# THE INFLUENCE OF PROTEIN-CALORIE MALNUTRITION ON PSYCHOLOGICAL TEST BEHAVIOR[1]

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## INTRODUCTION

Although it is well recognized that both heredity and environment influence mental development, the question of the relative importance of each is still controversial. Attention, thus far, has been centered primarily upon parental attitudes, and attitudes toward education, in conjunction with certain socio-economic variables. It has been assumed, furthermore, that several other environmental factors are either of such minor importance or are so higly correlated with socio-economic standards that they are not worth studying separately. It seems, therefore, that the effects of dietary deficiencies upon mental development have not been systematically investigated, probably because infantile malnutrition has been mistakenly equated with poor socio-economic status.

It is true that field studies aimed at evaluating the nutritional status of high and low socio-economic groups have revealed marked differences in dietary intake *per capita,* but a more important finding is that even among moderate and high income groups, traditional patterns of feeding often prevent, at the time most needed, infants from being fed adequate amounts of the nutritious foods consumed by older children and adults in the family (Autret and Béhar, 1955; Cravioto, 1958). As a consequence of this cultural practice, protein-calorie malnutrition is such a common ailment that in large areas of the world very few infants escape it in a more or less severe form (Davies, 1952).

Studies of somatic growth of infants where protein-calorie malnutrition is prevalent have shown that even those children who develop kwashiorkor have generally grown well during the early months of life when breast-feeding provides adequate nourishment (Sénécal, 1957; Ramos-Galván and Cravioto, 1958). Later, because suitable supplements are not added when the mother's milk can no longer supply the infant's requirements, growth begins to be retarded. This can easily be detected after the child is weaned, for then growth practically ceases (Waterlow, 1948). If the infant is then subjected to the added stress of an infection, he either dies or goes through several tortuous months of ups and downs until he finally improves his competitive position for food in the family and the family's prejudices about foods that are bad for him diminish. By this time, too, his food requirements have diminished because of his smaller dimensions (Scrimshaw, 1959).

Certain evidence, both in human infants and in experimental animals, has shown that severe protein malnutrition also affects the normal pattern of biochemical maturation (Cravioto, 1962), but at present

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little is known about the effect of chronic protein-calorie malnutrition on the neurological status of the child. The principal question to be answered in this regard is: Is the degree of protein-calorie malnutrition which can produce retardation of somatic growth and biochemical development also sufficient to produce transient or permanent retardation of mental development?

Preliminary attempts to estimate quantitatively the relationship between nutritional status and mental activity have been made in children of various ages, mainly in Uganda and Mexico. The present report summarizes the most important findings of these studies and draws attention to the importance of continuing these explorations through long-term longitudinal field studies.

## 1. The Child from Birth to Three Years

Cross-sectional studies of mental activity conducted in Africa and Mexico, using the André Thomas method and the stimuli of the Gesell (1951) technique, show that children in these areas are born in a more advanced state of psychomotor development than North American and European children. The Gesell tests, usually considered suitable only for children more than one month old, can be used with younger African and Mexican children because their development at 2 or 3 weeks often is equal to that of Western European children two or three times as old. Beginning at about 4 weeks, however, the African and Mexican children show a progressive decline, so that by the ages of 18–24 months, their scores are inferior to those obtained by their European counterparts (Faladé, 1955; Llopis de Peinado, 1956).

Expressing the Gesell development quotients ($Y$) for a given age ($x$) on the basis of a scale where 100 represents the performance of the "normal" North American or European child of the same age as the child being tested, the relationship suggested above could be described by a curve of the form $Y = ax^{-}b$ for the total age range; a

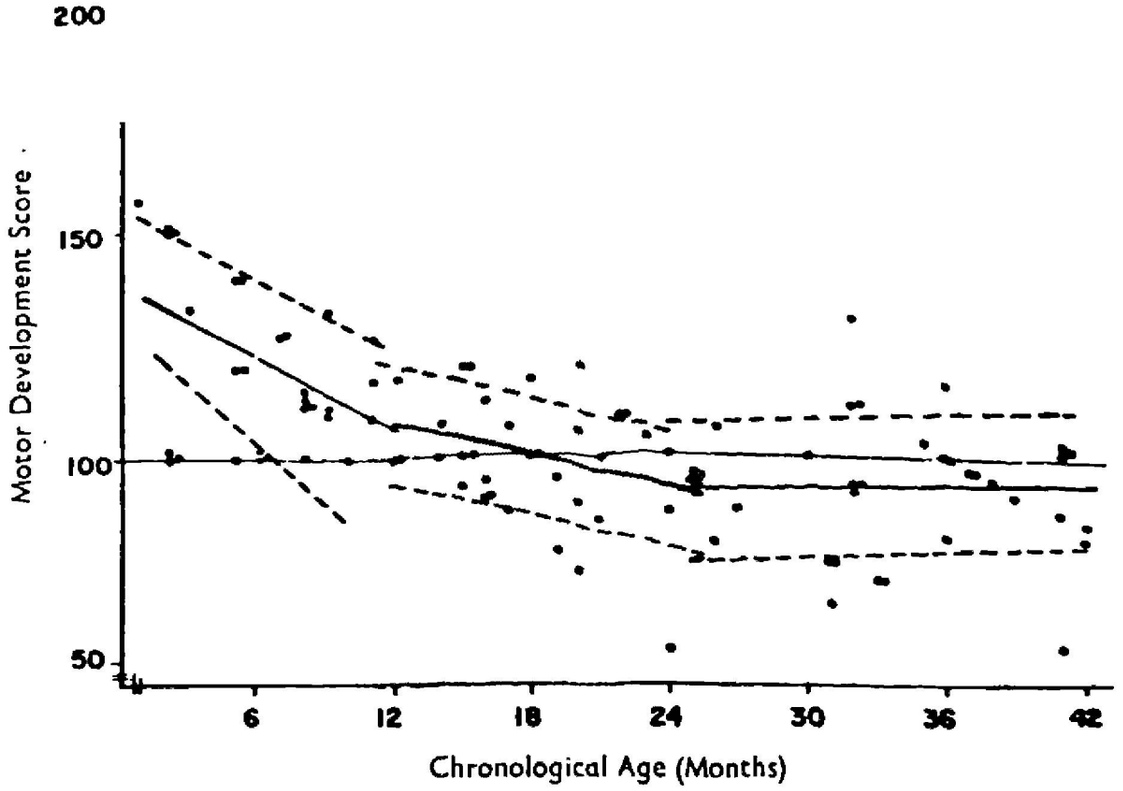


Fig. 1. Relationship between chronological age and motor development score.

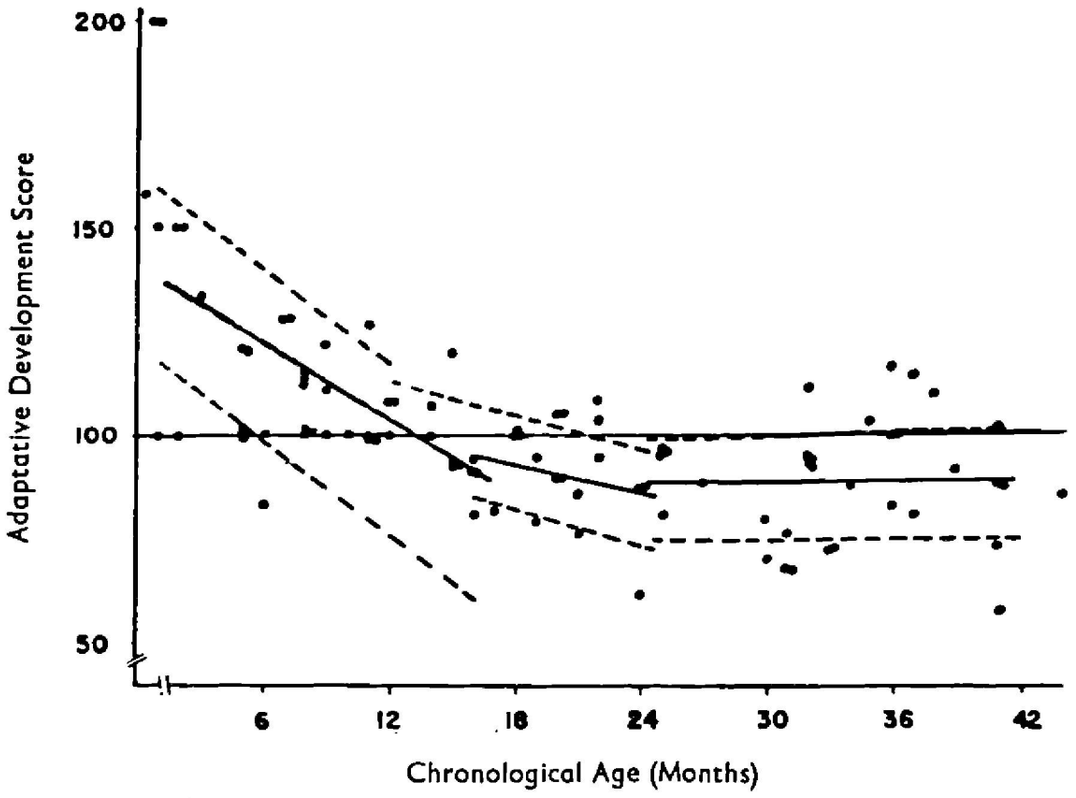


Fig. 2. Relationship between chronological age and adaptative development score.

satisfactory approximation to this curve could be obtained by fitting a series of straight lines over subsets of smaller age intervals, as shown in Figs. 1 through 4. The values derived from fitting straight lines to this data are shown in Table 1 (Geber and Dean, 1956; Robles and Cravioto, 1959). Additionally, Figs. 5 to 7 suggest a positive correlation between the weights and heights of these children and their Gesell scores.

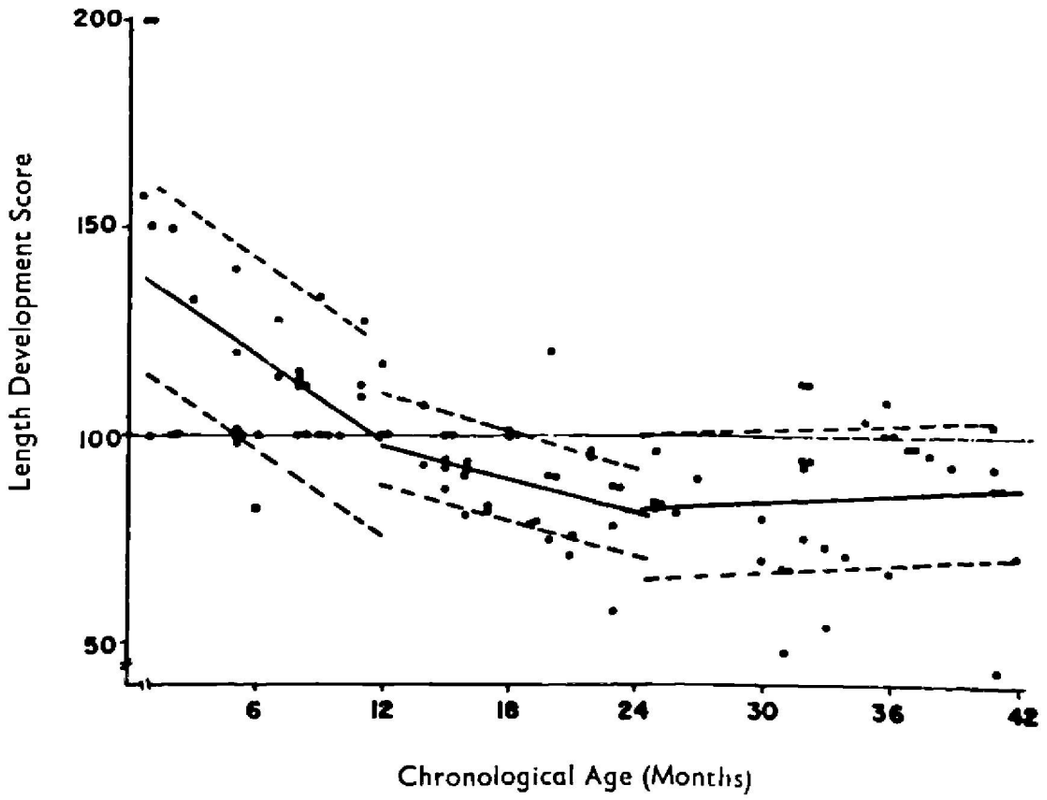


Fig. 3. Relationship between length development score and chronological age.

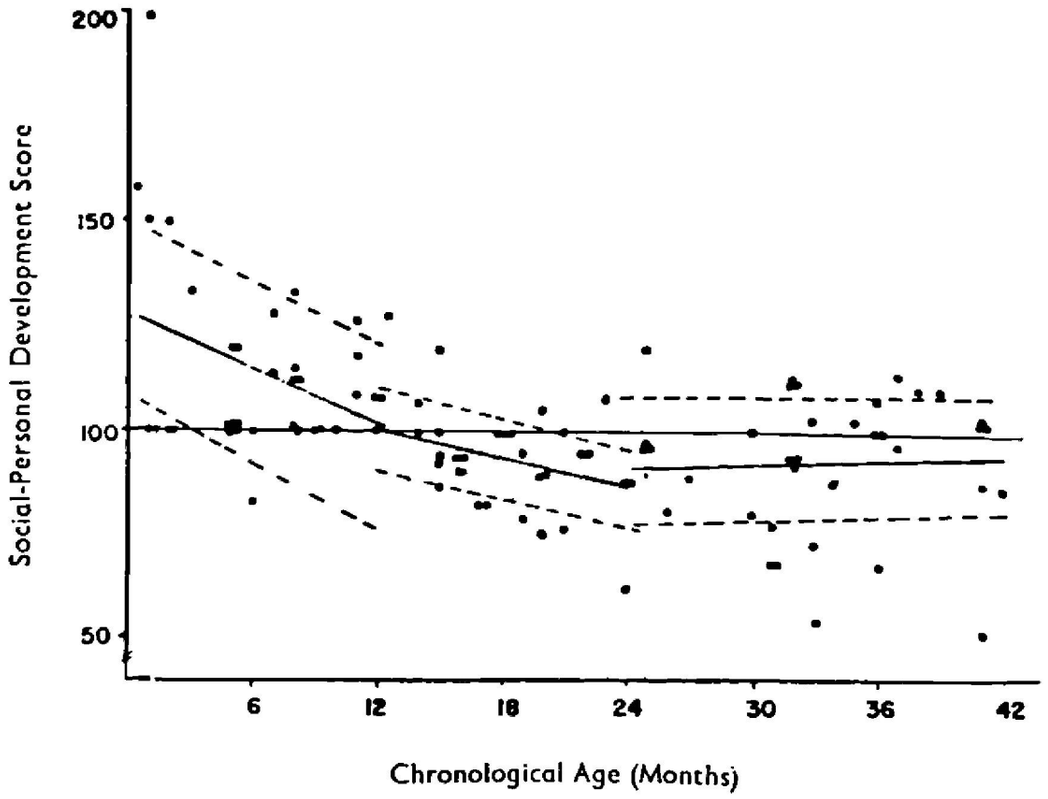


Fig. 4. Relationship between social–personal development score and chronological age.

## 2. The Preschool Child from Three to Six Years

Terman-Merril scores of intelligence ($Y$) determined in rural preschool children aged 30 to 72 months appeared to be negatively correlated with the chronological age ($x$) of the children. The least squares equation for the fitted straight line to this data is $Y = 1.37–0.86x$. Standard error of fit = 13.

As before, body weight and height were found to be positively correlated with the intelligence scores of these children. Mathematical expressions of these associations showed that the intelligence quotient was equal to 0.79 times the "height age" in

Table 1. *Regression equations of the form $Y = a + bx$, and error of fittings ($Sxy$) for the several fields of behaviour as determined in various age groups in rural Mexico by the Gesell technique.*

| Field of behaviour | Age groups (months) 1–12 | 13–24 | 25–36 |
|---|---|---|---|
| Motor | 137 – 2.61 $X$<br>$Sxy$ = 19 | 124 – 1.36 $X$<br>$Sxy$ = 13 | 77 + 0.54 $X$<br>$Sxy$ 15 |
| Adaptative | 143 – 3.77 $X$<br>$Sxy$ = 22 | 116 – 1.21 $X$<br>$Sxy$ = 12 | 78 + 0.35 $X$<br>$Sxy$ = 12 |
| Language | 139 – 3.29 $X$<br>$Sxy$ 23 | 116 – 1.44 $X$<br>$Sxy$ = 11 | 72 + 0.39 $X$<br>$Sxy$ = 17 |
| Social-personal | 128 – 2.09 $X$<br>$Sxy$ = 21 | 114 – 1.15 $X$<br>$Sxy$ = 10 | 101 – 0.32 $X$<br>$Sxy$ 21 |

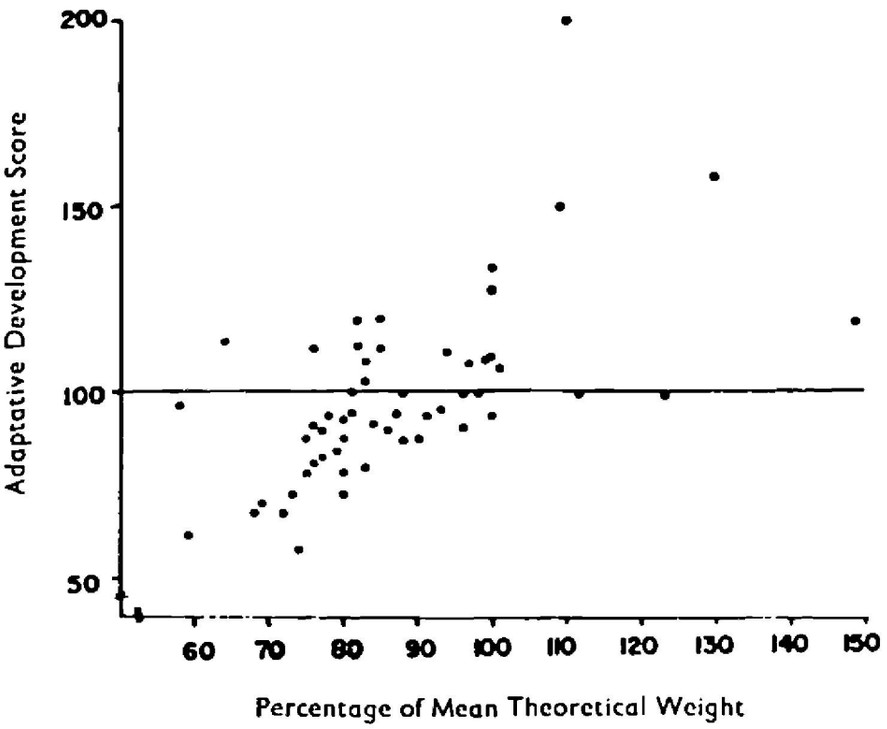


Fig. 5. Relationship between the motor development score and the percentage of mean theoretical weight for the age.

months, plus 12; or 0.51 times the "weight age" in months, plus 29; the errors of the fittings being 13 and 20, respectively (Cravioto, Robles, and Ramos-Galván, 1962) (Figs. 8 to 10).

## 3. The Child of School Age

The mental activity of school-age children has been estimated by using Goodenough's Draw-a-Man Test (Ramos-Galván,

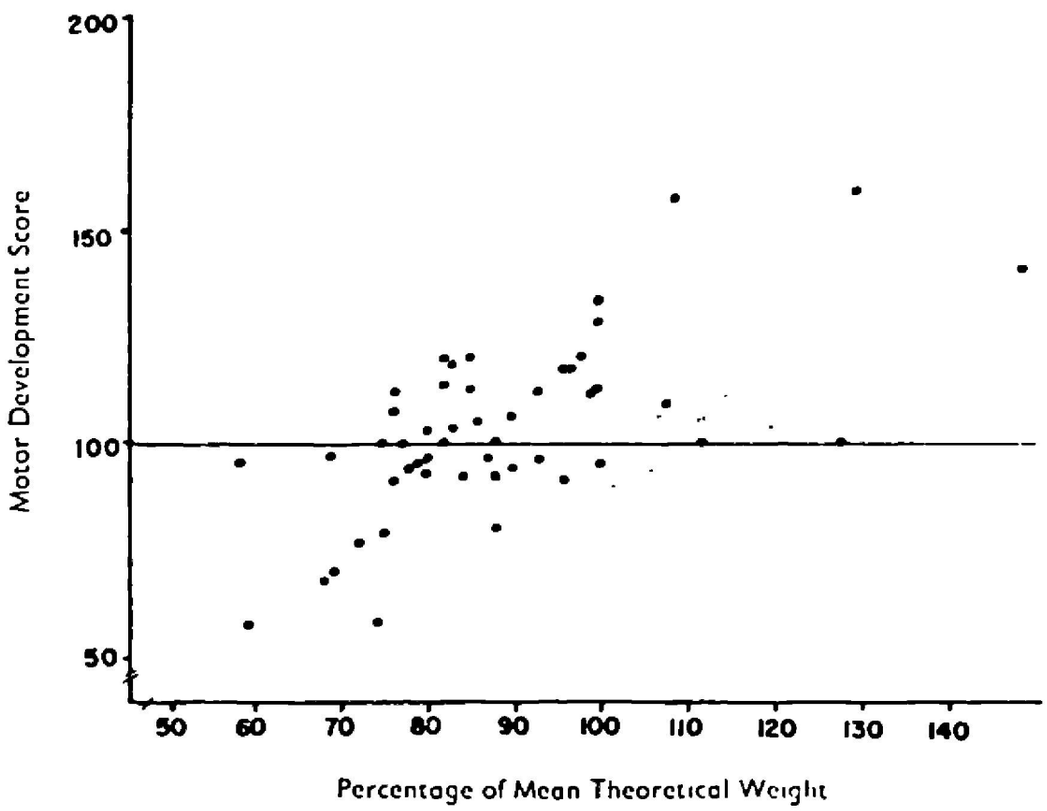


Fig. 6. Relationship between adaptative development score and percentage of mean theoretical weigh for the age.

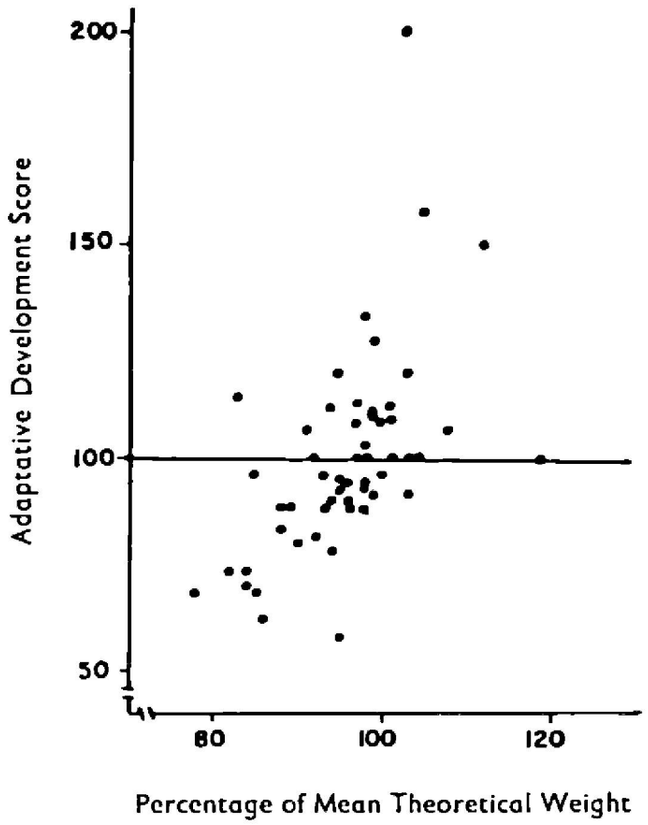


Fig. 7. Relationship between adaptative development score and the percentage of mean theoretica height for the age.

Cravioto and Vega, 1959). The data presented in Table 2 illustrates the relation between the weight deficit of these children, which may be considered a reflection of nutritional status, and their intelligence quotients, suggesting that as the weight deficit increases, the intelligence quotient decreases. More striking is the fact that

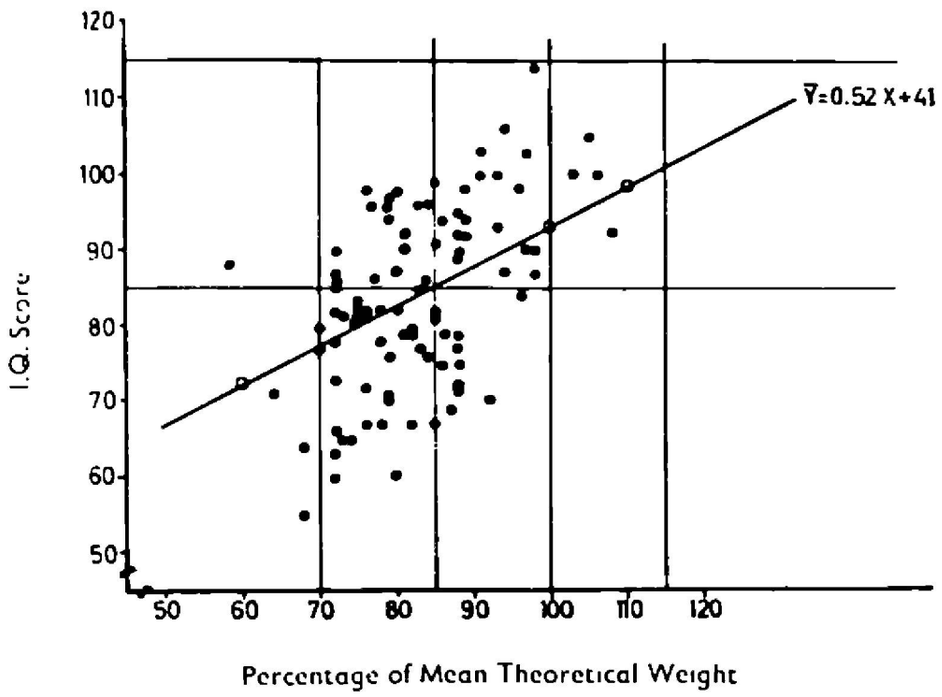


Fig. 8. Relationship between I.Q. (Terman-Merril) and percentage of mean theoretical weight for the age.

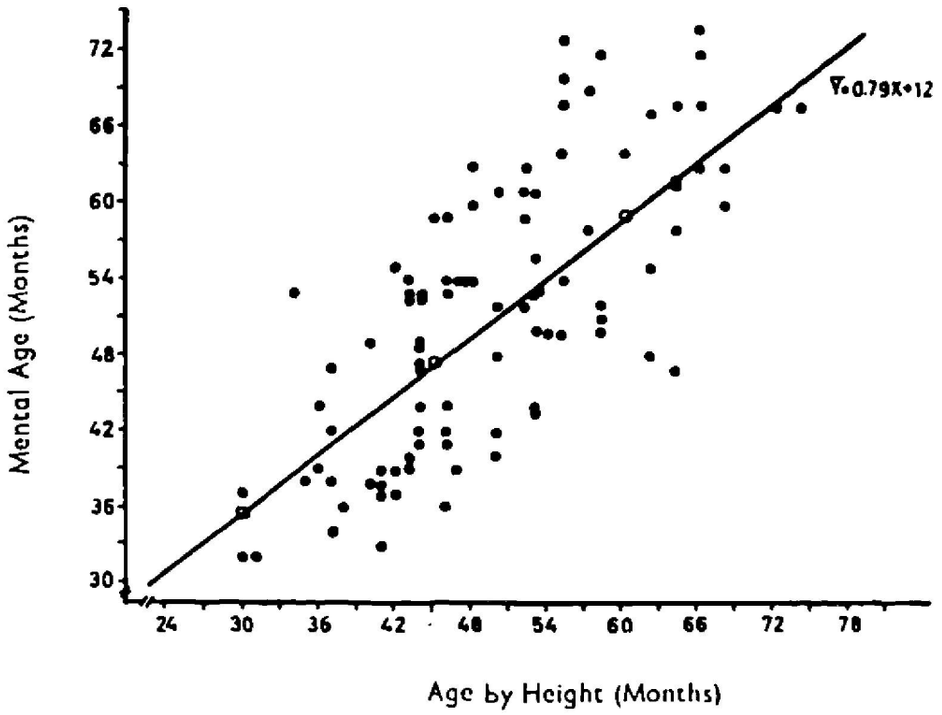


Fig. 9. Relationship between mental age calculated from the Terman-Merril score and "age by weight".

only 20% of the children with normal weights made scores between 51 and 70, whereas 53% of the children in the group whose weights were only 51 to 70% of the theoretical normal made similarly low scores and 3% did not reach even a score of 50.

## 4. The Malnourished Child

Gesell tests were administered to a group of 30 children suffering from severe kwashiorkor, just after the acute episode of infection or electrolyte disturbance had been corrected. All of them gave very low

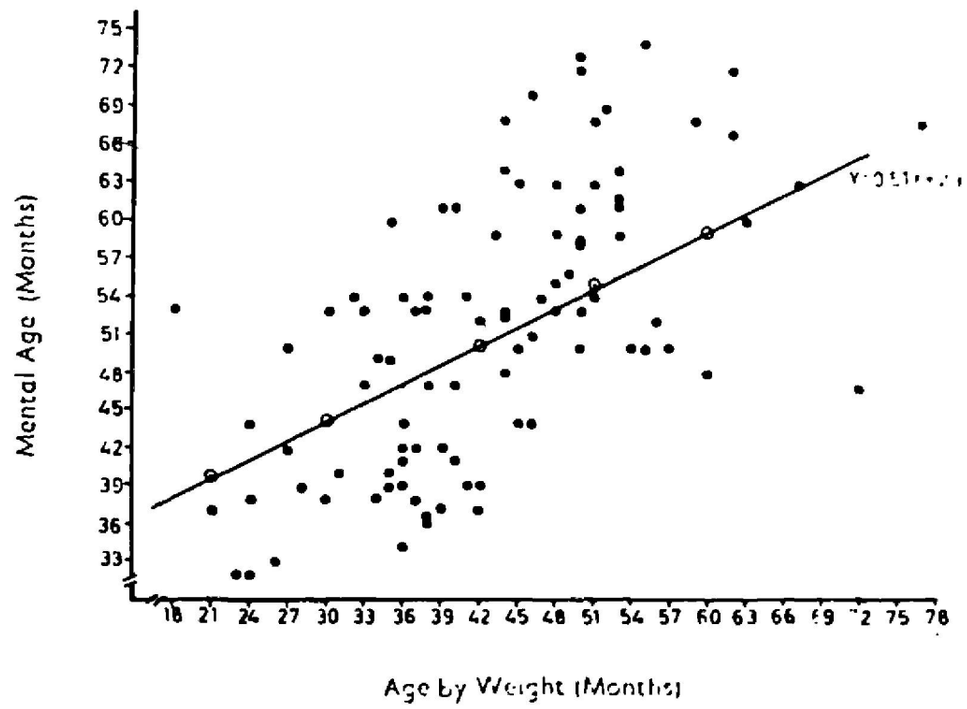


Fig. 10. Relationship between mental age calculated from the Terman-Merril score and "age by height"

TABLE 2. *Relationship between body weight deficit and mean intelligence quotient (Goodenough test) in a group of 299 school-age children.*

| % of mean theoretical weight for age | No. of children | Mean I.Q. |
|---|---|---|
| 51- 60 | 8 | 65 |
| 61- 70 | 22 | 70 |
| 71- 80 | 102 | 80 |
| 81- 90 | 88 | 82 |
| 91 100 | 56 | 87 |
| 101-110 | 23 | 89 |

scores, but the different fields of behavior explored, motor, adaptative, language, and personal-social, were not equally affected. In general, language development showed the lowest score and motor response was the least retarded (Robles, Ramos-Galván and Cravioto, 1959).

The mental performance of these kwashiorkor cases was tested at two-week intervals during their stay in the hospital. As recovery took place, the difference between their chronological and mental ages, computed on the basis of their psychological behavior, diminished in all the children except in those less than six months of age on admittance to the hospital whose increment in mental age was equal to the number of months of treatment. In other words, in the less than 6 months-old group the initial deficit held constant throughout the observation period which in some cases was extended up to six and one-half months (Table 3, Figs. 11, 12, 13) (Cravioto, Robles and Ramos-Galván, 1962).

## 5. NUTRITURE AND MENTAL DEVELOPMENT

It is interesting to mention here that the intellectual performance of a group of adult men tested in the classical experiment on caloric malnutrition conducted in Minnesota did not change significantly either during starvation or rehabilitation from it (Keys, Brozek, Henschel, Mickelson and Taylor, 1950). Spontaneous mental effort and achievement declined, however, during starvation, and it remained at a low level during the early phase of rehabilitation, returning to normal only gradually. One may speculate, therefore, that the degree of persistence of mental retardation and the clinical expression of the "psychological lesions" may vary according to the age of the subject, and that adults who have completed their mental growth perhaps show only a decrease in mental activity but not in actual mental capacity when malnutrition strikes.

TABLE 3. *Regression equations for the relation between psychological test behaviour (Y) and days of successful treatment (X) in three groups of children recovering from severe protein-calorie malnutrition.*

| Field of behaviour | Age group (months) 3–6 | 15–29 | 37–41 |
|---|---|---|---|
| Motor | 2.18 + 0.03 $X$ | 12 + 0.06 $X$ | 14 + 0.10 $X$ |
| Adaptative | 2.30 + 0.03 $X$ | 12 + 0.08 $X$ | 15 + 0.11 $X$ |
| Language | 2.0 + 0.03 $X$ | 9 + 0.05 $X$ | 15 + 0.07 $X$ |
| Social personal | 2.11 + 0.03 $X$ | 10.5 + 0.07 $X$ | 16 + 0.11 $X$ |

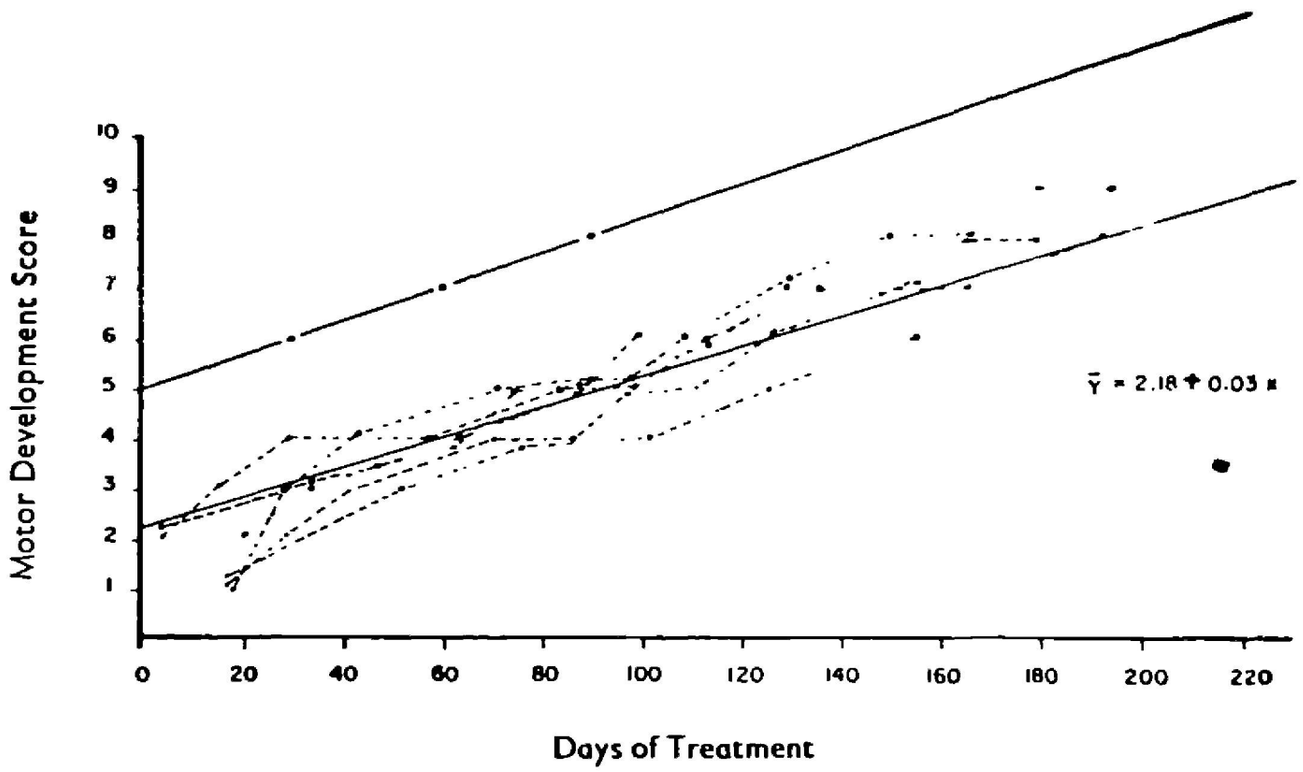


Fig. 11. Changes in psychmotor development of infants less than six months of age during recovery from severe protein-calorie malnutrition.

Kubala and Katz (1960) have recently investigated the effect of a dietary deficiency in citrus products upon mental test performance. Subjects from three schools ranging from Kindergarten through the ninth grade as well as a group of college women were studied. According to the level of serum ascorbic acid each individual was placed into either the higher range or the lower range group. All subjects placed into the higher range were considered as not having a deficiency in ascorbic acid.

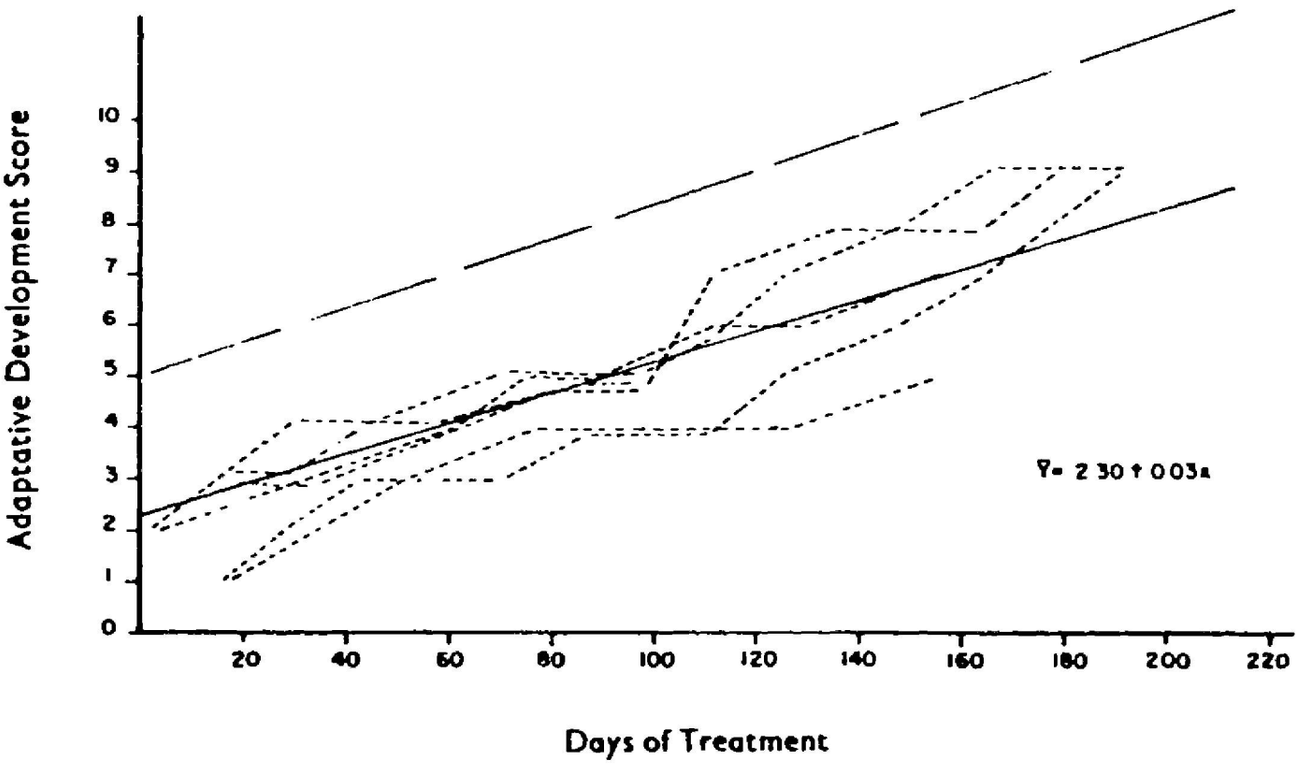


Fig. 12. Changes in adaptative development of infants less than six months of age during recovery from severe protein-calorie malnutrition.

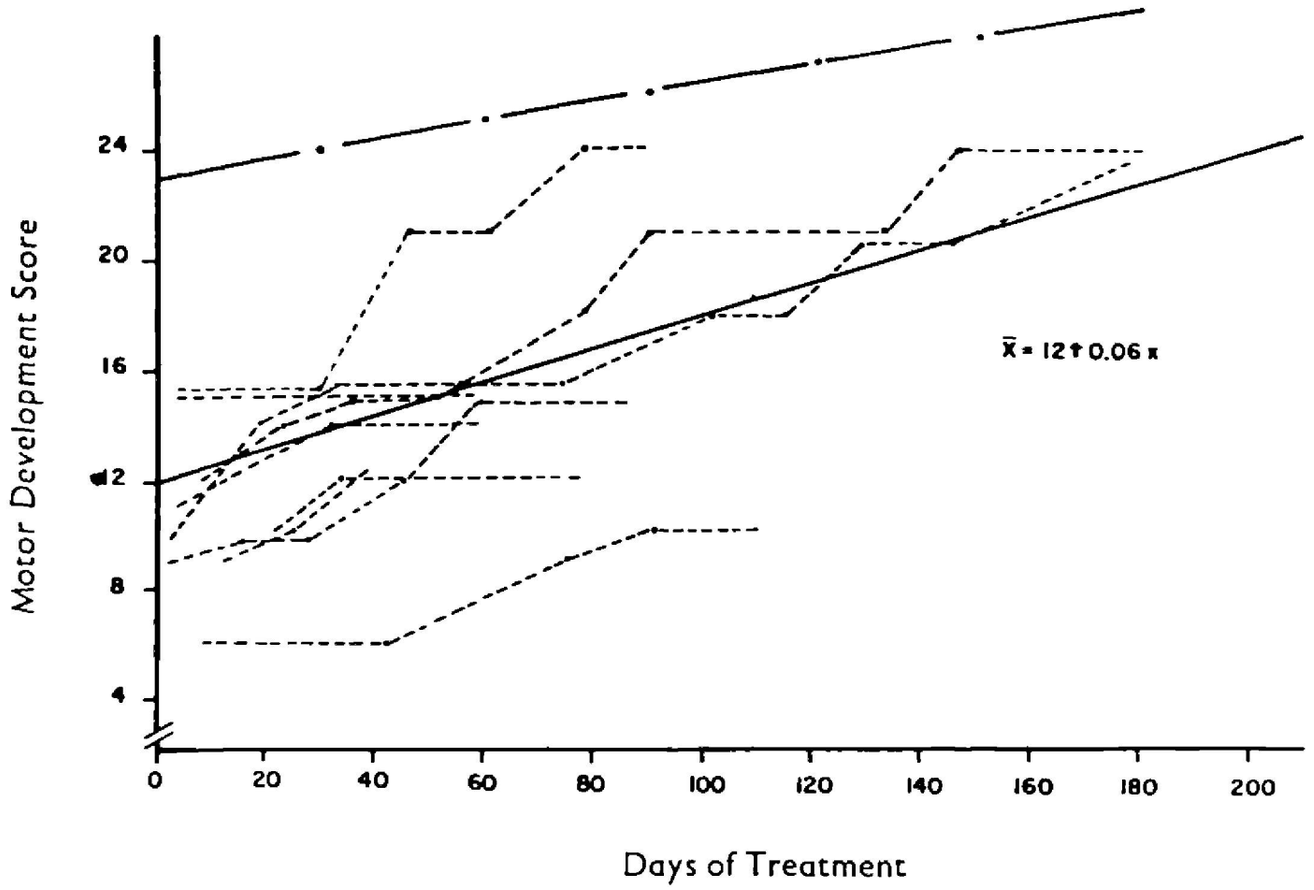


Fig. 13. Changes in psychomotor development of children aged 15 to 29 months during recovery from severe protein-calorie malnutrition.

Students within a given school system were matched on a series of socio-economic indicators, and the matched groups were compared with respect to mean Intelligence Quotients. The results showed a higher Intelligence quotient for the group without a dietary deficiency of ascorbic acid. When the two groups were re-tested after a period of supplementation with orange juice, the "initially deficient" group demonstrated a significant larger gain. Subjects from two elementary schools were tested a total of four times during the experiment. Changes in mean ascorbic acid concentration were closely parallelled by changes in mean Intelligence Quotient.

## 6. Concluding remarks

Reference must be made to the fact that very little is known about the effect of protein malnutrition on the mental capacity of children. The few available findings have concerned themselves with developmental quotients which attempt to summarize the pattern of behavior of the children in a single score. Comparisons of individual items might reveal differences hidden by a clinical summary in the form of a quotient (Knobloch and Pasamanick, 1960).

The high parent–child "I.Q." correlations found in Europe and North America, plus the role of maternal deprivation and other social variables in the mental development of infants make it necessary to assess the relative effect of each one of these factors separately in children affected by protein malnutrition. For this purpose INCAP has selected populations which will be followed from early life through a sufficiently long period of time to determine the effect of malnutrition and other factors which influence infant mental development.

The importance of studies of this type

cannot be overemphasized. A confirmation of the preliminary results obtained in Uganda and Mexico would lend greater urgency to the application of effective measures for the early prevention of infantile malnutrition in all countries of the world.

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## Discussion

*Dean:* As you know, we have found severe retardation (as measured by Gesell tests) in our children when they are acutely ill, and we have wondered whether it was related to the inability to metabolize phenylalanine. The doses of the amino acid that we gave did not, however, produce any recognisable mental changes.

*Friis-Hansen:* Is there any explanation of the precocity at birth?

*Dean:* No.

*Jelliffe:* The precocity in East Africa and Mexico has important nutritional implications: the baby is born with a vigorous sucking reflex that helps its survival. This is one of the reasons why we believe in Kampala that we should put our special-care level about 2 000 g.

Has the precocity at birth been found in upper socio-economic groups in Mexico?

*Cravioto:* We have not so far tested such groups, but they will be tested in Mexico and

in Guatemala. Different ethnic groups will also be studied.

We are wondering if the mother's lack of anxiety, and the degree of acceptance of pregnancy in her cultural group, may account for the precocity. It does not last indefinitely in the children we have followed.

*Dean:* I should perhaps emphasise that in Dakar, Uganda and Johannesburg, there was no evidence at all that the precocity of the children was related to malnutrition of the mothers. The mothers seemed to be well-nourished.

*Jelliffe:* Is there a genetic factor? Are negroes in the U.S. comparable?

*Dean:* Negro children in the U.S. are said to be precocious, but only in motor development. Our children (who are mostly unrelated to the negroes) are precocious in every way, not only in motor activity..

*Vahlquist:* Could the difference in the results of tests at the beginning and end of treatment be due to the extra care and attention the children receive?

*Dean:* Our children show such a large improvement in such a short time—14 days or so—that such an explanation seems unlikely.

*Mannheimer:* In the Ethio-Swedish pediatric clinic we find that mental disturbances are very constantly present in moderate and severe cases of kwashiorkor, but that they do not occur in nutritional marasmus. Is that your experience?

*Cravioto:* Cases of marasmus are difficult to find in Mexico, and we have not studied them in this way.

*Dean:* There is no doubt that in Kampala, the psychological changes found in kwashiorkor do not occur in marasmus. For instance, the one is nearly always anorexic, and the other nearly always eager to take food.

The changes are constant in *severe* cases: they are much less obvious in slight ones—at least in Kampala.

*Lowenstein:* Do you think that these psychological tests, which have been developed in North Amerikan children and in North American situations, are applicable to Mexican or Central American children, especially those of school age?

*Cravioto:* I think they are applicable, but cultural differences must, of course, be borne in mind.

*Dean:* We decided that the Gesell test was applicable up to about the age of three years, but that on older children this test, and others we tried, were of doubtful value because of the difference in cultures. We thought that adaptation—a difficult and dangerous process —was needed before the tests could be considered suitable for the older African children.