Nutritional Status and Intellectual Performance in a Rural Philippine Community[1]

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Undernutrition is known to result in depressed growth in height and weight, delayed skeletal development and biochemical maturity, and increased rates of morbidity and mortality. Recently, severe undernutrition in early infancy has also been found to be associated with a smaller head circumference which is a useful, if not absolute, criterion of brain size (Schimshaw, 1968). Thus, intellectual as well as physical development may be adversely affected by inadequate diets. Malnutrition of sufficient severity to curtail brain growth is mot likely to result when the child is weaned from the breast prematurely to a thin starchy gruel which is a very inadequate substitute for milk. In many cases, the mother does not know how to feed her child adequately, and, in addition, is unable to afford a suitable substitute for breast milk. Few infants survive on such an inadequate diet. For those who do, the prognosis in terms of normal mental development may be poor—a consideration which has far reaching social implications. As a result, attention has been focused on the survivors of severe undernutrition in early infancy. At present, there is sufficient evidence to determine precisely the role of nutrition in mental development, but information is accumulating which suggests that malnutrition exerts a permanent detrimental influence on learning capacity and behavior (Cravioto & Robles, 1965; Schrimshaw, 1967; Stoche & Smythe, 1967.)

Investigators have demonstrated that the child subjected to severe undernutrition, specially protein-calorie malnutrition, during the period of very rapid development of the central nervous system has a lower brain weight (Brown, 1965) and smaller head circumference (Graham, 1966) which does not respond to nutritional rehabilitation (Stoche & Smythe, 1967). Studies have been undertaken to determine whether the child whose brain growth had been irreparably impaired may also suffer a concomitant inhibition in learning capacity and social development (Ramos-Galvan, 1960; Cravioto, 1966). Such studies are difficult to design and the results present problems of interpretation because of the simultaneous influence of social, psychological, cultural, and genetic variables. Alternative factors which could account for limited intellectual performance such as low parental intelligence, lack of stimulation in a culturally impoverished home, lack of incentive, low energy level, apathy, frequent and severe infection with resultant high

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fevers potentially damaging to the central nervous system, loss of educational facilities are commonly found associated with malnutrition. In addition, there is a lack of suitable tests of learning capacity adaptable for use in the societies where malnutrition is most likely to occur.

The present study was undertaken to determine if a relationship existed between scores on a nonverbal intelligence test standardized for use with Philippine school children (Guthrie & Tayag, 1968) and head circumference and height, two parameters of physical growth believed to reflect nutritional adequacy.

Head circumference is influenced by nutrition in early life during which time the brain, which has achieved 25 percent of its adult weight at birth, reaches 70 percent at one year and 95 percent at four years. This is contrast to virtually all other tissues which are capable of growth by both hypertrophy and hyperplasia for a much longer time. Brain size is refractory to nutritional inadequacy after approximately one year of age. Except for the possible effect of undernutrition in causing the loss of temporal musculature and a thinning of the skull (Garn, 1966), head circumference also is virtually unaffected by nutritional factors after this age, and is generally accepted as an indication of brain size (Stoche & Smythe, 1968).

In spite of the fact that an individual's rate of growth varies from month to month, height for age is considered the best single criterion of nutritional status during the entire growth period. While children who suffer from prolonged periods of malnutrition exhibit very rapid growth in the initial period of nutritional rehabilitation, they never achieve an adult size of the same ethnic group who have never suffered from acute or chronic malnutrition (Cravioto et. al., 1966). In almost all cultures, children who are breast-fed for the first six months of life exhibit a growth pattern comparable to that observed for North American and European infants. It is only after this time, when breast milk, which is no longer capable of supporting an optimal rate of growth, is not supplemented by the introduction of solid foods to provide additional protein and calories, that undernutrition manifests itself in progressively smaller increments in height and weight. In addition, children in families from high socioeconomic groups in developing countries continue to grow in a pattern similar to that of well-nourished children in an industrialized society, while children from poorer families, in which undernutrition is most common, show a similar and improved growth pattern when their diet is supplemented. These observations suggest that their stature is influenced more by the level of nutrition than by energetic factors (Graham, 1966). In other words, among the well nourished, differences in height may be considered a reflection of genetic differences, while nutritional and social factors, which are close to optimal, play a less significant role. Among poorly nourished, however, nutritional adequacy is a factor in determining the extent to which genetic potential for growth is realized.

The parameters of growth affected will depend on the timing of the nutritional insult. Thus, while head circumference may be influenced by nutritional status during early infancy alone, height is affected by nutritional status throughout the growth period. A positive correlation between head size and learning capacity would suggest a role of nutritional factors in early infancy in intellectual development. Since the brain is preferentially

protected during undernutrition, such a relationship would be anticipated only among subjects who had suffered severe deprivation which is usually the result of early weaning. On the other hand, a zero correlation between head size and intelligence, but a positive correlation between height and scores on an intelligence test would indicate that later nutritional factors may have affected intellectual performance. While the latter may mean that the malnourished child has a reduced intellectual potential, it may merely indicate that the same factors which lead to nutritional inadequacy also predispose to the limited development of intellectual potential unless the non-nutritional factors are constant.

METHOD

The subjects were 413 children enrolled in grades one to six in an elementary school in a rural barrio in central Philippines where rice is the staple crop and where pottery-making, the main occupation, provides a subsistence level of income. Each child was given an individually administered nonverbal intelligence test. Height and head circumference were measured using standard anthropometric measures using standard anthropometric procedures (Jelliffe, 1966). Age was determined to the nearest month from school records and children's statements, an unusually reliable source of information in the Philippines were birthdays are celebrated and are well-remembered. Correlations were computed between scores on the intelligence test and head circumference and height for each age from 7 to 14, and for the total group..

The heights of the experimental subjects were compared with those reported as averages for Filipino children regardless of nutritional status (Matawaran, 1966; NCCSFCY, 1967) and with American children (Falkner, 1962). In addition, height measurements were obtained for children enrolled in grades two and five in an urban public school and urban private schools for girls and boys to provide a comparison of the stature of our experimental subjects from a low income area with ethnically similar children from more privileged socioeconomic circumstances.

RESULTS

Correlation coefficients between intelligence scores and height and head circumference are shown in Table 1. The relationship between head circumference and intelligence scores was essentially zero for the entire group and for all ages except the 11 and 14 year-olds when the correlation was significant at the 1 percent level of confidence. Head circumference of our subjects increased very slowly from 19.19 inches at age 7, to 20.16 inches at age 14, with the measurements being slightly higher for boys than for girls. Since the majority of Philippine children are breast-fed and thus adequately nourished during the period when the brain is most vulnerable to nutritional deprivation, it is not surprising that our data failed to reveal a similar correlation between head size and intelligence to that suggested by others investigating children known to have experienced extreme protein-calorie malnutrition in early infancy. The two significant correlations lead one to speculate that when these particular children were infants, some environmental factor, such as a crop failure or loss of income from the usual business of the community, resulted in a less adequate food intake for some mothers and their subsequent failure to support lactation adequately.

Table 1. Correlations Between Scores on Intelligence Test and Head Circumference and Height

Age	Number of Subjects	Male	Female	Correlation with circumference	Correlation with height
7	42	23	19	.040	.219
8	66	31	35	-.092	.220
9	55	28	27	-.134	.108
10	61	25	36	-.005	.130
11	74	36	38	.404**	.384**
12	65	33	32	-.029	.237*
13	28	15	13	-.076	.205
14	21	15	6	.393**	.524**
7-14	413			.066	.450**

*$p < .05$
**$p < .01$

The correlation between height and intelligence score was positive for each age. In all but one age group, it was higher than that with head circumference. At age 12, the correlation was significant at the 5 percent level and at 11 and 14, they were significant at the 1 percent level. It was in the latter age groups that a significant correlation was demonstrated also with head circumference. These data show that the taller children at any age performed better on the intelligence test than the shorter children. Since a child whose height deviates most from that of his agemates is the one most likely to have suffered from some degree of malnutrition, we assume that the shorter children were shorter, in part at least, because they were less well-nourished. Our findings confirm those of Cravioto et. al., (1966) who found among Guatemala children that the shorter children for age in a village gave a poorer performance on psychological tests. The likelihood that our subjects were undernourished is supported by a comparison of their height for age with averages of Philippine children (Matawaran, 1966; NCCSDFYS, 1967), with a U.S. growth standard (Falkner, 1962), and with the heights of children of the same age and grade from urban public and urban private schools, presented in Table 2. These comparisons show that the heights of our sample were approximately the same as those reported by the Food and Nutrition Research Center for children, some of whom were known, on the basis of results of a national nutrition survey, to suffer from undernutrition. In addition, our subjects were shorter by .6 to 5.7 (average 3.4) inches than children in the urban publish school and from 3.7 to 6.7 (average 4.7) inches shorter than children in the same grade and of the same age in an urban private school. From 47 to 74 percent of the rural subjects in each age group failed to achieve the height reached by 95 percent of American children. The number of urban and rural children who reached the 5th to 50th percentile on American norms shows that urban children, and specially those in private schools, had growth patterns approximating those of Western children of different genetic backgrounds (Table 3).

Table 2. Heights in Inches of Philippine School Children Compared with Philippine and U.S. Standards

Age	Urban private school	Urban public school	Rural public school	NCCSDFCY (1967) Average	FNRC Average Matawaran (1966)	5th percentile Falkner standard (1962)
Boys						
8	49.4	48.1	43.6	44.48	45.2	46.9
(16)	(3)	(31)				
9	50.4	48.0	46.0	46.9	47.2	48.8
(52)	(38)	(28)				
10	55.6	55.5	50.6	50.4	50.4	51.9
(18)	(12)	(36)				
11	57.3	54.2	53.6	52.1	52.2	53.5
(49)	(19)	(33)				
Girls						
8	49.9	47.8	44.8	43.8	44.9	46.4
(22)	(5)	(35)				
9	50.2	48.5	46.8	47.4	46.8	48.2
(51)	(41)	(27)				
10	56.9	54.2	51.1	50.2	51.2	51.9
(32)	(14)	(38)				
11	57.9	55.4	53.5	54.5	53.3	54.1
(50)	(36)	(32)				
12	60.1	59.1	53.4	56.4	55.8	57.1
(5)	(30)	(13)				

[1]Heights represented for age in years + 6 months
[2]Food and Nutrition Research Center
[3]Number in parenthesis-number of children in group.

Table 3. Percentage of Filipino Children from Urban Private, Urban Public, and Rural Grade Schools who have Reached Western Growth

Group	Below the 5th percentile	5th to 50th percentile	51st-95th percentile	9th percentile
Boys				
Urban private	16	61	22	-
Urban public	56	40	4	-
Rural public	71	25	4	-
Girls				
Urban private	11	62	27	-
Urban public	47	47	6	-
Rural public	73	26	1	-

[1]Falkner (1962) Growth Standards

Since most studies have shown that the role of genetics in accounting for group differences in stature is minimal, we conclude that our experimental group suffered from some degree of undernutrition during the growth period and failed to realize their genetically determined growth potential. Evidence of undernutrition can be substantiated by the biochemical data from the national nutritional surveys conducted in comparable areas in the Philippines.

DISCUSSION

While we have demonstrated a relationship between height, one criterion of nutritional status, and intellectual performance, it is not possible to conclude undernutrition per se was responsible for the depressed learning ability. By choosing a sample from a relatively homogenous socioeconomic and environmental background, we hoped to minimize the extent to which differences could be attributed to other factors such as an impoverished intellectual environment, social deprivation, and minimal motivation. These factors, which could have the same adverse effects on learning and behavior as malnutrition, vary little from family to family in our sample. These conditions are also part of the complex of sociocultural factors which limit the food supply, and result in lethargy and a reduced involvement with the environment.

Our finding of a relationship between a criterion of nutritional status and an assessment of learning ability has social significance which should not be overlooked. The self-perpetuating aspects of such a situation warrant attention since a malnourished individual of low intelligence is likely to foster a generation of similarly undernourished and intellectually deprived persons. The correlation between height and intellectual development has been demonstrated to be essentially zero among urban Philippine populations (Guthrie, 1968), among children of upper income families in Guatemala, and among samples from industrialized societies. The positive correlation found this sample, where a deficit in height is considered evidence of some degree of nutritional deprivation, suggests that the less well-nourished child is less capable of benefiting from the educational opportunities afforded him than is an adequately nourished child. This effect can be compounded when malnutrition interacts with infectious processes to interfere further with the intellectual growth of the child.

SUMMARY

A nonverbal intelligence test standardized for use in the Philippines was administered to 413 children from a homogenous socioeconomic background in an elementary school in a rural Philippine barrio. Measurements of height and head circumference, were made using standard anthropometric procedures. Correlations between head circumference and height and intelligence scores indicated that shorter children did less well than taller children of the same age. A significant relationship between head circumference and intelligence was demonstrated at only two ages. A comparison of heights of experimental children with children from urban public and private schools showed that the rural children had experienced a growth retardation.

NOTE

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