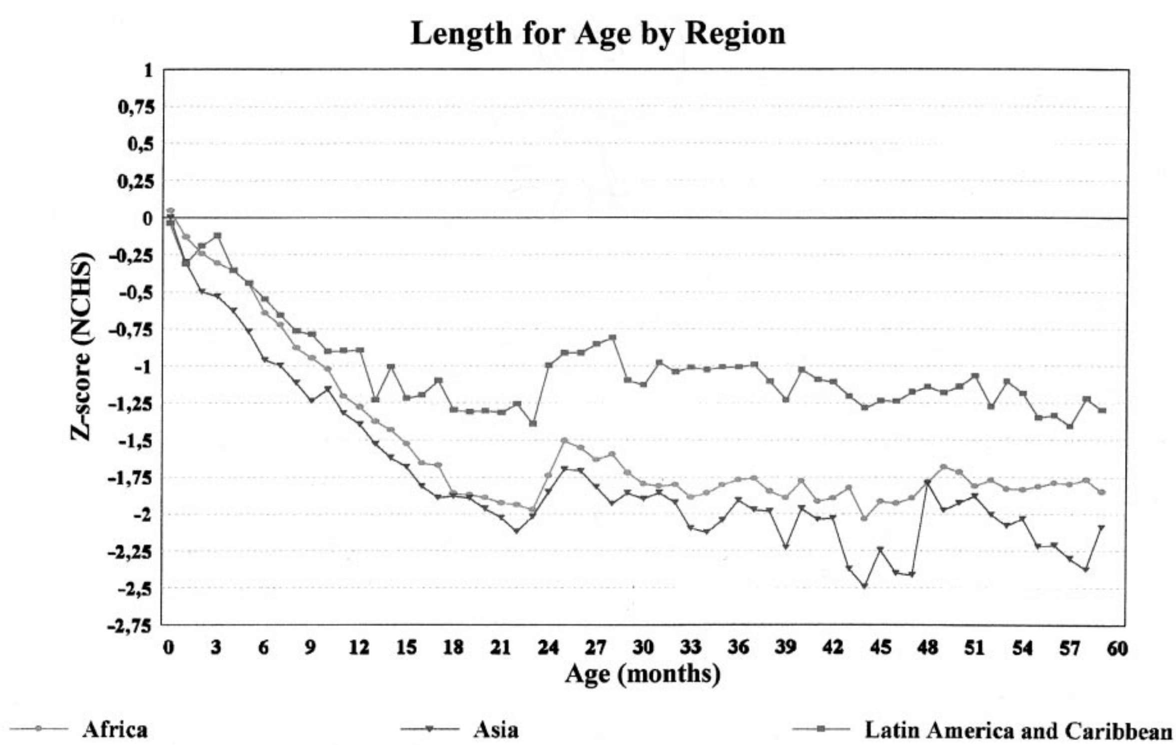

Fig 3. Mean length/height-for-age *z* scores by age, relative to the NCHS reference, by region (0–59 months).

is about 0.25 SD thinner, and the Asian child about 0.75 SD thinner than the average Latin American and Caribbean child. A possible tendency toward overweight children is observed in Latin America, where mean weight for height tends to be above the NCHS median after 39 months of age.

All analyses were repeated using the Cambridge reference (graphs available on request), but the conclusions were not affected.

Differences in the faltering patterns for height for age and weight for age were highly consistent across countries. For the 35 countries with data from birth

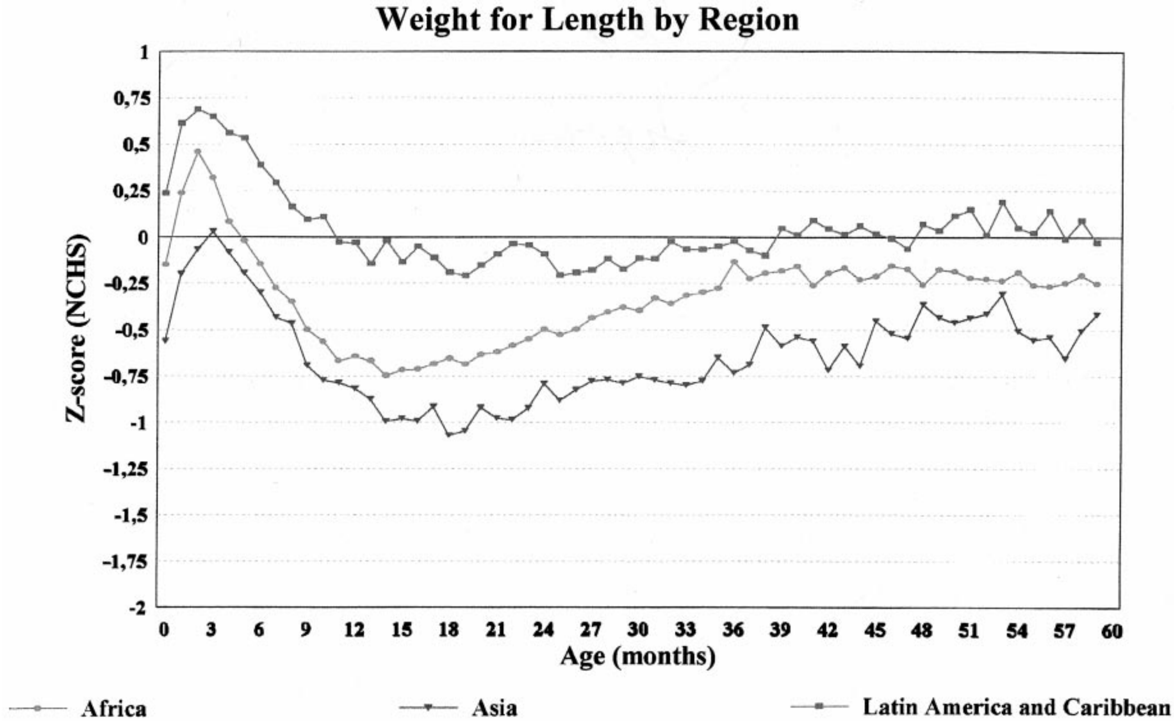

Fig 4. Mean weight-for-length/height *z* scores by age, relative to the NCHS reference, by region (0–59 months).

onwards (Table 1), 32 had negative *z* score changes in mean length for age from birth to 3 months. The average reduction was 0.37 *z* score (SD = 0.36). For weight for age, the average reduction was 0.07 *z* score (SD = 0.36); 17 of the 35 countries had reductions, and 18 had no change or increases.

DISCUSSION

This is the first attempt to investigate the timing of growth faltering on a global scale. The first striking finding was how similar the patterns of growth faltering were in different developing countries, not only within a region but also globally, despite the different instruments and measuring techniques used in the various surveys. A possible limitation is that although only nationally representative samples were included, data were not available for every country in each region, and thus the regional means are not necessarily representative. It was felt that weighting the results according to the country's populations was not warranted, for the same reason, and also because similar shapes of curves were obtained from the different surveys.

The NCHS reference has been criticized for several reasons,[5,14] including its inappropriateness to reflect the growth of breastfed infants and the 24-month disjunction. It is reassuring, however, that the analyses with both the NCHS and Cambridge references produced results that were very similar, with the exception of the artifacts resulting from the 24-month disjunction in the NCHS data.[5]

The use of data from 39 countries revealed interesting findings not apparent from previous analyses. The findings confirm the notion that, at the population level, wasting and stunting show different behaviors,[15] a fact not widely appreciated in relation to the timing of growth faltering. The findings also contradict common knowledge that faltering relative to international references starts at only about 3 months of age,[5] because faltering in length starts immediately after birth. This conclusion is supported by studies of the growth of individual children, showing that most of those malnourished at ages 3 to 5 years already presented anthropometric deficits at the end of the first year of life.[16,17] Additional research is needed to elucidate the reasons for the differences in the timing of height and weight faltering.

The importance of intrauterine growth retardation[18] on weight for age is evident. Because the curves for the 3 regions have similar shapes but markedly different starting points, improvements in intrauterine growth per se can be expected to reduce the prevalence of underweight. The sharp faltering in the first year of life confirms the importance of concentrating preventive interventions at this age or earlier. Curative interventions, on the other hand, are still important for older children, who will make up the majority of those diagnosed with malnutrition in health facilities.

The fact that in the 3 regions mean birth lengths were very close and similar to the NCHS reference median was unexpected and merits additional investigation. Accurate measurement of length is complex, but it is unlikely that errors would be systematic in all studies. Some type of intrauterine programming of birth length seems to be present, so that adverse fetal conditions affect weight but not length. In at least 1 study prenatal interventions have been shown to affect postnatal growth[19] despite having no effect on birth weight.[20] Therefore, prenatal interventions may still help prevent length faltering.

The main priority should be the development of effective interventions to stop the remarkable faltering—upwards of 2 SD in Asia—that occurs from birth to 18 months. Interventions should be sustained until the third year of life because faltering continues until this age.

Faltering in weight for length or height shows a very different pattern. Starting at about 3 months, it stops around 12 months and is followed by a marked recovery, particularly in Africa. In Latin America and the Caribbean, the recovery phase leads to mean values above the NCHS reference at around 40 months, indicating a higher prevalence of overweight. This is particularly worrisome because coronary heart disease seems to be particularly common among men who were thin at birth but whose weight caught up so that they had an average or above average body mass from age 7 years.[21]

It is unlikely that survival bias could explain the apparent catch-up in weight for length. First, prevalences of wasting were low in many countries that showed this pattern—for example, in the Latin American countries wasting is typically between 3 and 5%,[15] and mortality between ages 1 and 4 years is quite low. Second, it has been shown[5] that weight-for-length curves are remarkably similar in shape across a wide range of wasting prevalences. The whole weight-for-length curve seems to shift and there is no evidence that its shape would change resulting from selective mortality of wasted children.

Community-based growth monitoring was the central plank of the child survival and development revolution promoted by UNICEF during the 1980s.[6,7] The aim of growth monitoring is to weigh children and plot the weight on a growth chart to detect growth faltering early, allowing community workers to advise mothers on how to improve the growth of the faltering child. An evaluation of community-based growth monitoring programs in 6 countries in the early 1990s came to the conclusion that the weighing of children was often a mechanical act, which led to little action.[22] Insufficient effort went into training community workers. Growth monitoring has also been criticized for targeting all children under 5 years rather than being aimed at the first couple of years of life, when nutritional status is being determined.[15]

A somewhat different approach was adopted by the Integrated Management of Childhood Illness (IMCI) initiative. Promoted jointly by WHO and UNICEF, this is a broad strategy to reduce child mortality and morbidity in developing countries.[23] IMCI recommends that all children be weighed and that their weight be plotted on the weight-for-age chart. This preference for assessing weight for age rather than assessing adequacy of growth velocity is based on the recognition that often the sick child who comes to a health facility has no previous weight with which to compare current status.

Based on our findings, monitoring length or height would be more relevant than weight monitoring for the assessment of nutritional status. However, there are obviously many issues related to the feasibility and reliability of length measurement that would limit its wide adoption. Whatever the measurement being taken, growth monitoring constitutes primarily an individual-based, largely curative intervention in that it happens after the fact. Although it certainly has a role to play, the present results suggest that a preventive, population-based approach—aimed at improving the nutritional situation of affected populations rather than individuals[24]—would be more desirable, with efforts directed primarily at mothers and young infants. Much more attention needs to be given to the prevention of low birth weight.

Our findings have important policy implications. The data show that interventions during the earliest periods of life—prenatally and during infancy and early childhood—are likely to have the greatest impact in preventing child malnutrition. Types of interventions include culturally adaptable nutrition education on diet and feeding practices (with food supplementation if necessary), together with counseling on improved parental caring skills.[25] Given the complexity of the underlying and basic causes of the problem, new local specific efforts must be made to understand the specific economic, behavioral, dietary, and other factors affecting child growth and development. A number of community-based programs have had a substantial effect on declining child malnutrition rates.[26,27] Wider application of such programs is needed. Special effort should be made to improve the situation of women as primary child caregivers with particular attention to their health and nutrition throughout the life cycle. Similarly, a strong focus on complementary feeding and continued attention to the protection and promotion of breastfeeding remain key components for tackling the problem.

ACKNOWLEDGMENTS

This study was financed by the Nutrition Unit of UNICEF and by the Department of Nutrition for Health and Development of the World Health Organization.

We are grateful to Dr Allen Shoemaker for his assistance in the reanalysis of the national datasets.

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