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The Utility of Infancy Weight Curves for the Prediction of Linear Growth Retardation in Preschool Children

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ABSTRACT. Simondon, K. B., Simondon, F., Cornu, A. and Delpeuch, F. (ORSTOM, Institut Français de Recherche Scientifique pour le Développement en Coopération, Tropical Nutrition Units of Dakar, Senegal; Brazzaville, Congo and Montpellier, France). The utility of infancy weight curves for the prediction of linear growth retardation in preschool children. Acta Paediatr Scand 80: 1, 1991.

Routine weight measurements, recorded on health cards of 95 Congolese infants, were collected during a cross-sectional survey as the children were aged 1 to 5 years. The subjects were divided into two groups according to height-for-age (more or less than −2 SD of NCHS reference) at the time of the survey. Adjustment of a mathematical function to the infancy weight curves allowed comparison of groups using the means of the function's parameters: The stunted children had been significantly lighter than the healthy group during infancy. Predictive values of estimated weights and quarterly weight gains were assessed by discriminant analysis and cut-off points were computed. The weight gain between 3 and 6 months of age predicted stunting just as well as weight at age 1 year did. Sensitivity and specificity were at 77% and 74%, respectively. These results suggest that good prediction of stunting is possible from first-year weight measurements. ***Key words: infancy, weight, growth monitoring, protein-calorie malnutrition, modelling, prediction.***

Linear growth retardation, also named chronic malnutrition or stunting (1), is very prevalent in less developed countries and weight monitoring programmes aiming at centres during infancy were copied from the children's health cards, when these were available in their homes, and the corresponding ages noted. For weighing, most Congolese health centres use Salter Spring balances.

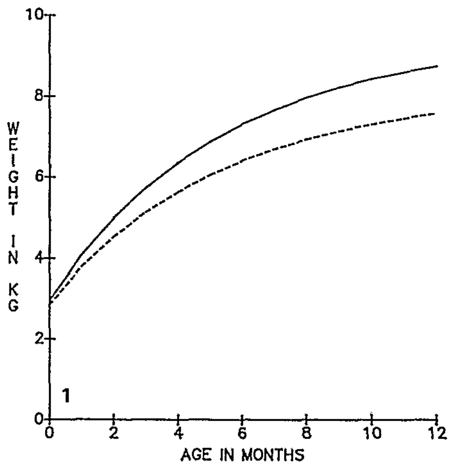
In 834 children health cards were available showing at least one weighing during infancy. Only 95 children had been monitored from birth up to age one year. These were selected for the present study. The number of readings ranged from 7 to 11, and birthweight was known for 79% of the children. The children's ages at the time of the survey ranged from 12 to 60 months with a mean of 28.0 months. Fourty-six children were aged 1 to 2 years, 24 children were aged 2 to 3 years and 25 children were aged 3 to 5 years. The majority of the children (94%) lived in the southern part of the country, 57% in large villages (more than 2000 inhabitants) and 37% in smaller villages.

Growth modelling. The statistical analysis of the growth data gave rise to some methodological problems, because measurement ages and spacing of measurements differed between children. Modelling of growth by adjustment of a mathematical function to the individual growth curves permitted comparison between curves and estimation of weight at any time-point, independently of measurement ages. The infancy component of the Karlberg model (5) was selected from the models proposed for early childhood, according to criteria of goodness of fit and independence of parameter estimates (6). This three-parameter non-linear model is as follows:

$$Y=A+B(1\text{-}\exp(-C\cdot t)),$$

where t is age (here in months) and Y is the anthropometric variable (here weight in kilograms). A, B and C are the parameters, which are constants for a particular child but allowed to vary between children. According to the function, birthweight is estimated by A and "final" weight by $(A+B)$. The curvature is estimated by $\exp(C)$. The fitting was achieved, child by child, by the non-linear regression programme BMDP 3R using Gauss–Newton iterations. Thus, the serial weight data for each child was reduced to three parameters.

Analyses. The aim of the analysis was to relate the infancy weight curves to the nutritional status of the children at the time of the survey, as they were aged one to five years. Children were separated into two groups, stunted or healthy according to height-for-age at the time of the survey. Linear growth retardation was defined by a height-for-age lower than −2 standard



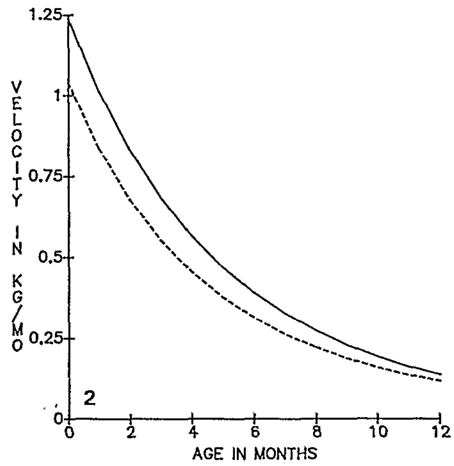


Fig. 1. Mean infancy weight curves of stunted and healthy children.

Fig. 2. Mean infancy velocity curves of stunted and healthy children.

Two discriminant analyses were carried out stepwise in order to assess the discriminating power of weights and quarterly weight gains. First, the 12 monthly birthday weights were months. Knowledge of weights at earlier ages did not improve the prediction. Neither did the initial risk factors like birthweight or mother's height. Only the knowledge of the sex of the infant improved the prediction. The prediction provided by weight at age 12 months and sex had a sensitivity of 77 % and a specificity of 76 %. At a prevalence of 23 %, the selection procedure had a PPV of 50 % and a NPV of 92 %. The function resulting from the discriminant analysis was used to calculate cut-off points for weight at age 12 months for boys and girls separately. Boys lighter than 8.80 kg and girls lighter than 7.35 kg belonged to the at-risk group, comprising 35 % of the sample.

Using the growth curve in this cross-sectional fashion is not very satisfactory. Therefore, weight gains (increments) were tested in a second discriminant analysis. The most predictive weight gain was the one between ages 3 and 6 months. Together with sex, it was as predictive as weight at age 12 months (sensitivity = 77 % and [redacted]

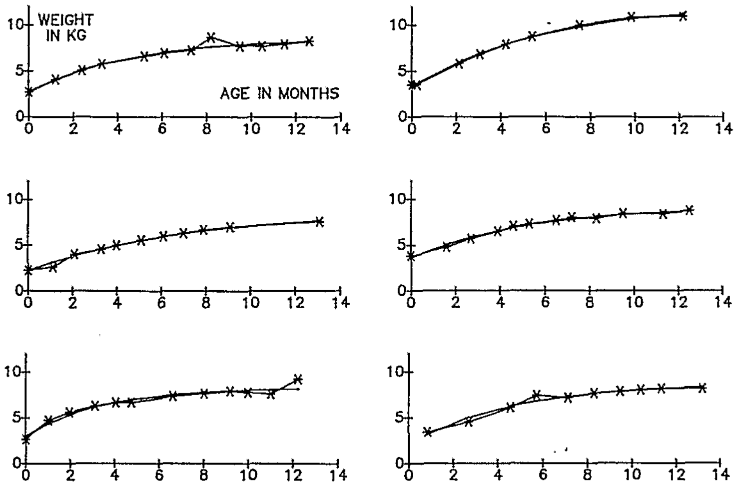


Fig. 3. Stimated infancy weight curves and raw data of six, randomly selected children.

nutritionally at-risk population, and that low weight gains at that age are closely associated with linear growth retardation later on.

Prediction of growth retardation by cross-sectional measurements of weight and height at different ages has previously been tested in a sample of 239 Mexican children by Scholl et al. (9). Weight at age one year had the same predictive power as in the present investigation (sensitivity = 73 % and specificity = 72 %) on growth failure at age 3 years. Length at age one year was less specific (sensitivity = 76 % and specificity = 63 %). The authors stated that "neither age related weight nor length adequately identifies growth failure from birth up to age 6 months".

An important finding of the present study is that early prediction of linear growth retardation can be provided by the weight gain between ages 3 and 6 months. Unless effectively treated, one-half of the selected at-risk infants will develop linear growth retardation, while only 8 % of the non-selected infants will become stunted. Weight gains from the second half of infancy have poor discriminating power, probably because all children slow down at that time.

The results presented here were obtained using estimated weights and weight gains. A comparison of estimated curves and raw weight data is given in Fig. 3. The model described the general growth pattern very well, but irregularities, due to measurement errors or temporary weight losses, were ignored. Therefore, predictions using raw weight data are not likely to perform so well. Furthermore, systematic under- and over-estimations at any of the ages under consideration would influence estimated weight gains more than estimated weights. However, very little bias was observed using the Karlberg model on this data (6).

In conclusion, the cut-off points should be considered merely as examples since they are likely to vary substantially between samples and populations. The predictive values obtained are very promising but need validation on large samples of raw infancy weight data from the Congo and other countries. It is especially important to determine whether weight gains permit earlier detection of at-risk infants than weights do, since early detection would improve the effectiveness of interventions.

Age at the onset of linear growth retardation, and the relationship between gains in weight and in recumbent length during infancy, are important topics for further studies.

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