THE ROLE OF NUTRITION

IN THE

INTELLECTUAL DEVELOPMENT OF CHILDREN

By

SYLVIA Y. BABAYAN

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ABSTRACT

The purpose of the present study was to observe the relationship between nutrition and intellectual development in children.

The subjects were drawn from a sample of children attending the Out Patients Department of the American University Hospital of Beirut, who had already taken part in a longitudinal study, in which their growth patterns were studied. The experimental group consisted of 22 subjects who had been severely undernourished early in infancy. They were matched with an equal number of adequately nourished children on the basis of age, sex, birth-weight, parents' age and education, as well as socio-economic background.

To control the effect of heredity, the parents were matched on the basis of their intellectual capacity. To do this Raven's Progressive Matrices Test was used.

The children's IQ's were assessed by the Stanford Binet Intelligence Test. When the mean IQ of both groups were compared, the undernourished group were found to score significantly lower.

Thus, the main hypothesis that undernutrition in infancy may affect the intellectual development of children was confirmed.

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INTRODUCTION

"Food, nutrition and health are basic needs of people everywhere. Hungry, underfed, malnourished populations can have little concern for anything but their need for food and wellbeing. They are subject to the ravages of disease, further diminishing their productive capacity. The result is a vicious, revolving chain of physical, mental and economic hardships". (30 p.677)

Among the outstanding problems which at present afflict humanity, undernutrition is perhaps one of the most serious, because it affects the well being of mankind. Moreover, undernutrition is considered to be the world's foremost pediatric problem of our time. It is particularly prevalent in developing countries, where, directly or indirectly, it is a major contribution to child mortality. Undernutrition and malnutrition are likely to claim more victims than tuberculosis, malaria and cancer, because they open the way for attack on the organism by other diseases.

It has been observed that undernutrition, in its various forms, is the most common and basic disorder in

infants and children in developing countries. Statistics show that an average of 70% of all preschool children in developing countries are undernourished while some surveys have shown the incidence in both children and adults to be as high as 100%.(14)

Many children considered to be healthy and of normal development suffer from nutritional deficiencies. In many parts of the world one may be misled at first sight by the good physique of the people, but very often it has been observed that the life expectancy is short and mortality among children is extremely high. It should be remembered that the weak or the undernourished are not seen walking down the roads and streets.

It seems logical to think with de Silva (32), that perhaps widespread undernutrition during childhood may, in part, be responsible for the underdeveloped state of some nations. Hence, the eradication of childhood malnutrition and undernutrition with all of their tragic consequences, should be a matter of special concern to child health specialists and child psychologists in developing countries.

The evident physical changes resulting from undernutrition are well recognized and have been extensively studied.(11,15,23) Much research has been done

on the effects of undernutrition on physical growth but until recently the possible effects of undernutrition on the intellectual development of children have been neglected.

Although undernutrition during infancy results in some reduction in the adult body size, this effect should be limited, since growth continues for about 18 years, providing subsequent nutrition is good; on the other hand Stoch and Smythe note: "The interesting possibility arises that undernutrition during infancy may result in failure of the brain to achieve its full potential in size and it is not unreasonable to suppose that this may also predispose the inhibition of optinum intellectual and personality development".(33 p.546)

So, the millions of children, who are undernourished early in their lives, in different parts of the world, would never fully realize their inherent potentialities and would be limited in their abilities to advance themselves in their society, because "...each new function makes its appearance chronologically at a 'critical period' in the total ongoing pattern and is apparently maximally operant at that time".(5 p.3)

On the other hand in adult studies it has been

shown that the brain is adversely affected by starvation. But with adequate nutritional therapy, brain performance can be expected to return to normal.(20,22)

These studies suggest that the first four years of life are the most important period of growth and development of the brain and that once the brain has evolved normally, it is capable of withstanding deprivations.

Coursin concludes: "The significant implication is that in dealing with the problem of undernutrition in developing countries, efforts must be focussed on reaching the infant and preschool child so that we may prevent not only physical growth failure, but may insure the integrity of brain structure as well".(5 p.8)

So far the few studies that have been carried out in the area of nutrition and intellectual development constitute isolated efforts and it is, therefore, essential that their findings be tested more widely.

Although it now seems that undernutrition in infancy and childhood may have serious effects on the intellectual development, it is felt that still some more evidence is needed, from different parts of the world, to confirm the findings before making broad generalizations. This constitutes the objective of the present study.

This thesis, then, represents an attempt to determine the relationship of undernutrition and mental development in children because:-

1. Very few studies have investigated this problem.

2. No similar studies have been carried out in Lebanon.

3. Criteria used for the assessment of the nutritional status of children were not comprehensive enough in previous studies.

CHAPTER I

REVIEW OF RELATED LITERATURE

In this chapter an attempt will be made to review and discuss some studies dealing with undernutrition and physical growth and intellectual development of children. However, for clarification and better communication, it is necessary to define some of nutritional deficiency states.

Chronic starvation refers to the state of an organism in which the tissue cells are chronically on the border of deficiency because of insufficient food.(13)

Undernutrition refers to the inadequacy in the quantity of the diet, that is, in calorie intake, which if continued over a long period, results in either loss of normal body weight or reduction in physical activity or both. This definition is strictly appropriate to adults. In the case of children, the consequences of low calorie intake are unsatisfactory growth and physical development, and a reduction of the high degree of activity characteristic of healthy children.(12)

Malnutrition refers to the inadequacy of the nutritional quality of the diet which, if made good, enables a

person to lead a healthy, active life. More specifically, it denotes inadequacy of a particular or several essential nutrients. In the case of serious shortages of nutrients the subject shows signs of specific deficiency disease; whereas minor degrees of deficiency result in poor general health.(12)

However, undernutrition and malnutrition are naturally not mutually exclusive; people who are undernourished are likely to be malnourished and particularly, if it is serious or prolonged, will lower resistance to disease. It should be mentioned here that all through the thesis the term undernutrition will be used, because all of our subjects were undernourished during the first 18 months of their lives.

Studies have shown that in areas where undernutrition is prevalent it is the recently weaned infant who receives the least food. Brock and Autret (4) report that in Africa parents serve themselves first, and that both the quantity and the quality of the food decreases with the age of the children in the family, the worst being that of the child being weaned.

It is generally observed that healthy children have an uninterrupted and smooth process of growth and development, so it is logical to think that the physical growth of the undernourished children, and possibly the intellec-

tual development, is either arrested or at least considerably retarded.

Several studies have shown that undernourished children exhibit retarded development, weight loss, physical incapacity and emotional disturbances. On the other hand the adults' defense against dietary deficiency is manifested by inactivity, indifference to the environment, depression and apathy.(15,13)

It has been shown that a number of factors, social, economic, sanitary, educational together with food production, transportation and population growth, play a definite role in the development of undernutrition. However, the chief cause of undernutrition is chronically deficient food consumption and it is, therefore particularly found at the lowest economic levels.

Causes of Undernutrition:-

The causes for undernutrition have been classified as primary or secondary.(7,13,32)

I. The primary causes are those that interfere in any manner with the ingestion of sufficient amounts of food of adequate quality. The factors that may be considered responsible for primary undernutrition include various environmental factors, economic factors and some faulty dietary habits.

A. Environmental Factors:-

1. Insufficient food production. The fundamental dependence of a satisfactory food supply upon a flourishing and sound agriculture is self evident. This is a fact which has been realized from the earliest times. Today, in India and China, where about half of the population of the world exist, much improvement in agricultural production is necessary for the elimination of widespread underfeeding and malnutrition. The chief causes of agricultural unproductiveness include climatic irregularities, war, and inefficient farming methods. Other factors include unequal distribution of food, lack or inadequate means of transport.

2. Sanitary conditions and facilities. Overcrowded living conditions are responsible for the more rapid and more frequent spread of infections. The need for adequate sanitary facilities and for personal cleanliness is of utmost importance because the lack of sanitation helps the spread of intestinal parasites with concomitant nutritional deficiencies. Moreover, various carriers of disease such as mosquitoes, lice and flies are prevalent in areas where sanitation is inadequate.

3. Ignorance. Parental ignorance contributes to childhood undernutrition. Many mothers know nothing about the need for a balanced diet, nor what it is. Cooking

methods often waste or destroy the nutritive factors of the foods used.

B. Economic Factors:-

1. Poverty is one of the most important factors responsible for the unequal distribution of food in the population. As a cause of underfeeding and malnutrition, the unequal distribution of food within a society is second only in importance to insufficient production. This fact affects urban communities, particularly in the enlarging towns of developing countries more severely than those living in rural areas, because the latter still have the opportunity to produce all, or a part of the food they require.

C. Customs and Taboos:-

1. Customs. In Asian countries as well as in other developing communities, the food intake of children being weaned is inadequate. In many areas, the father has the first choice of food, the older children next, the younger children after the older ones, and the mother last of all.

2. Taboos. Religions enforce many food taboos. Jews and Muslims are forbidden the flesh of the pig, but more important is the Hindu prohibition of the consumption of beef. Davidson and Passemore (7) note that a well-fed,

healthy cattle population is a sine-qua-non of a well-fed community whereas it has been estimated that half of India's cattle has no economic value because it provides neither milk nor can be used for transportation; and instead uses up the land needed for the production of human food.

Although poverty may be the most significant general factor which makes suitable food unavailable, it is not the chief one in some areas of many countries. Much ignorance of the general principles of good nutrition exists in all countries of the world. In many of the less developed countries lack of knowledge of the high nutritional requirements of growing children results in an appreciable incidence of undernutrition and malnutrition even when food supplies are adequate in quantity and quality.

It has been observed that nutrition and the environmental circumstances of infants and children in developing countries are so poor that "they may begin to show decline in their neurological competence by 4-6 months of age. Breast milk is the only source of nutrition of these babies. It serves them well until their needs begin to exceed supply. The inadequate milk supply is supplemented with substances that supply primarily carbohydrate for calories".(5 p.6) Thus the infants' growth and development depends on a restric-

ted nutritional intake that contains progressively smaller amounts of necessary nutrients for normal cellular metabolism. Moreover, after weaning, the diets of these children consist primarily of carbohydrate and furthermore, as it was mentioned, they may not participate fully in the family's food supply because the hierarchy of the household may channel important items to the elders.

'So, poverty, sanitation, ignorance, which results in loss of nutrients, and inappropriate feeding of children and some customs and taboos are important factors in causing a state of undernutrition and malnutrition in developing countries.

II. Secondary or conditioned undernutrition. "This type of undernutrition is produced when, despite adequate food intake, cellular assimilation is defective".(13 p.132)

A. In children the causes may be:-

1. Interference with the digestion and absorption of foods, due to a deficiency of digestive secretions or to diseases of the digestive apparatus which accelerate the intestinal passage of food.

2. Increase in nutritional requirements without satisfactory increase in food consumption as in accelerated tissue destruction.

3. Interference with utilization due to either enzymic deficiencies as in diabetes mellitus, hypothyroidism or to impaired oxygenation, as in chronic pulmonary diseases.

B. Indigenous medical practices:-

In many of the underdeveloped countries some indigenous medical practices are responsible for the inadequate nutritional status of infants and children, and the undernutrition following gastrointestinal and other infections. A child with an infection is often fed only cereal without milk or other proteins. "Such a diet increases the existing negative nitrogen balance and, in the presence of diarrhea and dehydration, results in severe electrolyte imbalances".(32 p.214)

Undernutrition and Physical Growth:-

The evident physical changes resulting from undernutrition are well recognized and have been studied. Undernutrition in children frequently results in retarded growth. It has been observed that the human organism fails to attain its potentiality in growth when the amount of food that he takes is insufficient or when the necessary qualitative substances such as vitamins and minerals are missing in the diet.

A universal sign of undernutrition is an inadequate rate of growth and development of the human organism.

Body weight, is considered to be the best guide to the nutritional state of children. However, since World War II surveys have been undertaken, in many parts of the world, with the increasing use of improved biochemical tests, in addition to the long established anthropometric measurements as criteria for undernutrition.

Growth of children in weight, and to a lesser degree in height, has been shown to be affected during war time by restrictions in food intake caused by scarcity of food. Jonxis (19) found that in Holland, in 1945, most children over one year of age lost weight toward the end of the famine period and ceased growing in height.

Chronic nutritive failure as a predisposing cause of growth lag in children has been extensively investigated by Dreizen.(11) In his study growth patterns of children with chronic nutritive failure were compared to a standard of reference developed from data obtained from an ethnically identical group of children without nutritive failure. He found that in children with nutritive failure a substantial lag in height and weight is present by the end of the third year of age.

Mann (23) compared 47 children with a history of previous or existing nutritional disease with an equal number of children free from dificiency disease for a

period of about 2 years. His objective was to determine the extent to which the growth of children is affected by nutritive failure. He found that the two groups showed a distinct difference in their respective schedules of development, the children in the test group being on slower schedules of development than those in the control group.(27)

Some studies have shown that improvement of inadequate diets can improve the health and growth of children.

Spies (31) has demonstrated that milk added as a supplement to poor diets of undernourished children has resulted in the improvement in growth of the children. During a 20 months period of supplementation the children gained an average of 1.23 cm. and 1.35 kg. more than another group of ethnically and nutritionally comparable children.(28)

So, observations of deprivations in war torn countries and experimental conditions and observations of the effects of supplements to the diet upon health and growth indicate the important effect food has upon the physical growth of individuals.

Undernutrition and Mental Development:-

Relatively little emphasis has been given to studies of the influence of nutrition on intellectual

development of children. However, within the past decade, a number of observers have begun to emphasize the effects of undernutrition on central nervous system activity of children; namely, neuromuscular function, behavior, and intelligence. At present, as a result of some studies, increasing evidence is obtained, suggesting that "... the abnormalities of the central nervous system activity arise from changes in the developing brain per se and that they may be irreversible with persistence of function at a subnormal level".(5 p.2) And the brain, which is the organ of intelligence, is nourished like all the other bodily organs from the food we eat. So it is logical to think that dietary deficiencies may sometimes affect the nervous system itself.(28)

The first 2.5years of life are not only the period of maximum growth, 70% of the adult brain weight is reached by the end of the first year, but also they constitute almost the entire period of brain growth.(5,33)

Stoch and Smythe (33) have conducted one of the best studies in this area. They selected a group of infants who, when first seen were undernourished. These children were matched with an adequately nourished control group from an approximately similar socioeconomic background. A comparative longitudinal study of head circumference and physical and intellectual development of the two groups is reported.

Measurements of weight, height, head circumference and intelligence of these children were made on each child at intervals from 6-12 months over periods of from 2-7 years. Their results indicated that throughout the period of study those who were initially undernourished, were significantly lighter and shorter, and had smaller head circumference and lower intelligence quotients than the control group. Moreover, what is more noteworthy is the finding that the undernourished children gave no evidence of making up their initial handicaps other than weight.

Poull (29) conducted an investigation with 41 undernourished children whose nutritional level was raised and a control group of matched children who were well nourished throughout the period. He found that the experimental children gained about 10 I.Q. points during the improved nutritional period of 18-24 months while the control group did not change in I.Q. level. The largest gains in I.Q. were found when the improved nutritional program was instituted during the first four years of child's life. Only slight gains in I.Q. were found among the older children.(34)

From the evidence it appears that improvements in I.Q. may be obtained at an early age by the administration of vitamins and chemical preparations. "However, these

improvements are usually found among children who have been suffering extreme nutritional deprivations. It does not follow that similar applications would affect I.Q. changes in a general child population where the nutritional level is reasonably adequate".(35 p.429)

Harrel's (16) study is one of the most carefully controlled studies on the effects of diet on children's mental functioning. An experimental group of 55 children and an equal number of other children were carefully matched on height, weight, sex, age, educational achievement and intelligence scores.(36) Then 2 milligrams of thiamine,(Vitamin B, a water solible Vitamin) was administered to the experimental group daily. At the end of one year the experimental group was significantly superior in reading achievement, memorizing of new materials, visual acuity and general educational achievement. Although this study throws no direct light on I.Q. changes, the findings do indicate that sufficient quantities of thiamine, over a long period of time, are beneficial to general intellectual functioning.

In Kugelmas' (21) study the experimental group consisted of 41 retarded and 50 normal children who were undernourished when first tested but well nourished at the time of the second test. The control group of 41 retarded and 50 normal children, were well nourished throughout the period covered by the experiment. The two groups were

equated for chronological age, initial I.Q. and time interval between tests. The results showed no improvement in average I.Q. for the control group but for the experimental group there was an average rise in I.Q. of 10 points for the retarded children and 18 for the normal children.

Moreover, the results indicated that the younger the undernourished child is when nutritional therapy is provided, the greater the improvement in mental functioning.

The finding that the earlier age at which nutritional therapy was instituted the better the rise in I.Q. and that after the age of 4 the rise was insignificant has important implications that are in line with the findings of Stoch and Smythe.(33)

Cravioto (6) reports findings from a village where undernutrition is so prevalent that no child escapes from at least a mild degree of it. The Terman-Merrill test was administered to preschool age children. The mental scores obtained were negatively related to chronological age, and the older the child the poorer was the performance relative to his age.

So, the results obtained from studies investigating the relation between nutrition and mental development may be summarized in the following manner: The degree of mental incompetency that is observed in undernourished children appears to be related to age at the onset of undernutrition, its degree of severity and duration. In the

children who had an earlier onset of severe undernutrition and those who have experienced deprivations throughout the first four years of life, central nervous system changes may not be completely reversible. There may be a continued lag in progress with a demonstrable permanent gap in ability compared to others under treatment and especially normal controls.

The number of studies investigating the relationship between nutrition and intelligence are very few, some criticisms of all these studies are that:

1. They have generally used one criterion, namely weight, as the only index of undernutrition.

2. They have either not specified the kind of Intelligence test that has been used or they have used different tests at different age levels. For example, Stoch and Smythe first used Gesell and Amatruda's Infant Scales of Mental Development and from 2-6 the Merrill-Palmer Test, and after age 6 the Individual Scale of the National Bureau of Education Research of South Africa, which is based on the 1916 Stanford Revision of the Binet-Simon Intelligence Scale. The objection to be raised here is that these tests do not correlate highly enough with each other in order to justify comparison of results obtained with them.

Relationship of Physical and Mental Development:-

There seems to be a slight relationship between physical growth and mental development. Positive relationships between intelligence and a number of physical measures are reported by many investigators. Abernathy (1) has reported one of the best studies in this area, he had found a correlation of .26 between intelligence test scores and height for boys and .16 for girls.

In Honzik's (17) study, scores from the Stanford Binet correlated slightly with physical growth. At age 7, intelligence test scores correlated .19 with height and .16 with weight.

Jones (18) studied the height and weight of 126 educationally subnormal people. He found that 73% were below the average weight and 68% were below the average height.

On the other hand Terman (34) found that intellectually gifted children tended to be superior throughout the growth period in many aspects of physical development as in height, weight and age of walking and also in school grades and achievement test scores.

Mussen and Conger (26) suggest that the positive relationship between physical status and intelligence may be due to the fact that environmental factors such as good home background may favor both superior intellectual

performance and greater physical development. Their conclusion is noteworthy. "Whatever their sources, it seems that within the normal range there are slight but nevertheless statistically significant relationships between such physical measures as height, and weight and such academic measures as school grades and achievement and intelligence scores".(26 p.364)

Relationship of Motor to Mental Development:-

A number of investigators have been interested in the relationship between motor and mental development.

Bayley (3) standardized an infant scale of motor development composed of 74 items on 61 children. These were tested repeatedly at regular intervals from birth to 36 months. His results showed a correlation of .50 between mental and motor scores during the first 15 months but very low though positive after that age.

Dennis (9) reports that the average age of walking given by various investigators ranges from 12.77-13.47 months. Recently many investigators have found that the onset of waling is definitely delayed in those of low intelligence. Moreover, the results show that the more severe the mental deficiency, the greater is the retardation in the onset of walking.(2,24,25,27)

However, Dennis has shown that the converse effect of low intelligence, namely, that unusually high intelli-

gence is associated with the early onset of walking is not established.(10) The assertion that this relationship exists was made by Terman.(34)

Abt (2) carried out an extensive study in this area; when the age of the onset of walking was correlated with I.Q. the correlation for boys was -.36 and for girls -.37.

When the relation between the age of speech onset and I.Q. was determined the correlation was -.41 for boys and -.39 for girls. He concludes. "The correlations are quite reliable and may be interpreted to mean that there is a definite relationship between these 2 factors".(2 p.1356)

Dennis, who has dealt with this problem extensively states. "The reason why mental deficiency should retard walking is not definitly ascertained. While feeble-mindedness undoubtedly means a slow development of the cortex it may also mean a slower maturation of sub-cortical structures and even of ossification and muscular structure".(10 p.209)

It appears from the preceding discussion that there is some relationship between the physical, motor and mental development in children. And since it has been shown clearly that undernutrition has a retarding effect on the physical growth of children, it seems logical to think that its influence might extend to the intellectual development as well.

CHAPTER II

SAMPLING, METHOD & PROCEDURE

The aim of the present study was to observe the relationship of nutrition to intellectual development.

The hypotheses to be tested were:-

1. Children who have been undernourished in early infancy are likely to have retarded intellectual development at the age of 4-5 years, when all other factors are controlled.

After controlling most of the possible factors which might have an effect on the results, the mean I.Q. of an experimental group was expected to be significantly lower than the mean I.Q. of a control group.

2. Since the data on the age of the onset of walking and talking was available, it was thought worthwhile to see if the undernourished children were also retarded in their motor development.

So, the mean age at the onset of walking and talking of the experimental group was expected to be significantly greater than the mean age at the onset of walking and talking of the control group.

If the undernourished children were found to be retarded in their motor development then it was also expected that they would score lower on the performance items of the intelligence test than the experimental group.

To test these hypotheses a group of children was selected, who had been undernourished during the first 18 months of life. They were matched with an adequately nourished control group from an approximately similar socio-economic background. The intelligence of these children was assessed and compared.

The subjects were drawn from a bigger sample of 316 children who took part in a longitudinal study conducted by Dr. Harfouche, a university pediatrician. The study lasted for about 5 years, during which anthropometric data on these children were collected and their growth patterns were studied.

The experimental group consisted of 22 children (8 boys and 14 girls) who were severely undernourished from the age of 1-18 months. The children in the control group were matched with the undernourished children on a basis of age and sex.

Since our choice was limited to the most severely undernourished cases, it was not possible to have them all from one ethnic group. The distribution of the subject in

each ethnic group and according to sex is presented in table 1.

TABLE 1

DISTRIBUTION OF SUBJECTS ACCORDING TO ETHNIC GROUP AND SEX

	Boys	Girls	Total
Sunni Moslem	10	18	28
Maronite	-	6	6
Armenian	6	4	10
TOTAL	16	28	44

Criteria for Undernutrition:-

The measurement of nutritional needs and deficiencies has never been easy. In spite of much effort no rule of thumb method is available. The factors determining the health of a community are so varied and numerous that a single measurement of any one type alone is of little value in assessing nutritional s tatus quantitatively.

So, the application of a selection of methods, over a period of time, should make it possible to determine the nutritional status of people with confidence.

In many studies body weight has been considered as the best single criterion for undernutrition. Dean who has worked in this field claims weight to be "... the simplest and possibly the most valuable indicator of poor growth. We can offer no other test so easy, so competent, and so reliable.(8 p.73)

In the present study our criteria for assessing the nutritional status of the subjects included:

1. Period of Undernutrition: All our subjects were undernourished during the first 18 months of their lives.

2. Growth Pattern: Anthropometric measurements included weight, height, and subscapular skinfold thickness and their respective increments.

a. Body weight is considered to be an objective measure of growth and development, as well as, of nutritional adequacy by many authorities.(13,15)

b. Length is an important component of body weight but, unlike the traditional approach it is considered separately from weight. Length increment, rather than length per se, was used as a subindex in the assessment of the severity of undernutrition.

c. Subscapular skinfold thickness. Recently adipose tissue and its relative fatness as a measure of nutritional excess or inadequacy has been stressed.

3. Clinical Subindices: These did not have a measuring unit but were used only for subjective rating. They supplemented clinical observations and the other criteria as well.

a. General appearance. It was observed that the undernourished children in general were apathetic, irritable and had poor appetite. Harfouche (15) found that 93.7% of the undernourished infants were strikingly pale.

b. Muscle tone. Although it is a relatively crude measure, it serves as a good guide in assessing nutritional status. It has been found that skeletal muscle constitutes the largest single tissue of the body. It accounts for 25% of body weight in infants.(15)

c. Mental state. During every physical examination the infants were observed for evidence of mental changes. Their reflexes were tested too, to detect neurological disturbances. Harfouche (15) had observed that 68% of the undernourished children were apathetic, inactive and irritable towards the end of the period of undernutrition whereas the control group did not show any of the above signs.

4. Biochemical Indices: Consisted of hemoglobin, serum protein, albumin and globulin tests.

Matching of Subjects:-

The children in both groups were carefully matched on age. The mean age for both groups was 4.6 years. /Appendix I7

The mean birthweight was also matched (Table 2), that is no difference was found, but their weights at 18 months were significantly different from each other, thus indicating that the experimental group was definitely undernourished before and at 18 months of age.(Table 3). /Appendix II and III present the weights at birth and at 18 months of each group7.

TABLE 2

BIRTHWEIGHT OF CHILDREN

(In Grams)

	Undernourished	Well-Nourished
Range	2550 - 3950	2710 - 3970
Mean	3324.77	3332.73

t = .095 p > .10

TABLE 3

CHILDREN'S WEIGHT AT 18 MONTHS

(In Grams)

	Undernourished	Wellnourished
Range	8040 - 11060	8920 - 12010
Mean	9482.22	10849.00

$t = 5.193 \quad p < .001$

In order to have a control of the effects of the genetic factors on the results, the parents' age, education and intellectual capacity were also matched. The parents in both groups had comparable age (Table 4) and fairly similar intellectual capacity.(Table 5)

TABLE 4(a)

AGE OF MOTHERS

(In Years)

	Undernourished	Wellnourished
Range	24 - 45	23 - 42
Mean	31.2	29.6

$t = .860 \quad p > .10$

TABLE 4(b)

AGE OF FATHERS

(In Years)

	Undernourished	Wellnourished
Range	26 - 50	29 - 45
Mean	36.8	35.3

$t = .915 \quad p > .10$

TABLE 5(a)

MOTHERS' INTELLECTUAL CAPACITY

(In Percentile Rank)

	Undernourished	Wellnourished
Range	5 - 90	5 - 50
Mean	18.6	17.9

$t = .740 \quad p > .10$

TABLE 5(b)

FATHERS' INTELLECTUAL CAPACITY

(In Percentile Rank)

	Undernourished	Wellnourished
Range	5 - 50	5 - 50
Mean	21.7	22.5

$t = .233 \quad p > .10$

Parents' age and the intellectual capacity (in percentile rank) are presented respectively -- Appendix IV, V. XI, XII. As to the educational level of parents in both groups, it was fairly comparable. There were a few who had gone beyond the elementary education level and only one illiterate. The majority reported to have gone to elementary school at least for a few years.

Tests and Administration:-

1. To determine the parents' intellectual capacity Raven's Standard Progressive Matrices Test was used, because it provides an index of intellectual capacity, whatever the nationality, education and literacy of the individual is. The instructions given in the booklet were translated and explained to the subjects orally. Attempts were made to establish rapport and put the mother and the father,

respectively at ease.

The responses were recorded on data sheets. No interference, whatsoever, was allowed from outside and no time limits were set. In general, cooperation was excellent on the part of mothers and fathers. In general the fathers took more time to complete the test than the mothers.

2. The intelligence of the children was assessed by the Stanford-Binet Intelligence Test. Some selected items of the test, (presented in Appendix X) were translated into the appropriate languages and administered following the directions of Dennis who is presently using the same test in Lebanon with some adaptations such as leaving out items which have cultural connotations.

The children were tested at home or in the clinic. Ample time, sometimes around an hour was spent just to be acquainted with the parents and the children and explaining to them what the tester was planning to do. In this way the task of establishing rapport with the child was facilitated. Before the testing procedure started the tester explained to the mother that it was preferable to leave the tester and the child alone so that better results could be obtained. In general, very few of them seemed to understand the logic behind leaving the room because their curiosity was great. But, at least the tester could persuade them to sit at

the opposite corner of the room and watch from there.

To further facilitate the establishment of good rapport, the tester would spend a few minutes talking to the child about his interests, friends, likes and dislikes.

Difficulties Encountered in Carrying out the Procedure:-

The main difficulty was in locating the houses of the selected subjects. Although the addresses were available, a good number of the families had moved to other quarters. Another problem was to find the father, the mother and the child at home together, so in most cases more than one visit was necessary.

However, once the house was located, it was rather easy to establish rapport with the parents, because of their previous relationships with Harfouche. In general it was easy to establish rapport with the children, except in some cases which were later found to be from the under-nourished group.

As to the administration of the Stanford-Binet, here some more problems were encountered. Some of the children were brought to the clinic, others were tested at home, but under both situations it was quite difficult to satisfy

the curiosity of the mothers , they were never persuaded to leave the room. But at least it was possible to isolate them at the opposite end of the room and let them watch from there.

CHAPTER III

RESULTS AND DISCUSSION

The purpose of the present study was to observe the relationship of nutrition to intellectual development in children. To do this some severely undernourished cases were selected. The choice was limited only to severe cases because the factors that might affect intelligence are so many that only by comparing extreme degrees of undernutrition its effect could be observed clearly.

An advantage of the present study is that the criteria which were used in the assessment of the nutritional states of children were comprehensive. So, in addition to weight, which is considered to be the best indicator of undernutrition some other criteria were used as well in the assessment of the nutritional state of these children.

Harfouche (15) had studied the growth pattern of these children, anthropometric measurements were obtained and some clinical subindices, such as general appearance and muscle tone of the children, were considered.

In such studies the question of bias arises when the tester is personally involved and is interested in the outcome of the tests. To avoid this, the testing in

the present investigation was conducted along the lines of a 'blind' study. However, in a few cases it was very conspicuous that the child was undernourished. He was weak, pale and thin; in spite of this the tester tried to be objective in the administration and scoring of the test.

In the evaluation of the results it was observed that in general it had been more difficult to establish rapport with the undernourished children; 70% of them were shy, withdrawing and not cooperating and some of them had even cried. In such cases, when it was not possible to establish rapport on the first visit, the testing was postponed to another visit.

As to the test itself, it should be mentioned that although some necessary adaptations were made following the instruction of Dennis, still most children in both groups had trouble mostly with the verbal items, especially the comprehension items. An intelligence test standardized in Lebanon, if available, would have been preferable.

However, the test yielded significant results. The mean I.Q. of the undernourished group was 79.5 whereas that of the wellnourished group was 103 ($t=10.28$ $p<.001$). The undernourished children had scored significantly lower. /Appendix VI7

In Fig. 1, are plotted the I.Qs. of the 2 groups of

children. It can be seen that the mean of the undernourished group is well below the control group. The mean I.Q. of the undernourished (79.5) differs from that of the con- group (103) by 23.5 points. This is statistically significant.

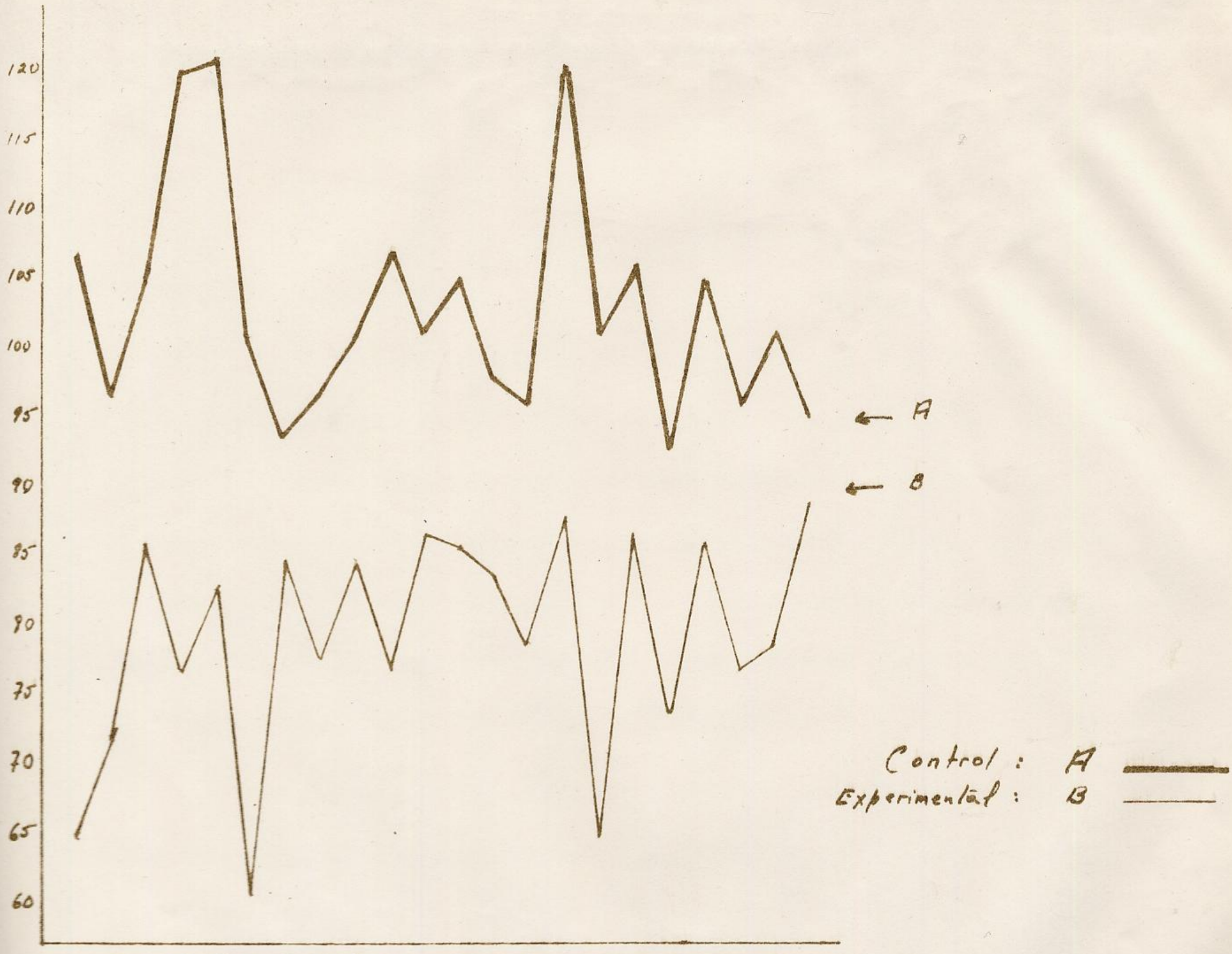

Fig. 1.— Comparison of IQ's obtained by both groups.

Since all other possible factors which were thought to have an effect on the I.Q. of the children were controlled, the difference appears to be due to the nutritional state of the children. Thus the hypothesis that undernutrition in early infancy has an effect on the intellectual development of children is supported.

The findings in Lebanon are in line with findings reported from South Africa and other studies.

Some other hypotheses were tested as well. Since the effects of undernutrition are found to be retarded growth and development, it was postulated that the undernourished would have retarded motor development as well. Thus, since data was available on the age at onset of walking and talking it was thought worthwhile to test the hypothesis that undernourished children are likely to have retarded motor development; more specifically, the mean age at the onset of walking and talking was expected to be significantly greater in the case of the undernourished children as compared to their matches.

The results showed that the mean age at onset of walking for undernourished children was 13.5 months whereas that of the well-nourished group was 11.8 months. The undernourished children were significantly retarded in walking when compared with the control group. (Table 6)

When the age at the onset of talking was considered, for the undernourished the age of onset was 16.7 months, whereas for the wellnourished it was 14.4. (Table 7)

However, before we come to any conclusion we should see what Harfouche has observed in Lebanon. She has made the following interesting observation that "...with severe illness a regression in motor function usually was recorded. The severity and duration of the illness, reflected in the nutritional state, were determining factors in both delay and regression of motor function. When illness occurred at the time that the infant was about to sit or walk alone, he was delayed from attaining these functions at the expected age. However, when illness occurred after the expected age of function attainment, the infant performed the motor function at the expected time.(15 p.183)

The interesting possibility that the undernourished children, who were retarded in their motor development, will also score lower on the performance items of the intelligence test than the experimental group, was tested. The results showed that their performance scores were significantly lower than those of the well-nourished but the verbal scores were significantly lower as well. (Table 8) So, undernourished children had scored lower in both the verbal and performance items which were selected arbitrarily since the Stanford Binet does not have specific items for these categories.

Perhaps it would have been preferable to use the WISC in the present investigation because it has verbal and performance items and may give a verbal and performance I.Q. of the children. Its use could have been justified by making similar adaptations to the ones made in the case of the Stanford Binet.

TABLE 6

AGE AT THE ONSET OF WALKING

(In Months)

	Undernourished	Wellnourished
Range	9.5 - 14	8 - 14.5
Mean	13.5	11.8

$t = 2.24 \quad p < .05$

TABLE 7

AGE AT THE ONSET OF TALKING

(In months)

	Undernourished	Wellnourished
Range	14 - 24	11 - 18
Mean	16.7	14.4

$t = 3.05 \quad p < .01$

Note: Appendix VII and Appendix VIII present the age at the onset of walking and talking of the whole group.

TABLE 8

MEAN PERFORMANCE & VERBAL SCORES OF CHILDREN

	Undernourished	Wellnourished
(1) Performance	3.68	9.28
(2) Verbal	5.54	14.00

(1) $t = 8.45$ $p < .001$ (2) $t = 10.2$ $p < .001$

The respective performance and verbal scores for both groups are presented in Appendix IX.

Advantages and Disadvantages of the Present Study:-

A shortcoming of the present study is that no objective indication of the intellectual functioning of these children had been obtained at or before 18 months. Although the work can justify itself on the grounds that:

1. No mentally retarded cases were noticed all through the longitudinal study, by the pediatrician.

2. The genetic factor was controlled by matching the intellectual capacities of the parents in both groups.

Ideally, then some measure of the intellectual functioning of these children should have been obtained before

18 months and then their I.Q's be measured at certain intervals, and finally at their present age. It would also be preferable to have all the subjects from the same ethnic group.

However, it is hoped that the information obtained in the present study will be of some interest and value to public health specialists and child psychologists because:

1. The number of studies which have made an attempt to determine the relationship of undernutrition and intellectual development in children is very few.

2. It is the first study which has investigated this problem in Lebanon.

3. Criteria used for the assessment of the nutritional status of children, in the present study, are comprehensive.

SUMMARY AND CONCLUSIONS

The objective of the present study was mainly to test the hypothesis that severe undernutrition in infancy, which is the most important period for brain growth, may retard the intellectual development of children in Lebanon.

The results obtained confirmed the hypothesis thus the scores of the experimental (undernourished) group on the Stanford Binet were significantly lower than those of the control (wellnourished) group. Our findings are in line with those reported in other studies.

The finding that undernutrition has an effect on the intellectual development of children reported from different parts of the world, adds much emphasis and urgency to the need for good nutrition in infancy in particular, and in later years in general.

If the present estimates are valid then with improvement of the nutritional states of infants and children in developing countries, as well as conditions that cause nutritional diseases, one would expect to achieve some improvement of intelligence and this would enable the children to be more productive adults in the future.

APPENDIX I

AGE OF CHILDREN

(In Years & Months)

Undernourished	Wellnourished
4 : 6	4 : 4
4 : 1	4 : 0
4 : 3	4 : 4
4 : 10	4 : 5
4 : 11	4 : 0
4 : 2	4 : 7
3 : 11	3 : 11
5 : 2	5 : 1
5 : 4	5 : 3
4 : 10	4 : 8
4 : 10	5 : 2
4 : 7	4 : 6
5 : 1	5 : 2
4 : 1	4 : 9
4 : 6	4 : 10
4 : 11	5 : 2
4 : 2	4 : 4
4 : 7	4 : 4
3 : 11	4 : 6
5 : 0	5 : 0
4 : 10	5 : 0
4 : 7	5 : 3
Mean = 4.6	Mean = 4.6

APPENDIX II

BIRTHWEIGHT OF CHILDREN

(In Grams)

Undernourished	Wellnourished
2865	2860
3950	3970
3860	3750
2550	2800
3100	3135
3800	3900
3400	3410
3000	3020
3920	3650
3600	3625
3265	3220
3300	3200
3470	3435
3640	3700
2740	2860
3300	3225
3300	3300
3100	3100
3560	3450
2650	2710
3245	3275
3530	3590
3324.77	3332.73

$t = .095$ $p > .1$

APPENDIX III

WEIGHT OF CHILDREN AT 18 MONTHS

(In Grams)

Undernourished	Wellnourished
9630	10900
8480	12000
9650	10500
8880	11090
9360	11680
8730	11010
8040	10420
8170	10100
9360	10160
9620	9400
9500	12010
10230	11500
9850	11760
10370	11440
9700	8920
9530	9570
10850	9660
11060	11390
9180	11320
8120	9820
10330	10970
9980	11290
9482.22	10849.00

$t = 5.193$ $p < .001$

APPENDIX IV

PARENTS' AGE

(In Years)

Mothers		Fathers	
Undernourished	Wellnourished	Undernourished	Wellnourished
32	39	40	31
45	26	50	33
34	32	40	33
25	35	30	37
32	30	37	41
27	42	31	45
30	25	35	28
33	24	36	32
35	33	38	38
34	28	43	29
41	28	46	39
27	27	32	27
33	40	35	41
35	28	45	38
26	25	30	33
24	35	26	36
31	24	33	37
29	34	41	42
26	26	35	32
35	26	37	39
29	23	41	35
24	23	30	32
Mean 31.2	Mean = 29.6	Mean 36.8	Mean = 35.3
t = .860	p $>$ .10	t = .915	p $>$ .10

APPENDIX V

PARENTS' INTELLECTUAL CAPACITY

(In Percentile Rank)

Mothers		Fathers	
Undernourished	Wellnourished	Undernourished	Wellnourished
5	10	10	5
10	25	5	10
5	10	50	25
10	25	25	50
5	50	10	50
5	10	5	5
5	10	5	25
10	5	5	10
50	50	25	25
5	25	10	50
90	25	25	25
5	5	25	10
5	5	25	10
10	10	10	25
5	50	25	50
10	5	10	25
5	25	10	25
10	5	25	10
25	10	25	25
10	5	50	10
25	25	50	10
10	5	50	25
18.6	17.9	21.7	22.5

$t = .740$ $p > .10$

$t = .233$ $p > .10$

APPENDIX VI

IQ OF CHILDREN AT PRESENT

Undernourished	Wellnourished
65	107
72	97
87	105
77	120
83	121
61	101
85	94
78	97
85	101
77	107
87	101
86	105
84	98
78	96
88	120
65	101
87	106
74	93
86	105
77	96
79	101
89	95
Mean 79.5	Mean 103.0

$t = 10.28 \quad p < .001$

APPENDIX VII

AGE OF ONSET OF WALKING (UNSUPPORTED)

(In months)

Undernourished	Wellnourished
14	11
14.5	11.5
15.5	14
14	13
9.5	11
17	13
19	12.5
17	13
14	9
12.5	13
13	12
14.5	13
10.5	11.5
11	11.5
13	11
20	12
13.5	13
10	12.5
9	11
12.5	13
11	9
13.5	8
Mean 13.5	Mean 11.8

$t = 2.24 \quad p < .05$

APPENDIX VIII

AGE OF ONSET OF TALKING (WORDS)

(In Months)

Undernourished	Wellnourished
14	11
15	12
14	18
14	14
15	15
14	15
18	18
15	15
15	12
23	17
18	12
18.5	18
12	18
20	15
14	12
24	12
14	14
17	14
18	14
23	18
16	12
18	12
Mean 16.7	Mean 14.4

$t = 3.05$ $p < .01$

APPENDIX IX

Performance		Verbal	
Undernourished	Wellnourished	Undernourished	Wellnourished
3	9	6	13
2	8	3	15
4	9	6	13
5	10	6	18
4	11	4	16
2	11	3	18
2	6	6	9
2	4	6	10
4	5	7	10
4	14	8	10
8	10	8	17
4	7	7	19
4	10	3	15
4	10	4	13
3	9	6	12
5	10	7	19
3	11	4	15
4	15	7	11
5	9	6	10
2	8	8	16
4	11	3	12
3	7	4	17
Mean 3.68	Mean 9.28	Mean 5.54	Mean 14.00

$t = 8.45$ $p < .001$ $t = 10.2$ $p < .001$

APPENDIX X

Year II (4 tests x 1½)

1. Form board (1 +) ⌐¬ a... b...
2. Delayed response (2 +) ⌐¬ a... b... c...
3. Parts of body (4 +) ⌐¬ a... b... c... d... e... f... g...
4. Block tower (±) ⌐¬

Year II-6 (4 tests x 1½)

1. Parts of body (6 +) ⌐¬
2. Picture vocabulary (8 +) ⌐¬
3. 2 digits (1 +) ⌐¬ 47... 63... 58...
4. Form board: rot. (2 +) ⌐¬ a... b... c...

Year III (4 tests x 1½)

1. Stringing beads (4 +) 2 min. ⌐¬
2. Block bridge (±) ⌐¬
3. Copying circle (1 +) ⌐¬ a... b... c...
4. 3 digits (1 +) ⌐¬ 641... 352... 837...

Year III-6 (4 tests x 1½)

1. Comp. balls (3 of 3, or 5 of 6 +) ⌐¬ a... b... c... d... e... f...
2. Discr. animal pictures (4 +) ⌐¬
3. Sorting buttons (2 min.) Errors... ⌐¬
4. Comp. Sticks (3 of 3, or 5 of 6 +) ⌐¬ a... b... c... d... e... f...

Year IV (4 tests x 1½)

1. Obj. from memory (2 +) ⌐¬
2. Opp. analogies 1 (2 +) ⌐¬ a... b... c...
3. Discr. forms (8 +) ⌐¬
4. Comprehension II (2 +) ⌐¬ a... b...

Year IV-6 (4 tests x 1½)

1. Aesth. comp. (3 +) ⌐¬ a... b... c...
2. Opp. analogies 1 (3 +) ⌐¬

APPENDIX X

Year IV-6 (4 tests x 1½) (Cont'd.)

3. Pict. sim. & diff. 1 (3 +) ⌐¬
4. Comprehension III (1 +) ⌐¬ a... b...

Year V (4 tests x 1½)

1. Pict. compl.: man (2 pts. +) ⌐¬
2. Folding triangle (±) ⌐¬
3. Copying square (1 +) ⌐¬ a... b... c...
4. Knot (±) ⌐¬

Year VI (4 tests x 31)

1. Differences (2 +) ⌐¬ a... b... c...
2. Mut. pictures (4 +) ⌐¬ a... b... c... d... e...
3. Number concepts (4 +) ⌐¬ a... b... c... d... e...
4. Maze (2 +) ⌐¬ a... b... c...

Year VII (4 tests x 31)

1. Simil.: 2 (2 +) ⌐¬ a... b... c... d...
2. Copying diamond (1 +) ⌐¬ a... b... c...
3. Opp. analogies III (2 +) ⌐¬ a... b... c... d...
4. 5 digits (1 +) ⌐¬ 31859... 48372... 96183...

Year VIII (4 tests x 31)

1. Verb. absurd. 1(3 +) ⌐¬ a... b... c... d... e... f...
2. Sim. & diff. (3 +) ⌐¬ a... b... c... d...
3. Comprehension IV (4 +) ⌐¬
4. Days of week (order, 2 checks +) ⌐¬ Tu... Th... F...

APPENDIX XI

PARENTS' INTELLECTUAL CAPACITY

(Raw Scores)

Mothers		Fathers	
Undernourished	Wellnourished	Undernourished	Wellnourished
19	20	26	19
22	37	22	23
18	25	39	32
26	29	35	39
42	43	23	37
23	22	19	15
18	26	17	36
27	21	26	23
40	41	28	29
21	35	21	41
49	36	24	28
21	20	32	26
22	15	29	21
27	26	21	29
45	44	34	41
27	17	28	29
18	36	23	28
25	18	26	20
37	27	30	33
23	23	39	20
34	38	38	23
28	23	41	28

APPENDIX XII

ANALYSIS OF VARIANCE OF PARENTS' INTELLIGENCE SCORES (Raw scores)

Source	SS	df	MS	F	Sig.
Between parent pairs	3698.5	43			
* Between parents (P)	1.3	1	1.3	<1	n.s.
Error (between)	3697.2	42	88.03		
Within pairs	1969.5	44			
**Between sexes (S)	.9	1	.9	<1	n.s.
P x S	1	1	1	<1	n.s.
Error (within)	1967.6	42	46.85		
TOTAL	5668	87			

* Difference between parents(fathers & mothers) of the undernourished and well-nourished groups.

** Difference between sexes, all fathers and all mothers, irrespective of nourishment grouping.

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