Timing of growth faltering in rural Malawi

K Maleta, S Virtanen, M Espo, T Kulmala, P Ashorn

Aim: To determine the timing of growth faltering among under 3 year old children.

Methods: Prospective population based cohort study in Lungwena, rural Malawi, southeast Africa. A total of 767 live born babies were regularly visited from birth until 3 years of age. Weight, height, and mid upper arm circumference were measured at monthly intervals until 18 months and at three month intervals thereafter. Growth charts were constructed using the LMS method and comparisons made to two international databases: the traditional United States National Center for Health Statistics/World Health Organisation (NCHS/WHO) reference and the recently developed 2000 Centers for Disease Control (CDC) growth reference.

Results: Compared to the 2000 CDC reference population, newborns in Lungwena were on average 2.5 cm shorter and 510 g lighter. On a population level, height faltering was present at birth and continued throughout the first three years. Weight faltering, on the other hand, occurred mainly between 3 and 12 months of age. At 36 months, the mean weight and height of the study children were 2.3 kg and 10.5 cm lower than those of the reference population, respectively. The results remained essentially similar when the comparisons were made to the NCHS/WHO reference.

Conclusions: The fact that weight and height faltering do not follow identical time patterns suggests that they may have different origin and determinants. Further studies on the aetiology of height faltering and different approaches to preventive interventions are needed.

Suboptimal growth is a sensitive and readily measurable indicator of malnutrition or other health problems of under 5 year old children. Furthermore, growth faltering is associated with subsequent cognitive and physical disadvantage, morbidity, and mortality. Anthropometric assessment of growing children thus facilitates early identification and timely interventions for emerging health problems. On a public health level, analysis of growth patterns of specific populations allows the identification of the periods of greatest risk for malnutrition. This process is enabled by the universal similarity of growth potential in various populations of under 5 year old children. Comparison of growth in defined child populations to that of an international reference may thus lead to directed hypotheses of local growth limiting factors and most feasible health interventions in that specific area.

Poor childhood growth is a widespread public health problem in many low income countries, especially in Asia and sub-Saharan Africa. Most available evidence suggests that such growth faltering starts when the children are 4-6 months old. During the past decades, earlier growth faltering has been documented in some communities. Such findings have, however, at least partly been attributed to problems in the United States National Center for Health Statistics/World Health Organisation (NCHS/WHO) reference. Provoked by the criticisms, studies are currently underway to develop a more appropriate international growth reference. Meanwhile, however, a new reference, developed by the Centers for Disease Control (CDC) for the United States has been published. The new reference has addressed all the technical inadequacies of the earlier NCHS/WHO growth curves. Therefore, it is considered superior to its predecessor, although it is still based on largely formula fed infants. To date, however, not many large studies have used this reference to analyse the growth of infants from low income countries.

The time of onset of suboptimal growth is not a trivial question, as it significantly affects the target group and optimal strategy of effective health interventions against childhood malnutrition. In order to characterise growth and to identify main age periods of growth faltering, we carried out a cohort study in rural Malawi, a sub-Saharan country with widespread childhood malnutrition problems. For this purpose, a group of live born babies was prospectively followed from birth up to 3 years of age. Because of concerns about the reference, we compared growth in the study population to two international standards: the traditional NCHS/WHO reference and the recently developed CDC reference.

METHODS
Study area and subjects
The study was done in Lungwena, Mangochi District, in southern Malawi. A government health centre served an approximately 100 km² rural area with some 17 000 people in 23 villages. Most of the inhabitants were Muslims of the Yao tribe. The literacy rate was very low and subsistence farming (mainly for maize) and fishing formed the main occupation. The cultivated land areas were often small and many farmers had no alternative sources of income, leading to poor food security in the area. The climate was monomodal and the staple food, maize, was harvested in March to April.

The study participants were 767 live born babies from a community based cohort of 795 pregnant women. Because of a very high enrolment rate, the study cohort comprised approximately 95% of all newborn children in the area during the time of enrolment. Details of recruitment, collection of background data, and follow up have been described previously. The research protocol was reviewed and approved by the Malawi National Health Science Research Committee and informed consent was obtained verbally from each pregnant woman before enrolment.

Anthropometric measurements
Eight trained research assistants made home visits to collect anthropometric measurements at monthly intervals from

Abbreviations: CDC, Centers for Disease Control; NCHS, United States National Center for Health Statistics; WHO, World Health Organisation
growth reference from the United States CDC,\(^1\) and the traditional NCHS reference, promoted by the WHO (NCHS/WHO).\(^3\)

**Construction of growth curves**

The construction of the attained size growth curves was done using the LMS method described by Cole.\(^4\) In brief, the data were treated cross-sectionally in terms of computing the mean and standard deviation for each anthropometric measurement at each age group. One month age groups were used from birth to 18 months of age, and three month age groups thereafter. All visits done within three days (up to 18 months of age) and seven days (up to 36 months of age) of the expected date of examination were included in the analysis (age grouping). The distributions of weight and height were examined for normality, before and after transformation, by calculating skewness, kurtosis, and checking normality plots for the distribution at each age group. Data points suggesting a

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of primiparas</td>
<td>24%</td>
</tr>
<tr>
<td>Mean (SD) maternal height</td>
<td>153 (6) cm</td>
</tr>
<tr>
<td>Proportion of mothers with HIV infection</td>
<td>18%</td>
</tr>
<tr>
<td>Sex ratio of the newborns (male:female)</td>
<td>1.05:1.00</td>
</tr>
<tr>
<td>Mean (SD) term singleton birth weight</td>
<td>3100 (500) g</td>
</tr>
<tr>
<td>Proportion of preterm births (&lt;37 completed gestation weeks)</td>
<td>22%</td>
</tr>
<tr>
<td>Proportion low birth weight (&lt;2500 g)</td>
<td>15%</td>
</tr>
<tr>
<td>Proportion of twin births</td>
<td>2%</td>
</tr>
<tr>
<td>Median (25th, 75th centile) duration of exclusive breastfeeding</td>
<td>0.5 (0.5, 1.0) months</td>
</tr>
<tr>
<td>Median (25th, 75th centile) age at onset of complementary porridge</td>
<td>1.5 (1.0, 2.5) months</td>
</tr>
<tr>
<td>Median (25th, 75th centile) age at onset of family foods (Nshima)</td>
<td>6.2 (5.6, 6.8) months</td>
</tr>
<tr>
<td>Median (25th, 75th centile) size of annual diarrhoea episodes (infancy)</td>
<td>1.1 (0.8, 2.2) months</td>
</tr>
<tr>
<td>Median (25th, 75th centile) size of cultivated farm land (hectares)</td>
<td>0.4 (0.3, 0.8) hectares</td>
</tr>
<tr>
<td>Proportion of families without safe water</td>
<td>37%</td>
</tr>
<tr>
<td>Proportion of families with radio, mattress, or bicycle</td>
<td>46%</td>
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</table>

\(n=767,\) except for birth weight \(n=197).\n
### Table 2

<table>
<thead>
<tr>
<th>Age (mth)</th>
<th>Lungwena</th>
<th>WHO</th>
<th>CDC</th>
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<tr>
<td></td>
<td>3rd 50th 97th</td>
<td>3rd 50th 97th</td>
<td>3rd 50th 97th</td>
</tr>
<tr>
<td>0</td>
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<td>2.4 3.3 4.1</td>
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<td>3.5 5.0 6.4</td>
<td>3.8 5.1 6.3</td>
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<td>5.8 7.5 9.3</td>
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<td>9.9 12.2 15.0</td>
<td>10.2 12.4 15.3</td>
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<tr>
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<td>11.5 14.4 17.9</td>
<td>11.5 14.1 17.8</td>
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</tbody>
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\(3rd\text{ centile }= 1.18\text{ SD},\) \(50th\text{ centile }= \text{ median (0 SD)},\) \(97th\text{ centile }= 1.88\text{ SD}.\)

\(*\text{Data obtained from CDC growth charts, United States. Percentile data files with LMS values. http://www.cdc.gov/growthcharts (accessed 8 August 2002). Combined sex values obtained by averaging the male and female values.}\)

\(†\text{Data obtained from World Health Organisation. Measuring change in nutritional status: guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups. Geneva: WHO, 1983. Combined sex values obtained by averaging male and female values.}\)
significant deviation from examination of individual growth
trend line were considered questionable and discarded from
the analysis. For weight, deviations over 2 kg or 15% of the
interpolated value on the individual growth trend line were
excluded, whereas height values over 4 cm from the individual
growth trend line were similarly excluded. The estimated cen-
tile lines were plotted and smoothed using the LMS computer
program.

RESULTS

Subjects
Table 1 presents the background characteristics of the partici-
pants and their mothers. Of the 767 live born babies who
started the follow up, 128 had died and 62 absconded by 36
months of age. Measurements collected before their death or
losses to follow up were, however, included in the analysis. For
all participating children, the median (range) follow up time
was 27 (1–36) months.

In total, anthropometric data were collected at 13 728
independent home visits, of which 961 (7.0%) were excluded
from analysis because of age grouping and 38 (0.3%) home
visits were excluded because of questionable data quality. After
birth, the mean (range) monthly number of measurements
included in the analysis was 532 (504–562). Because of the large
number of home deliveries, birth measurements (within 48
hours of birth) were available from only 197 children (26 %).

Growth in Lungwena in comparison to the reference
populations
Figure 1 illustrates the growth pattern of the Lungwena chil-
dren compared to the 2000 CDC growth reference. At birth,
newborns in Lungwena were on average 510 g lighter and 2.5
cm shorter (table 2) than the reference babies. During the first
three months, the median weight in Lungwena increased rap-
20
16

110
100
90
80
70
60
50
40
30
20
10
0

lungwena
CDC

lungwena
WHO

lungwena
CDC

lungwena
WHO

Figure 1 Attained weight (A) and height (B) centiles (3rd, 50th,
and 97th) for Lungwena children compared to the 2000 CDC
reference; both sexes combined.

Figure 2 Attained weight (A) and height (B) centiles (3rd, 50th,
and 97th) for Lungwena children compared to the NCHS/WHO
reference; both sexes combined.

Growth in Lungwena in comparison to the reference
populations

reference population. Between 3 and 12 months of age, both
the median weight and the median height in Lungwena devi-
ated significantly downwards from the reference. After 12
months, the median weight in Lungwena consistently paralleled the 3rd weight centile of the reference population. For height, the Lungwena curves showed persistent, though slight, deviation from the reference even during the second and third year of life. At 36 months of age, Lungwena children
were approximately 2.3 kg lighter and 10.5 cm shorter than
the reference children.

DISCUSSION
Several factors have been associated with poor childhood
growth in low income countries. Of these, the most commonly
identified explanatory variables include suboptimal weaning
from breast feeding, enteral and other infections, and
inadequate dietary intakes. The first two—complementary
feeding and a concomitant increase in the incidence of enteral
infections—have received special attention, because their
occurrence presumably coincides in time with the typical age
of onset for growth faltering. However, strong conclusions
have been hampered by the fact that the commonly used
NCHS/WHO reference is based on mostly formula fed
infants, who are known to grow differently from their exclu-
sively breast fed counterparts. Therefore, the age of onset of
ture growth retardation in low income countries has remained
debatable.
In this community based cohort of rural Malawian children using both the new CDC as well as the traditional NCHS/WHO reference, babies appear not short at birth and linear growth faltering continued throughout the first three years of life. Weight faltering, on the other hand, was largely restricted to the period between 3 and 12 months. During the first three months, babies in Malawi actually gained more weight than the reference children, and after 12 months the populations were comparable in weight increments. The initial weight spurt in Lungwena could be explained by the fact that, although not exclusively breast fed by the WHO definition, the babies were predominantly breast fed during the first three months of life. At this age, exclusively breast fed infants are known to gain more weight than formula fed babies.  

Besides the known growth retarding effects of common infections and inappropriate complementary feeding, there are at least three potential explanations to the small birth lengths and poor linear growth in Lungwena. First, the prevalence of preterm deliveries was very high (22%), resulting in smaller than expected newborns. Additionally, because of the frequency of malaria and the low maternal intakes of energy during pregnancy, many babies may have suffered from intrauterine growth retardation. The fact that lengths were more compromised than birth weights is consistent with the hypothesis that fetal growth was affected before the third trimester. In such conditions, not only lipid accumulation but also cellular synthesis is compromised, leading to short newborns who do not express much catch up growth postnatally.  

A third possible explanation for the linear growth faltering is perinatal HIV infection, which was a widespread problem in the current study area (18% seroprevalence among the pregnant women). Previous studies from Malawi and elsewhere have shown that babies born to HIV positive women are lighter than those whose mothers are not infected, and they more often exhibit faltering of both weight gain and linear growth during infancy.  

Undoubtedly, there was also a familial component in the length gain of children in Lungwena. Mean adult female height in this population was only 155 cm. Male adult heights were not available, but in a comparable Malawian population the mean was 162 cm. Thus, a part of the apparent childhood growth retardation could have been a “physiological” shift across centiles to follow a predetermined familial path. However, this trend is unlikely to be genetic in origin, since under 3 year old children from more affluent families in Malawi and elsewhere in low income countries grow close to the NCHS/WHO reference.  

Until now, the community prevention and management of childhood malnutrition has largely focused on weight faltering and the period between 6 and 24 months after birth. Relatively little attention has been put on height gain faltering, although in many countries, especially in sub-Saharan Africa, stunting is much more prevalent than wasting. Although not often directly stated, inherent in this approach is the assumption that weight and height faltering have similar aetiologies and that the same interventions may correct both problems. In the light of the present results and those of others, it is not surprising that few interventions have been successful in correcting or preventing linear growth faltering. If linear growth is slowed down at birth (as in the present study) and remains so throughout the first three years of life, interventions focusing on a narrow age range do not address the whole problem. In areas where stunting is a major problem, intervention programmes targeting the infancy period coupled with early enough antenatal period interventions may thus prove to be more successful. 

One issue needs to be considered when interpreting the current results. Because of the high number of home deliveries, anthropometric data at birth were available only from every fourth newborn. Theoretically, this might have biased our results on low birth lengths. In practice, this was not a problem since the difference to the reference populations remained identical at 1 month of age, when length data were available from almost every study subject. Some studies have, however, not documented low birth lengths compared to the international reference standard. Thus, some caution is required when applying the current results to other conditions. However, because of the prospective community based design and high enrolment with very low dropout rate, the conclusion that weight and height faltering started at different periods is likely to be a true reflection of the situation in the study area. Similar results have been observed before in some other low income countries. 

Taken together, we have documented different periods of greatest risk for weight and height faltering among a cohort of rural Malawian children. Compared to two separate reference populations, weight gain faltering was generally restricted to the ages between 3 and 12 months of age, whereas height faltering occurred from birth and continued throughout the first three years of life. Because both weight and height faltering have important health consequences for growing children, both forms of growth failure need to be considered in a malnutrition prevention and management strategy. Traditional programmes encouraging breast feeding, correct weaning practices, and prevention of enteric infections should be complemented with appropriate antenatal and postnatal interventions against stunting. Further studies are however needed to clarify the details of such interventions.

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REFERENCES

Safety first

POSTCARD FROM THE ROAD

We arrived in Ayutthaya, about 60 km north of Bangkok in Thailand at the start of the festival Loi Krathong. Celebrated on the full moon day of the twelfth lunar month the event involves, at its simplest and most benign, the floating of little plate sized islands of flowers and candles down the river. At the other extreme it degenerates into the utterly uncontrolled release of fireworks in the street by adults and children alike. For a few pence you can buy a handful of fireworks and contribute to the mayhem. Or, you can buy a large sausage shaped bin bag with fuel source. This, held inverted with the fuel lit, becomes a little hot air balloon. After several moments of anxiety that the whole thing is about to catch fire, it soars up into the warm night air. After a while it winks out of existence—either too far away to see, or burning out, to be discovered in someone’s garden the next day like the sticks of rockets I’d search for on the 6th of November as a boy.

It’s preposterous of course. Dangerous beyond belief, and must result in as many casualties as the British 5th of November bonfire nights of old. Amidst the chaos you’ll see the familiar Thai spectacle of entire families of five crammed onto the one motor scooter—of course none wearing any sort of head protection. At other times and in other countries you’ll see children diving into rivers thick with effluent, and coming up laughing, looking as healthy as any child I’ve seen in the UK or Australia. You’ll see children balance with bare feet on needle sharp coral reefs before executing a beautiful, exuberant 1/2 somersault into barely a puddle of water. In still other parts of the world you can see children behind windows of houses or cars, motionless except for the fingers and thumbs which are intent on making Lara Croft execute a similar 1/2 somersault, in between conveying high fat, high sugar snacks into their mouths.

This is a jaded, cynical, and somewhat sarcastic comparison, and I’m almost ashamed to write it—but only almost. Risk, and risk taking, is such an essential feature of childhood and growing up—starting right from the peek-a-boo game where the child “risks” losing their playmate—that we’d be foolish to dismiss the essential role of risk in normal development. Being in dangerous—or apparently dangerous—situations teaches us a tremendous amount about how to handle them. However, this can put us, and those around us, at terrible risk of harm, injury, maiming, or even death. If we were to foolishly expose young middle class British children to Loi Krathong, in some sort of misguided attempt to toughen them up, they would do appallingly, and only those that survived would gain anything from the experience. Even as an adult I feared for my safety in a way that those around me must have found amusing. Learning by your mistakes as a useful educational tool only when the stakes are low—like a few bruises or a bump to the ego—but an entirely different matter when life and limb—your own, those around you, or those of your patients—are actually at stake.

As a boy of 10 I’d cycle near our house and further afield, unsupervised, mostly on quiet roads. If now, I saw an equivalent of myself, knocked off my bicycle and in an emergency department, would I have to fight the urge to scold my mother? Was the fact that I never ended up in an emergency room based on luck, or was it some superior ability to cope with my environment? I would say that I’m glad that I was never given fireworks to play with. I’m glad too that many children seem to wear cycle helmets. I feel less happy about some of the bubble wrapped children we see; who can rarely if ever play out in the street, and who are ferried in four-wheel drive cars to friends’ houses because the traffic is too dangerous—on account of all the four-wheel drive cars on the roads.

A few winters ago, a light fall of snow was taken by dozens of children as a cue to launch themselves down hills on poorly designed sleds, and, ultimately, into the emergency department where I was working. What struck me was our disapproval as we patched up these broken limbed children. Yes, I’d have preferred it if they’d worn a helmet, and maybe a face guard, and perhaps even done the simple calculation that they weren’t going to stop before getting to the trees at the bottom. But this has to be better than sitting at home and watching Lara Croft living their lives for them, doesn’t it?

I D Wacogne

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