

MENTAL AND MOTOR DEVELOPMENT OF PERUVIAN CHILDREN TREATED FOR SEVERE MALNUTRITION*

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INTRODUCTION

An underdeveloped country such as Peru, because of the high incidence of kwashiorkor and marasmus in its infant age group (Graham and Morales, 1963), is particularly well suited for the study of a possible relationship between mental deficiency and the nutritional state of the individual during infancy (Coursin, 1965).

Studies of children treated for kwashiorkor in Uganda by Geber and Dean (1956), in Venezuela by Barreda Moncada (1963), and in Mexico by Cravioto and Robles (1965) have indicated that the levels of mental and motor development in these children are retarded. Following treatment for malnutrition, however, progressive improvement in mental and motor function was noted.

Prolonged starvation leading to critical states of malnutrition might maximally influence the brain if it occurs during periods of brain growth and maturation. Experiments in animals support this hypothesis. Food restriction has been shown to influence brain cell division (DNA), reduce brain cell synthetic activity (RNA) and delay myelination (cholesterol, phospholipids and cerebrosides) in the rapidly growing brain of rodents (Howard, 1965; Culley and Mertz, 1965). On the other hand, attempts to demonstrate comparable changes in rodents' food restricted later in life, once brain growth has plateaued, have thus far been unsuccessful (Lehr and Gayet, 1963).

Maze learning experiments have yielded similar data. Rats undernourished during nursing and then fed with low protein diets for eight weeks after weaning, subsequently showed significant retardation in learning behavior. In contrast rats fed with low protein diets after weaning fail to show significant retardation (Bernhart, 1936; Robertson, 1965; Barnes, et al., 1966).

Previous reports of the use of psychometric tests on children malnourished early in life were primarily confined to children who exhibited symptoms of

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kwashiorkor (hypoalbumenemia, edema, and hair and pigmentation changes). The purpose of the present paper is to report the results of the administration of the Bayley Infant Scales of Mental and Motor Development to children treated for and having shown somatic recovery from marasmus while hospitalized at the Research Department of the British American Hospital in Lima, Peru.

SAMPLE SELECTION

Twenty-seven children from the *barriadas* or slums surrounding Lima constituted the full sample. Nineteen of the twenty-seven had been treated for severe protein-calorie malnutrition while the remaining eight children were siblings and constituted the control group.

The malnourished children at the time of hospital admission showed the symptoms of marasmus as described by Graham and Morales (1963): (1) they were free from apparent edema, (2) they had, with the exception of one patient, normal serum albumin, (3) they had a weight deficit of at least 40 percent for their age.

The nineteen children ranging in age from eleven to thirty-two months were hospitalized at either the Metabolic Ward of the British American Hospital (eight children), or at the Convalescent Unit of the El Milagro Hospital (eleven children).

The nineteen children ranging in age from eleven to thirty-two months were included in the nine nutritional study cases because they met the following criteria at the time of evaluation: (1) they were clinically considered recovered from a state of severe protein-calorie malnutrition which had been the primary reason for their hospital admission; (2) they were younger than thirty-six months of age; (3) they were not at an investigative phase of their treatment that required them to be secured to metabolic beds. It is noteworthy, that there are thirteen children included in our sample who had been in metabolic beds¹ for intervals up to several weeks.

The eight children in the Metabolic Ward ranged in age from eleven to twenty-eight months with a mean age of sixteen months. The period of individual hospitalization varied from three to nine months (mean = 6 months). The children in the Convalescent Unit were older than the Metabolic Ward group and had been admitted to the Metabolic Ward of the British American Hospital and then transferred for further observation and continuation of the

¹ Children in metabolic beds at the time of this study were excluded because the collection procedures required that their movement be restricted 24 hours a day for periods up to several weeks. They wore cloth-bandages which secured their ankles and legs to the bed, resulting in limitation of movement of the lower limbs and pelvis. The children were removed from the metabolic beds during feeding time.

study with experimental diets. The eleven children at the Convalescent Unit ranged in age from fifteen to thirty-two months with a mean age of twenty-two months. Their individual periods of hospitalization ranged from five to fourteen months (mean = 12 months).

The eight controls comprised all the children obtainable for testing who met the following selective criteria: (1) each was a sibling of a patient at the Metabolic Ward or at the Convalescent Unit; (2) each was younger than thirty-six months of age; (3) each had an unremarkable medical history with height, weight and head circumference judged to be within normal Peruvian limits; (4) in the case where two siblings in one family met the selective criteria, only the older sibling was selected to as not to represent one family twice. The age of the control children ranged from three and a half to thirty months with a mean age of nine months.

The small size of the control group reflected the difficulty in obtaining suitable siblings. The layout of the slums was extremely disorganized, so that the research personnel had difficulty in locating the families of the patients. In several instances mothers could not be found, and no information could be obtained as to their whereabouts. All families who were located with siblings under thirty-six months of age willingly consented to bring the child to the hospital for psychological and physical examination.

PROCEDURE

Somatic

Data on the height, weight and head circumference at the time of hospital admission and at the time of psychological evaluation were obtained from the clinical histories of the nineteen children treated for malnutrition. In the case of the normal siblings, somatic data were obtained prior to psychological and motor testing.

Mental and Motor

The Bayley Infant Scales for Mental and Motor Development (Bayley, 1961a and b) were used in the course of evaluation of the children. Both Scales were translated into Spanish (Pollitt, unpublished) for use in this investigation. Patients in both the Metabolic Ward and Convalescent Unit were evaluated at their respective places of hospitalization. The control children were evaluated at either hospital according to the convenience of whoever brought the child. The evaluations were made by either of the investigators using the instructions set for the Scales.

The Scales were administered jointly and the evaluation took about forty-five minutes for each child. The hospitalized patients who were unable to sit

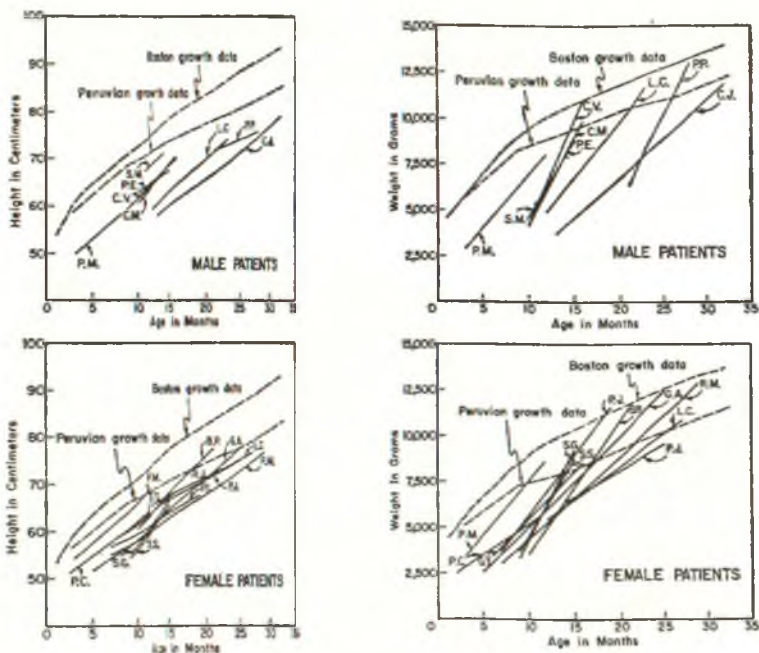


FIGURE 1. The heights and height changes during hospitalization of male and female patients. The data are compared with the 50th percentile of heights taken from American and Peruvian norms (see text).

FIGURE 2. The weights and weight changes during hospitalization of male and female patients. The data are compared with the 50th percentile of weights taken from American and Peruvian norms (see text).

in the high chair were evaluated while held in a nurse's lap. The control children who were not able to sit in the chair were held by their mothers.

FINDINGS

Somatic

The heights of the male and female patients at the time of hospital admission and at the time of testing are presented in Figure 1. The corresponding weights are shown in Figure 2. In these figures the expected heights and weights of children living in North America are taken from the data of Stuart and Meredith,² and the average heights and weights of Peruvian village children are taken from the preliminary growth data of a recent study on a Peruvian population (Baertl, personal communication).

² Adapted by the Health Department, Milwaukee, Wisconsin, from anthropometric charts based on original data of H. C. Stuart and H. V. Meredith and prepared for use in Children's Medical Center, Boston (Watson and Lowrey, 1954).

The curve of Stuart and Meredith's growth data represents the 50th percentile of the measurements taken from the total North American population evaluated. The growth data from the Peruvian study fall generally below the 10th percentile of the Boston measurements.

A comparison of Figure 1 with Figure 2 suggests that increases in weight observed in the children during and subsequent to treatment for severe malnutrition occurred at a faster rate than increases in height. For example, at the time of testing all but three patients had retarded heights. By contrast, at the same time, all but four patients had weights above the average of the reported Peruvian children of comparable ages.

Mental and Motor

I. Test Scores

Experimental group: Table 1 summarizes the scores obtained from the evaluation of the patients at the Metabolic Ward and Convalescent Unit. The number of standard deviations each group scored below the expected means for the scales is given in the form of the average sigma scores for each group. On the basis of the results of the Bayley Scales, the patients who were treated for malnutrition were found to be severely retarded in both mental and motor development. In fact, all the patients but two (G.A. and P.J.) obtained developmental intelligence and motor quotients below the basal intelligence and motor quotients found in the corresponding tables of the Bayley Mental and Motor Scales.

A comparison of the sigma scores of the children at the Metabolic Ward and Convalescent Unit, according to the Mann-Whitney U test (Seigel, 1956) indicated that the degree of motor retardation of the children at the Convalescent Unit was less severe ($U = 11.0; p < 0.02$). By contrast, when the mental development scores were compared no significant differences were found ($U = 30; p < 0.10$) both being significantly impaired.

Control Siblings: The variance in the ages of children in the control group was much greater than the variance in the ages of the patients in the experimental group. Half of the siblings were less than eleven months of age, this age being the minimum in the experimental group. Statistical comparisons cannot therefore be made with confidence. Inspection of the data, however (see Figure 3), shows quite clearly that these control children were developing normally for their ages according to the American standardization of the Bayley Scales. This finding offers preliminary indication of the applicability of the Bayles Scales outside the United States.³

³ Bayley (1965) has shown that Negro, White and a small group of Puerto Rican children, ages one to fifteen months, show no significant scoring differences on items testing mental de-

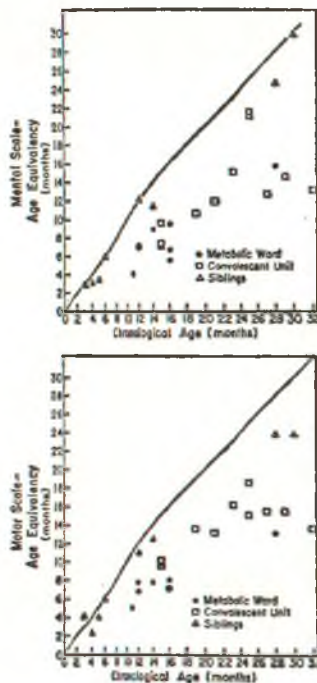


FIGURE 3. Mental and Motor age equivalency scores. Scores of the control siblings are contrasted with scores of the children treated for protein-calorie malnutrition.

II. Descriptive Examples

The results from individual items taken from motor and mental development scales are presented in order to demonstrate more specifically noteworthy deficits observed in the patients treated for malnutrition.

Metabolic Ward. With the exception of the child twenty-eight months old, the age range of the seven remaining children tested at the British American Hospital sample was eleven to sixteen months old. It would be expected that these seven children would pass mental and motor scale items at a level approximating their chronological ages, even taking into consideration errors arising from the cultural differences between the present sample and the American norms. However, none of the seven children passed items from the motor scale above the 8.6 month level, again demonstrating the degree of

development. Negro children, however, at every age category up to twelve months demonstrated significantly higher levels of motor ability as measured by their performance on items on the motor scale. Interestingly enough, this difference was found to decrease with age and was no longer significant in the group older than twelve months.

generalized retardation in motor development. When individual items were considered, no child from the group could accomplish, for example, "stepping movements," passed normally at 9.2 months of age. Moreover only one of the seven could "stand up" (8.4 months) and this same child was the only one who could "raise himself to sitting position" (8.2 months).

For descriptive purposes, items from the Mental Scale testing vocalizing and work formation were selected for analysis. Again considering the same seven children, none was able to "vocalize four different syllables," an item expected in a 7.4 month-old-child; none could say "'dada' or equivalent" (8.5 months).

Convalescent Unit. The older Convalescent Unit children passed mental and motor items that all seven of the children selected from the Metabolic Ward failed. The Convalescent Unit patients, however, still gave evidence of marked developmental retardation when their age-corrected scores were considered. This retardation can be appreciated by considering that only two of the eleven patients passed motor scale items above the fourteen month level (mean age of patients in the Convalescent Unit was 22.5 months). Moreover, half of the sample could not walk sideways (13.5 months); over half could not walk backwards (10.2 months); and not a single infant could stand on the right or left foot with assistance, an ability expected in a child age eighteen months.

DISCUSSION

There are serious methodological problems to be faced in clinical studies of mental and motor development in children treated for malnutrition because of the many variables that have to be controlled, namely: (1) the conditions and duration of hospitalization to which the child was exposed—for example, Geber and Dean have emphasized the importance of the quality of the maternal-infant interaction during hospitalization as a crucial factor in the rate and degree of somatic and mental recovery shown by kwashiorkor infants they studied; (2) the infant's age at onset of severe malnutrition—Cravioto and Robles have reported a greater persistence of low performance scores in adaptive behavior on the part of infants who experienced the onset of malnutrition prior to six months of age than in infants whose onset of malnutrition came at a later age; (3) the health and nutritional status of the mother during pregnancy and nursing—Chow and Chi-jen (1964) reported that the weight gain, after weaning, of the offspring of albino rats fed during pregnancy and nursing with a 25% reduced diet, in comparison to a control group, was retarded; (4) the type of malnutrition present in the patient—whether the pathology was one predominantly of protein calorie deficiency as marasmus or protein depletion as kwashiorkor. It is noteworthy that the patients studied by

Cravioto and Robles, Barreda Moncada, and Geber and Dean presented kwashiorkor-like symptoms whereas the children in the present investigation were primarily considered protein-calorie deficient.

Finally, the absence of appropriate techniques of intelligence testing standardized in underdeveloped countries together with the difficulties in selecting suitable control groups increase the serious problems in experimental design.

The present data and the results of earlier investigations demonstrate the presence of retarded levels of mental and motor development in children at different stages of rehabilitation from severe malnutrition. Our findings, however, show a significantly greater impairment of mental and motor development than in patients studied in the earlier investigations, but evaluated on the Gesell Schedule.

The patients in our sample demonstrated severe mental retardation regardless of length of hospitalization and treatment. In contrast, the degree of motor retardation was less severe ($p < 0.04$) in children with longer periods of hospitalization and more severe ($p < 0.05$) in children who underwent the motor restriction while in metabolic beds. However, since there was a considerable overlapping between the group of patients with long hospitalization and the group of patients who has never been in metabolic beds, it is not possible at this time to specify the effect of either variable when acting alone.

Recently Brockman (1966) has completed a study of cognitive and manipulative behavior in children from Lima who were treated for severe malnutrition. On the basis of the results from a series of sorting tasks of eight objects, Brockman demonstrated that children who showed somatic recovery from severe protein-calorie malnutrition were nevertheless severely retarded in cognitive and manipulative behavior when compared with control children with no history of undernutrition ($p < 0.001$).

Twelve of the twenty children studied by Brockman were among those in the present sample tested for this investigation. Moreover, all of the twenty patients in her group had been treated at the same units as in the present study. The findings of Brockman then help to confirm the validity of the present data obtained by us earlier using the Bayley Infant Scales of Mental and Motor Development.

REFERENCES

- Baertl, J. M., Personal communication, unpublished data on the anthropometric measurement of village children of Pucará, Peru.
- Barreda Moncada, G., 1963. Estudios sobre alteraciones del crecimiento y del desarrollo psicológico del síndrome pluricausal (kwashiorkor). Editora Grafos, Caracas, Venezuela.

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- Barnes, R. H., Cunnold, S. R., Zimmermann, R. R., Simons, H., MacLeod, R. B., and Krook, L., 1966. Influence of nutritional deprivation in early life on learning behavior of rats as measured by performance in a water maze. *Journal of Nutrition*, in press.
- Bayley, N., 1961a. Bayley Infant Scale of Mental Development (Revised Form). Unpublished, National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland.
- Bayley, N., 1961b. Bayley Infant Scale of Motor Development (Revised Form). Unpublished, National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland.
- Bayley, N., 1965. Comparisons of mental and motor test scores for ages 1–15 months by sex, birth order, race, geographic location and education of parents. *Child Development*, 36: 379–411.
- Bernhart, K. S., 1936. Protein deficiency and learning in rats. *Journal of Comparative Psychology*, 22: 269–272.
- Brockman, L., 1966. The effects of severe undernutrition on cognitive development in infants. Unpublished doctoral dissertation, Cornell University, Ithaca, New York.
- Chow, B. F. and Chin-jen L., 1964. Effect of dietary restriction of pregnant rats on body weight gain of the offspring. *Journal of Nutrition*, 82: 10–18.
- Coursin, D. B., 1965. Undernutrition and brain function. *Borden's Review of Nutrition Research*, 26: 1.
- Cravioto, J. and Robles, B., 1965. Evolution of adaptive and motor behavior during rehabilitation from kwashiorkor. *American Journal of Orthopsychiatry*, 35: 449–464.
- Culley, W. J. and Mertz, E. T., 1965. Effect of restricted food intake on growth and composition of preweanling rat brain. *Proceedings of the Society for Experimental Biology and Medicine*, 118: 233–235.
- Geber, M. and Dean, R., 1956. The psychological changes accompanying kwashiorkor. *Courrier*, 6: 3–14.
- Graham, G. and Morales, E., 1963. Studies in infantile malnutrition I. Nature of the Problem in Peru. *Journal of Nutrition*, 79: 479–487.
- Howard, E., 1965. Effects of corticosterone and food restriction on growth and on DNA, RNA and cholesterol contents of the brain and liver in infant mice. *Journal of Neurochemistry*, 12: 181–191.
- Lehr, P. and Gayet, J., 1963. Response of the cerebral cortex of the rat to prolonged protein depletion — I. *Journal of Neurochemistry*, 10: 169–176.
- Robertson, M. S., 1965. Effects of protein-calorie malnutrition early in life on growth and learning behavior in the albino rat. Report on a special problem for the degree of Master of Nutritional Science, Cornell University, Ithaca, New York.
- Siegel, S., 1956. *Nonparametric Statistics for the Behavioral Sciences*. New York: McGraw-Hill, pp. 116–127.
- Watson, E. H. and Lowrey, G. H., 1954. *Growth and Development of Children*. Chicago: Year Book Publishers.

TABLE I

*Mean Mental and Motor Sigma Scores**

	Metabolic Ward	Convalescent Unit	All Patients	Control Siblings
Mental Scale	-4.84 (S.D. = 1.64)	-3.63 (S.D. = 1.30)	-4.15 (S.D. = 1.57)	-0.69 (S.D. = 0.71)
Motor Scale	-4.85 (S.D. = 1.21)	-2.96 (S.D. = 1.04)	-3.76 (S.D. = 1.47)	-0.54 (S.D. = 0.71)

* The number of standard deviations away from the expected norms.

SUMMARY

Twenty-seven children from the slums of Lima, Peru hospitalized and treated for severe protein-calorie malnutrition were given the Bayley Infant Scale of Mental Development and the Bayley Infant Scale of Motor Development. They ranged in age from eleven to thirty-two months with a mean age of 19.5 months. Only two of the children obtained scores above the basal levels of the Scales, thus indicating severe mental and motor retardation despite their apparent somatic recovery from starvation. There was, however, a degree of motor improvement relative to the duration of hospitalization. Eight sibling controls from the slums scored within the normal range for their age, according to the American standardization of Scales.

RESUMEN

El propósito del trabajo es presentar los resultados de la administración de las Escalas Bayley de Desarrollo Mental y Motor a niños tratados de severa malnutrición calórico-proteínica.

La muestra la constituyeron 27 niños de las barriadas en los alrededores de Lima. Se obtuvieron datos somáticos y se evaluó el desarrollo mental y motor. Sobre la base de estos resultados, se pudo observar que los pacientes tratados de malnutrición estaban severamente retardados en relación a la norma.

RESUMO

Este trabalho apresenta os resultados da administração das Escalas Bayley de Desenvolvimento Mental e Motor a crianças tratadas para severa malnutrição calórico-proteínica.

A amostra se constituiu de 27 crianças dos subúrbios ao redor de Lima. Obtivemos dados somáticos e verificamos o desenvolvimento mental e motor. Tendo estes dados como base se nota que pacientes tratados para malnutrição são severamente retardados com relação à norma.