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GROWTH OF PREVIOUSLY WELL-NOURISHED INFANTS IN POOR HOMES

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Critical Evaluation of New (or Enriched) Protein Sources (For the Prevention of Malnutrition)

ABSTRACT

Twenty-six children from very poor families were assured an adequate diet in a protected environment until 7.4 to 33 (average 17.6) months of age. Mean length for the 10 girls reached the 10th percentile, weight was near the 50th; mean length for the 16 boys reached the 25th percentile, weight was near the 75th. The norm for children from the same or similar families living in their habitual poor environment is near the 3rd percentile for length, the 10th for weight, from late infancy through childhood. In the first 6 months after returning to their original homes, the 26 children lost weight and failed to grow in length and head circumference, coming down to the same percentiles as the norm for their environment. Their growth then followed this norm until 4 to 8 years of age. In all groups, head circumference growth paralleled linear growth. In very poor environments, nearly maximal growth during most of the first two years of life does not offer any apparent protection against the stunting which is characteristic, and which may represent an appropriate adaptation.

It is commonly assumed that finite periods of severe undernutrition in early life lead to permanent stunting and probably to impaired mental development. Our own observations (1) and those of others (2) indicate that infants who were severely malnourished in early life may catch up in growth to their siblings, and suggest that such episodes do not produce deficits over and above those resulting from the chronic undernutrition characteristic of their home environments. Furthermore, a number of such severely malnourished infants who at some point after discharge from the hospital were adopted into much healthier environments demonstrated remarkable catch-up growth, bringing them very close to their presumed genetic potential (3). Eighteen infants from the same poor families were placed in a protected environment from shortly after birth until 18-27 months of age, when they had attained a height approximating the 25th percentile of U.S. standards. Within a year of returning to their original home environments, their mean height was below the 3rd percentile, indistinguishable from that of their so-called "healthy" or previously malnourished siblings (1). These observations demonstrated that an adverse environment was quite capable of wiping out, in a short time, the advantages of a favorable start in life.

When combined, the results of these studies suggest that among the very poor, chronic undernutrition and frequent infections determine the rate of growth shown by most children, significantly masking genetically determined patterns. Within

a family, whether a child has had an optimum start in life, has been severely malnourished as an infant, or has grown always at the relatively slow pace characteristic of that family and its total environment, would seem to make little difference to the body size achieved. It is important to consider the possibility that this "typical" growth pattern may be the most convenient for survival in such environments.

This report describes in some detail the growth of 26 children who were admitted to a convalescent unit before 3.4 months of age and remained there until 7.4 to 33 months of age, when they were returned to their original home environments. Included in the present 26 are most of the 18 previously reported (1). Their growth until a maximum of 8 years of age is compared to that of a large group of siblings of severely malnourished infants (4). All of the children in this large group had always lived at home and none had ever been treated or hospitalized for malnutrition. The 26 children all came from families included in this larger population.

METHODS

All 26 infants admitted to the convalescent unit were younger siblings of severely malnourished infants. Their mothers had repeatedly failed to feed their older siblings successfully at the breast, and their attempts at artificial feeding in their very poor homes had resulted in severe malnutrition and high death rates. The 26 infants in question

had already been weaned from the breast and were facing an equal or worse fate. Most of them were still in excellent health, and those that were not, responded promptly to proper feeding and a clean environment.

In the convalescent unit all infants were given modified cow's milk formulas, with supplementary feedings of solid foods after 6 months of age. After one year of age evaporated milk replaced the formulas. Routine immunizations were carried out at appropriate ages, all intercurrent illnesses were carefully monitored, and treatment was given when indicated. Within the constraints of an institutional setting, a concerted effort was made to provide a maximum of stimulation and learning opportunities. After some unfortunate early experiences, all the infants were offered, for some weeks prior to discharge, dietary items similar to those characteristic of their homes, and were taught to be as self-reliant in eating and other bodily functions as was compatible with their ages.

Of the 10 girls included in this report, 5 were admitted to the convalescent unit during the first two weeks of life, one during the second month, three during the third month, and one at 3.4 months of age. Of the 16 boys, 6 were admitted during the first month, 8 during the second month, and two during the third month of life.

Three of the girls were discharged home at 16 months of age, 4 at 18 months, one at 19 months, one at 27 months, and one at 28 months of age. One of the boys was discharged home at 7.4 months of age, one at 10 months, two at 11 months, one at 13

months, one at 14 months, three at 15 months, three at 18 months, one at 19 months, one at 22 months, one at 24 months, and one at 33 months of age. The date of discharge was determined primarily by our judgment of each mother's ability to offer her child a reasonable chance of healthy survival.

Measurements of length, weight and head circumference were made monthly, on the day corresponding to the birth date, during the stays in the unit. After discharge the children were measured every six months during the first year, and yearly thereafter, usually on the anniversary of their discharge from the unit.

Because durations of stay in the convalescent unit were not equal for all the children, only the ages of 0.5 to 18 months, during which most of them were represented, were chosen for regression analysis, individually and by sex. A computer program was used to determine the polynomial equations that best fit the data for length, weight, and head circumference, each parameter regressed against age (5). The 95% confidence limits were calculated by a "General Regression Program" written by D. R. Bolling, Department of Medicine, Johns Hopkins University School of Medicine.

After discharge, the anthropometric data were grouped by age and sex, with means and standard deviations calculated for 12-month periods with mid-points at 24, 36, 48, 60, 72, 84 and 96 months of age. It must be noted that, because they remained in the unit beyond the age of 18 months, some of the boys and girls are included in the post-discharge mean measurements at

24 months (18 to 30 months) when in reality they were still in the unit. One boy is similarly included in the mean for 36 months. This was done to simplify presentation.

RESULTS

The regression equations for each sex which best fit weight, length and head circumference on chronological age up to age 18 months were cubic in nature, i.e. third degree polynomials (Table I). In figures 1 and 2, for girls and boys respectively, these equations for length (height) and weight are represented graphically, with their 95% confidence limits, against a background of the mean measurements (±2 S.D.) of the large group of typical siblings of malnourished infants, already published (4). Beginning at 24 months of age, we have plotted the means ±2 S.D. of the subjects of the present study when at least 10 were represented, and the means plus individual data when less than 10 were represented. Figure 3 does the same for the head circumference of both sexes.

When the growth of the 10 female infants during their stay in the unit was plotted against the commonly used United States standard (6), length followed its 10th percentile, and weight the 25th percentile until 14 months, almost reaching the 50th at 18 months. In the larger population of typical infants, length fell from the 10th percentile at 6 months to just below the 3rd at 18 months, although weight remained close to the 10th percentile (4). The difference between the two groups after 6 months of age is apparent in figure 1, where they are

plotted together. When the individual growth patterns for each of the 10 female infants in the present study were examined, it was apparent that the percentiles achieved by 6 months of age were maintained only until the time of discharge, whether this occurred before or after 18 months of age. At the time of the "24 month" measurement, when most of those represented had been home for 6 months, there had been an insignificant gain in mean body length and a loss of almost 300 gm in mean body weight (figure 1). As a result, their mean measurements were now almost identical to those of girls who had spent the first 24 months of life in very poor environments. From that time until 96 months (8 years) of age the measurements of the two groups remained indistinguishable. Head circumference growth (figure 3) followed a pattern very similar to that of body length (height), but with less difference at 12 and 18 months of age. When compared to the United States standard, the head circumference of these 10 female infants had been near the 3rd percentile at 12 months, the 10th at 18 months.

When the growth of the 16 male infants was plotted against the United States standard, length was very near the 25th percentile at 18 months, weight just over the 75th percentile. For the larger group of typical males, length had fallen to just above the 3rd percentile, weight to approximately the 10th at 18 months. Figure 2 illustrates the widening difference between the two groups after 6 months of age, when as in the case of the girls, they were quite similar. By the time of the

"24 month" measurement there had been no further linear growth and a mean weight loss of 1.1 kg, so that length was just below the 3rd U.S. percentile and weight at the 10th percentile. From that point until 96 months of age, mean lengths and weights were almost identical to those of boys who had always lived at home. Head circumference (figure 3) followed a course almost identical to that for body length.

DISCUSSION

In a group of 26 children (10 girls and 16 boys) from extremely poor families, we have demonstrated that a protected environment and a generous diet will result in growth patterns, from 6 to 18 months of age, which are far superior to those of their own siblings or those of a larger population, seemingly healthy, but living continuously in poor homes. These last grew as well as the study group until 6 months of age, when there began a considerable slowing in the rate of linear growth, weight gain, and head growth. Whether growth was maximal, as presumed in the 26 children, or considerably slowed by the adverse environment, as in the larger group, the children were not underweight for length (or height) by United States standards. Whether this mild "obesity" is a racial characteristic, as seems to be the case for Eskimos (7), or a tendency of some poor children, even of European origin (8), is not clarified by these studies.

Within less than one year of returning to their original home environments, these 26 children were not different in

height, weight, or head circumference from the norm for the population from which they came. During this initial period at home they lost weight and failed to grow in length or head circumference. Thereafter they resumed growth at the same rates as the larger population, remaining indistinguishable from it for as long as they have thus far been observed, 4 to 8 years of age.

Although one might speculate about various environmental factors adversely affecting growth, it is almost certain that they all act by altering food intake and utilization. Preliminary analysis of data collected from 7-day individual dietary weighings in many of these families by Miss Hilary M. Creed suggests that the important factors limiting total food intake are meal frequency and the intakes of fat and of animal protein. Body size in these families is to a great extent a function of the environment, particularly as it relates to food. A larger child, with greater calorie and protein requirements, would first be "brought down to size" before growth could proceed.

It is generally accepted that head circumference predicts brain weight and cellularity (9) and, because of the much more rapid early growth of the brain relative to the whole body that malnutrition in early life will selectively affect brain growth (10). The logical corollary of this last assumption would be that adequate nutrition during the first two years of life should assure nearly optimal brain growth. All our studies to date suggest that brain growth, as estimated from head circumference, closely follows linear growth, slows or stops when

this does, and accelerates when it does, regardless of age (3).

ACKNOWLEDGEMENTS

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Table I

Best fit linear regression equations between body weight, length, and head circumference on chronologic age, between 2 weeks and 18 months of age, for 16 boys and 10 girls.

	Sex	Linear Regression Equations	"P" of cubic Component
Body Weight (kg)	boys	$Y=2.49+1.112x-0.0624x^2+0.0017x^3$	<0.005
	girls	$Y=2.41+0.984x-0.0537x^2+0.0014x^3$	<0.01
Length (cm)	boys	$Y=48.9+3.908x-0.234x^2+0.0063x^3$	<0.001
	girls	$Y=47.3+3.633x-0.203x^2+0.0052x^3$	<0.001
Head Circumference (cm)	boys	$Y=34.7+1.862x-0.115x^2+0.0028x^3$	<0.001
	girls	$Y=32.8+1.930x-0.120x^2+0.0029x^3$	<0.001

LEGENDS FOR FIGURES

Figure 1 - Growth in length and weight of 10 girls in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 72 months, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).

Figure 2 - Growth in length and weight of 16 boys in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 48 months, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).

Figure 3 - Growth in head circumference of 10 girls and 16 boys in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 72 months for girls, to 48 months for boys, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).

Figure 1

Growth in length and weight of 10 girls in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 72 months, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).

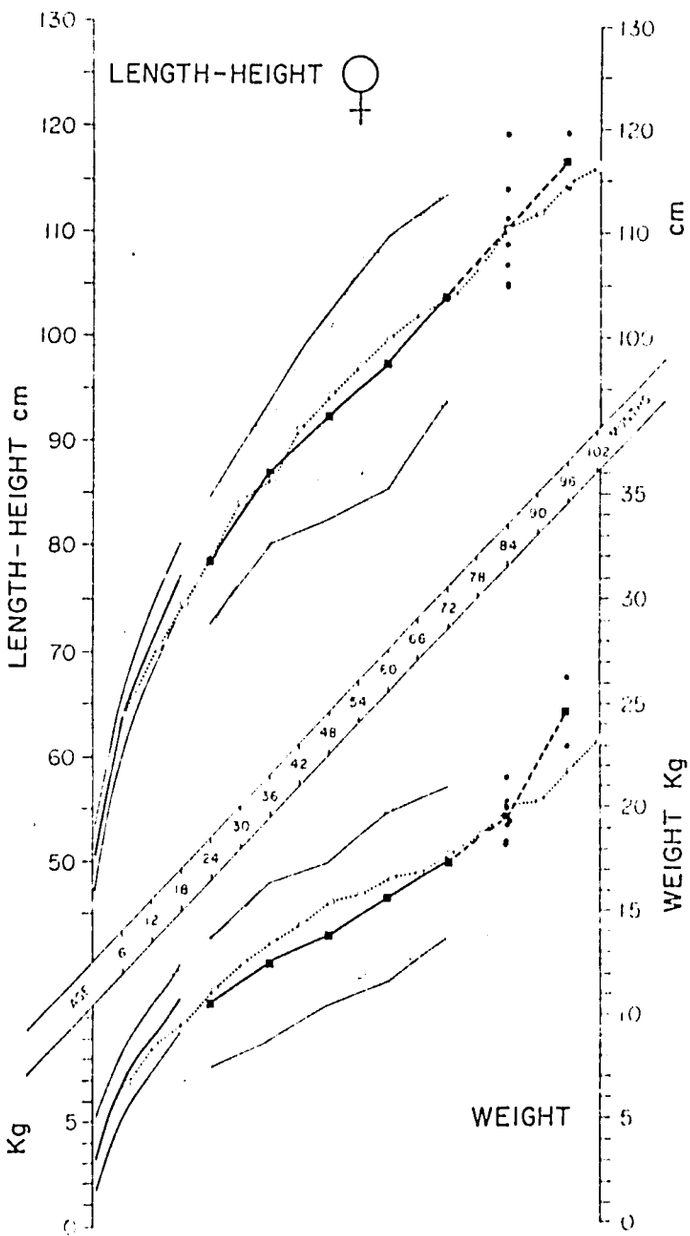


Figure 2

Growth in length and weight of 16 boys in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 48 months, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).

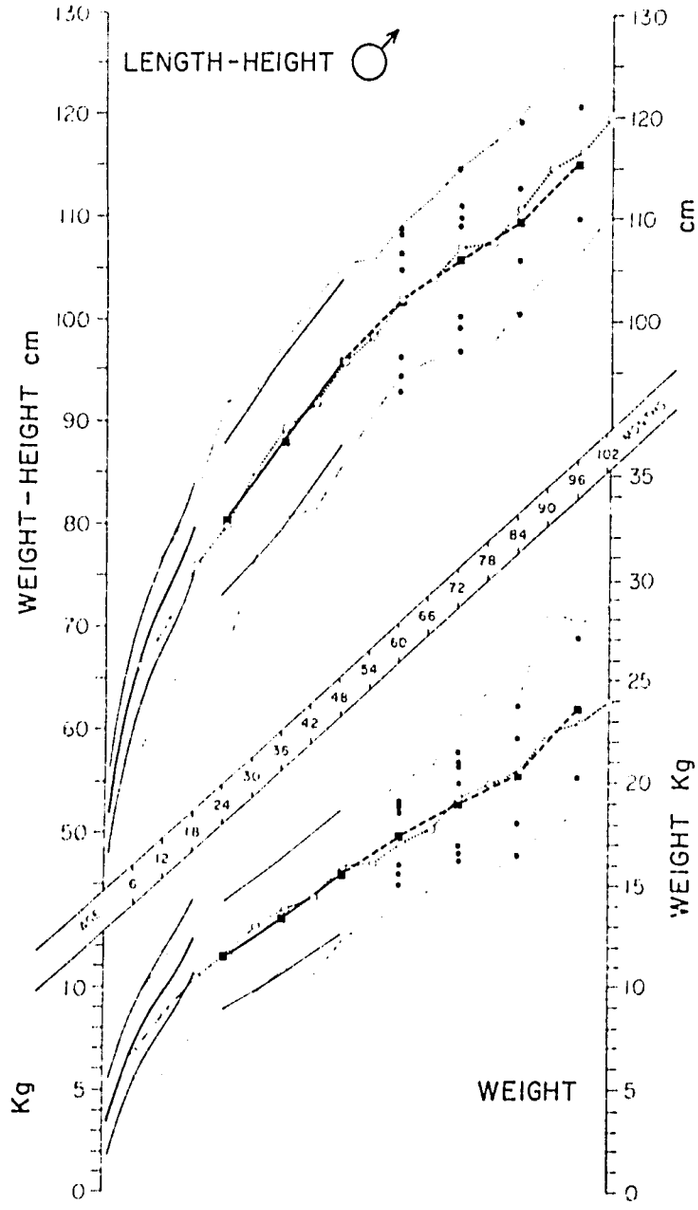
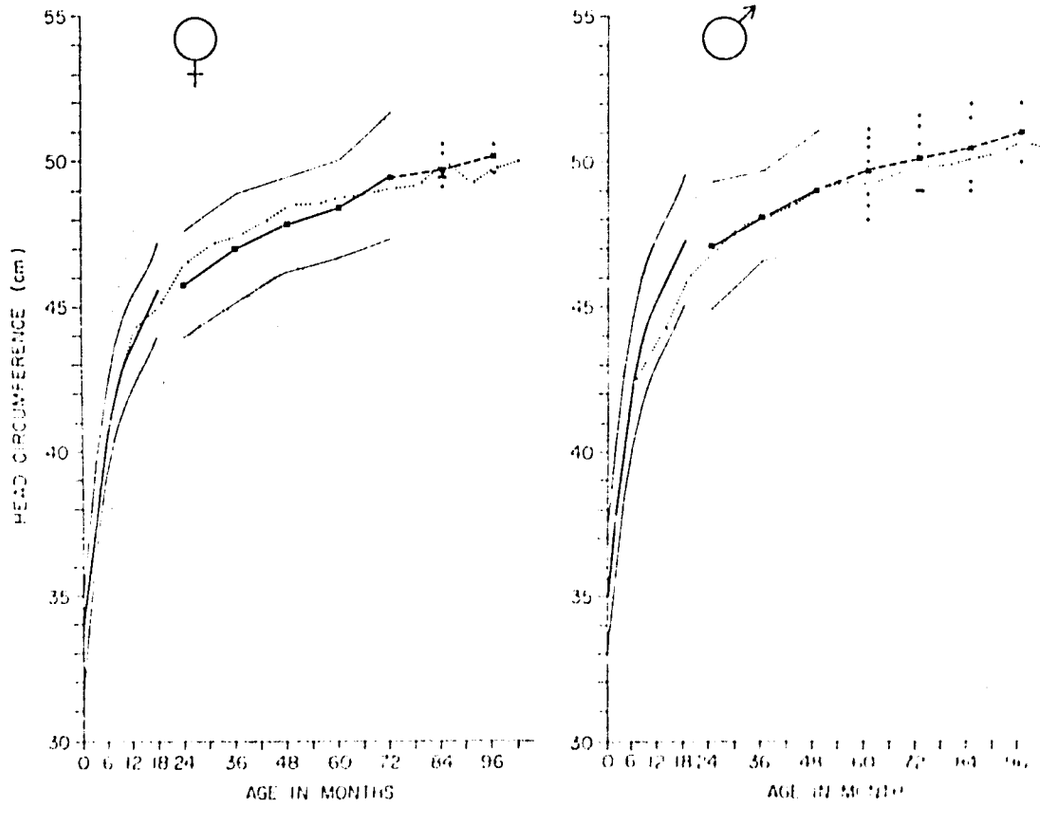


Figure 3

Growth in head circumference of 10 girls and 16 boys in a protected environment until 18 months of age (regression equation and 95% confidence limits in solid lines) and in very poor homes thereafter (mean ±2 S.D. in solid lines from 24 to 72 months for girls, to 48 months for boys, mean in broken line and individual values to 96 months), compared to usual growth in same poor environment (mean ±2 S.D. in dotted lines).