Med. J. Cairo Univ., Vol. 62, No. 1, March: 49 -58, 1994

Behavioral Correlates to Nutritional Status of Preschool Children

ZEINAB BISHRY, M.D.; SOHAIR I. SALEM, Ph.D.;
FEISAL A. YUNIS, Ph.D.; HAGER A. ORABY, Ph.D.;
HANAA A. WAFAY, Ph.D.; ABLA G. KHALIFA, Ph.D.
and ZEINAB M. MONEER, Ph.D.

The Childhood Studies, Ain Shams University and
the Child Health Department, National Research Center,
Faculty of Arts, Cairo University.

Abstract

In this study, nutritional status of 185 preschool children aged between 3 and 6 years was assessed by investigating dietary intake, anthropometric measurements and protein status. Results of nutritional status parameters were correlated with a battery of psychological tests that covered intelligence, memory, learning, thinking, problem solving and attention. Dietary intake data showed that 49% of the children had caloric intake and 12% had protein intake that were lower than the recommended dietary allowance. A significant positive correlation was shown between caloric intake and intelligence. Plant protein as well showed significant correlation with thinking and problem solving. Height for age showed deficit in 19% of the children when compared to NCHS standards. Percentage weight for age and height for age were significantly correlated to thinking, problem solving and to intelligence. None of the protein status parameters showed significant correlation with the results of any of the psychological tests.

Introduction

DEVELOPMENT is a function of nutrition and learning. Physical maturation including maturation of the central nervous system, consists of increase of size and greater complexity of structure that leads to greater functional capacity. Child development during the preschool and middle school years is variable with respect to different domains of development [1].

Children living in disadvantaged environment display deficits in cognitive development [2,3]. Those children are mostly characterized by chronic protein-energy malnutrition (PEM), as well as by iron deficiency anemia [4]. Accordingly, investigators have considered cognitive deficits as correlates of nutritional status as well as of iron-deficiency anemia [5,6].

Malnutrition, per se, clearly alters the central nervous system by acutely or chronically limiting its metabolic, structural and functional capabilities and performance. In other circumstances, malnutrition, reflected in chronic limitation of amounts of food consumed, may result in general stunting of growth accompanied by reduced brain size, decreased brain cell number and immature or incomplete biochemical organization of the brain [7].

The availability of several criteria to assess the nutritional status raises the possibility to demonstrate the existence of a relationship between nutritional status per se and behavior.

The aim of this study was to explore the relationship between nutritional status and behavior in a group of preschool children.

Material and Methods

Recruitment of the subjects:

One hundred eighty five children aged 3-6 years, of both sex were randomly chosen from two-day care centers that are located into two zones in a semi-urban community "Boulak El-Dakrour", In Giza governorate, Children having congenital anomalies of any degree of mental retardation, or any chronic disease that may interfere with behavioral assessment were excluded from the study. The aim of the study design was primarily explained to the mothers of the children. Accordingly, mothers signed a written consent that allowed their children to be included in the study.

Study design:

At the first visit every child was subjected to a thorough clinical examination that included chest, heart, abdominal and neurological systems. Nutritional status was assessed by correlating dietary intake, anthropometric measurements and biochemical tests of protein status.

Dietary intake was assessed by using 24 hours recall procedure. It was carried out by asking the mothers about the type and approximate amount of each food consumed by each child per day and for two successive days [8].

Anthropometric measurements included weight, height, triceps, biceps and subscapular skinfold thickness and mid upper arm circumference [9].

Psychological assessment of the children was accomplished by a battery of behavioral tests that covered intelligence, memory, learning, thinking, problem solving and attention.

For blood analysis 5 mls blood sample was collected from each child between 9-11 am, serum was separated and kept at -20°C until analysis for albumin, prealbumin and transferrin.

Biochemical methods:

Serum albumin was determined by using bioanalytic Kit No. 27001.2, after the method of Doumes et al., [10].

Serum prealbumin was determined by using the M-partigen Immuno Diffusion plates that were purchased from Behring Corp. code no. O.T. 3 W.O. [11].

Serum transferrin was determined by using Nor partigen Radial Immuno Diffusion plates that were purchased from Behring Corp. Code no. DUCKO, [11].

Psychological tests:

The children were individually tested by professional psychologist. Raven's colored progressive matrix (CPM), [12], Digit span forward and digit span backward, sub-subjects from the Wechsler Intelligence Scale for children (WISC) [13]. A free recall test [14] that assesses the child's short term memory and organization ability, a discrimination learning task (DL) [15] that measures a variety of aspects of short term memory, short term buffer (rehearsal memory) and long term memory as a function of the particular trial and spacing condition [15]. Block Building Design (BD) is one of the non-verbal test in the MC-Carthy scales of children, [14]. It assesses the child's reasoning ability through the manipulation of materials. It demonstrates such skills as imitation logical classification and visual organization. Attention is a measure of the efficiency of signal stimuli in the context of non-signal stimuli [14].

Results

Mean (± SD) of daily nutrients intake as compared to their recommended daily allowances (RDA), are shown in table (1).

Mean (± SD) of anthropometric measurements of children included in the study are shown in table 2. Percentage weight for age and percentage height for age distribution in standard deviation units (values were calculated with respect to NCHS standard) are represented in Figs. 1 & 2.

Mean (± SD) of serum levels of albumin, prealbumin and transferrin of children included in the study are shown in table 3.

Mean (± SD) and ranges of all the behavioral parameters that have been used in our study are shown in table 4.

Positive correlation was shown between caloric intake with intelligence (p <0.01) as well as between thinking and problem solving with plant proteins (p <0.01) (table 5).

Positive correlation was shown between % Wt/age and % Ht/age and MAC with thinking and problem solving (p <0.05). Positive and strong correlation were also shown between each of % Wt/age and % Ht/age with intelligence (p <0.001) (table 5).

Significant correlation was shown between serum albumin and attention (p <0.05) (table 5).

Multiple coefficients showing the effects of some selected variables on intelligence and on thinking and problem solving, are shown in tables 6 & 7.

Table (1): Mean (± SD) of Daily Nutrients Intake of Children (n = 185).

	Protein		Fat		Carbohydrates (gm)	Total calories (Kcal.)
	An.	Pl.	An.	Pl.		
Mean	16.9	26.5	19.9	27.1	190.0	1319.0
± SD	13.5	12.0	16.9	13.3	82.8	850.2
Range	2.0-91.5	1.2-93.7	4.0-57.8	3.3-50.8	46.5-571.0	427.0-3753.9

Table (2): Mean (± SD) of Anthropometric Measurements of Children (n = 185.

Measurement	Mean	(SD)	Range
Wt (kg)	17.1	(3.2)	10 - 29
Ht (cm)	104.9	(7.9)	80 - 121
MAC* (cm)	15.9	(1.4)	10 - 21
Biceps SF** (mm)	7.1	(2.8)	3 - 19
Triceps (mm)	10.2	(2.9)	3 - 22
Subscapular SF (mm)	6.5	(2.1)	4 - 17
Fat index (mm)	16.7	(4.6)	7 - 39

* MAC = Mid arm cirumference.
** SF = Skin fold thickness.

Table (3): Mean (± SD) of Serum Levels of Albumin, Prealbumin and Transferrin of Children Included in the Study.

Parameter	N	Mean	(SD)	Range
Albumin (gm /dl)	163	4.3	(0.3)	2.7 - 5.1
Prealbumin (ng /dl)	134	16.4	(4.9)	3.5 - 43.7
Transferrin (mg /dl)	174	312.0	(56.8)	122.0 - 474.0

Table (4): Mean Scores (± S.D.) of behavioral Tests (n = 168).

Tests	Mean scores (± SD)		Range
Memory and learning (ML)	90.4	(4.4)	11 - 38
Free recall (FROR)	6.9	(1.6)	3 -12
Organization (ORG)	2.0	(1.2)	0 - 8
Digit span (DS)	6.0	(2.1)	0 - 26
Discrimination learning (DL)	5.6	(4.3)	0 - 26
Thinking and problem solving (BD)	9.1	(1.8)	0 - 12
Intelligance	17.6	(4.9)	2 - 31
Attention (VIG)	26.7	(4.9)	3 - 32

Table (5): Pearson Correlation Cofficient between Behavioral Scores and Indicators of Nutritional Status.

	Memory and learning	Thinking and problem solving	Intelligence	Attention
Dietary intake:				
Calories	-0.02	0.13	0.18	-0.01
Animal proteins	0.10	0.09	0.02	-0.03
Plant proteins	-0.12	0.19	0.11	0.03
Anthropometric measurement:				
Weight /age	-0.08	0.21	0.22	0.12
Height /age	-0.13	0.19	0.26	0.06
Mid arm circumference	-0.08	0.20	0.14	0.08
Serum proteins:				
Albumin	-0.08	-0.03	-0.10	-0.15
Prealbumin	-0.04	-0.01	-0.14	-0.001
Transferrin	0.01	-0.10	-0.02	0.04

* $p < 0.05$ ** $p < 0.001$

Table (6): Multiple Regression Coefficients Showing the Effect of Some Selected Variables on Intelligence.

Variables	Regession coefficient	Standard error	p -value
Age	0.798	0.657	0.228
Height	0.074	0.080	0.036
Prealbumin	-0.186	0.098	0.059
Calories	0.001	0.001	0.354
R-square	0.196		

* Variables that entered the regression equation

Table (7): Multiple Regression Coefficients Showing the Effect of Some Selected Variables on Thinking and Problem Solving.

Variables	Regession coefficient	Standard error	p -value
Age	0.739	0.190	0.001
Height	0.050	0.022	0.027
Calories	0.001	0.001	0.894
Plant protein	0.019	0.011	0.101
R-square	0.316		

* Variables that entered the regression equation

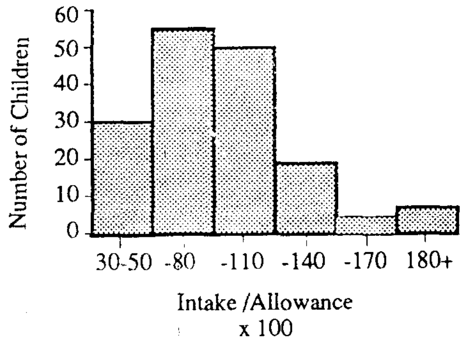

Fig. (1): Distribution of percentage caloric intake as related to caloric allowance of children in age range of 3-6 years.

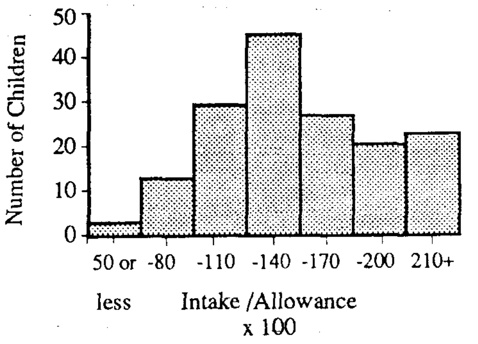

Fig. (2): Distribution of percentage protein intake as related to protein allowance of children in age range of 3-6 years.

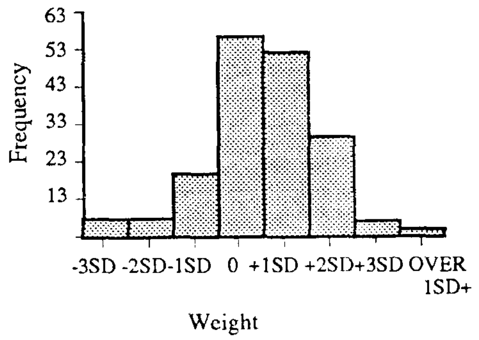

Fig. (3): Weight for age distribution in standard deviation units (values were calculated with respect to NCHS standard).

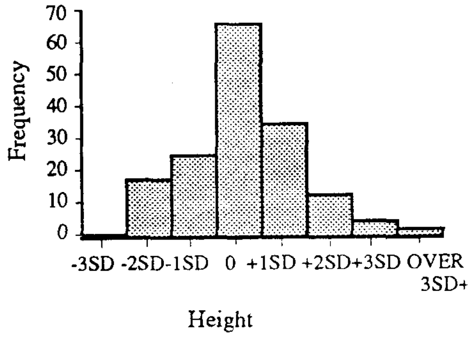

Fig. (4): Height for age distribution in standard deviation units (values were calculated with respect to NCHS standards.

Discussion

In this study, nutritional status of 185 preschool children age between 3 and 6 years was assessed by correlating dietary, anthropometric and biochemical parameters. Behavior was assessed by a battery of tests that covered intelligence, thinking and problem solving, memory and attention.

The daily caloric intake of children in the different age groups ranged from 427 to 3753.9 Kcal/day with a mean of 1319.0 ± 530.2 Kcal (table 1). Fifteen percent of cases were taking between 30-50% of their daily recommended caloric allowance and 34% of them were taking 80% of their recommended caloric allowance (Fig. 1). This amounts to a total of 49% of the children were taking lower caloric intake than their recommended allowance.

The daily intake of animal protein ranged from 2 to 91.5 gm with a mean of 16.9 ± 13.5 gm and that of plant prote ranged from 1.2 to 93.7 gm with a me level of 26.5 ± 12 gm (table 1). On comparing total protein intake of those children with recommended daily allowance for this age range (Fig. 2), it was shown that 12%

of the children were taking 65% of the recommended daily protein allowance. The rest of the children were having adequate protein intake. This denotes that dietary protein intake of the children was more adequate as compared to their caloric intake. However, the higher intake of dietary plant proteins that amounted to 78.6% of the total protein intake is not favorable.

Frequency distribution histograms for weight per age and height per age of the children as related to NCHS standards [16] showed normal distributions. Height deficit was more pronounced since 19% of the children were less than -2 SD of Ht/age (Fig. 4). This may reflect the reduced caloric intake of the children as mentioned above. This was demonstrated by the significant correlation ($p < 0.05$) that was shown between height and caloric intake of the children.

Triceps, biceps and subscapular skinfold thickness and upper are circumference were assessed. The use of skinfold thickness in the assessment of nutritional status of children was based on the assumption that increased subcutaneous fat resulting from either high caloric intake or low energy expenditure reflected caloric reserve [17]. In our study, it was found that there was relative thinness in both sexes. This was demonstrated in that 37% of the children were below 3 SD of their biceps skinfold thickness, 32% of them were below 3 SD of their triceps skinfold thickness and that 14% of them were below 3 SD of their subscapular skinfold thickness. Similar thinness in triceps skinfold was previously reported in black children as compared to the white ones [18]. The authors attributed the small triceps skinfold thickness in their cases either due to differences in socioeconomic levels or due to genetic differences between black and white. Martorell et al. [19] attributed the same phenomenon in their children to limitation in their caloric intake as opposed to protein ingestion. Apparently the major problem of our children was the reduced caloric intake as reflected in height deficit and skinfold deficits.

In this study protein status was assessed by measuring serum albumin, serum prealbumin and transferrin. Serum albumen ranged between 2.7 and 5.1 gm/dl, with a mean value of 4.2 ± 0.22 gm/dl (table 3). These results are in accordance with those previously reported for children in this age range [20,21]. Serum albumin level could be maintained despite the reduced protein supply since the biological half life of albumin is 20 days [22,23]. Serum albumin level is considered a poor index of short term status of protein and energy intakes. Cases in this study with serum albumin less than 3.0 gm/dl are considered at risk.

Serum prealbumin ranged between 3.5 mg/dl and 43.7 mg/dl with a mean value of 16.4 ± 4.9 mg/dl (table 3). Normal distribution of serum prealbumin was shown, with 26.4% of the children had serum prealbumin less than 15 mg/dl. Serum prealbumin is more responsive to dietary changes than either albumin or transferrin since it has a biological half life of two days [22]. Shetty et al. [20] found that restriction of both caloric and protein intake led to rapid fall in prealbumin concentration. This finding was to some extent demonstrated in our study since cases with reduced serum prealbumin had less caloric and less protein intakes. Our study as well showed that both albumin and prealbumin levels were significantly correlated ($p < 0.001$). This means that in some cases serum albumin was slightly reduced whenever serum prealbumin was markedly reduced. The lack of international cut-off level of prealbumin is a limitation to assess protein deficiency by using this parameter. Serum transferrin ranged from 122 to 474 mg/dl with a mean level of 312 ± 56.8 mg/dl (table 3). Only two children showed reduced serum transferrin level (122.0 and 180 mg/dl). It is worthy to mention that albumin levels of those children were 2.8 and 2.9 gm/dl respectively and prealbumin level were 10.9 & 12.1 mg/dl. i.e protein status of those two children was considerably affected. Apart from that no significant correlation was shown between transferrin levels and each of albumin and prealbumin levels.

Means, standard deviations and ranges of the scores of all behavioral parameters that have been used in our study are shown in table (4). Memory and learning score (ML) were calculated by adding, free recall test (FReR), organization test (ORG), Digit span test (DS) and discrimination learning test (D1). This procedure was justified on the grounds of the highly significantly intercorrelations among these individual tests (*p* <0.00).

Pearson's correlation coefficients between behavioral scores and indicators of nutritional status used in this study are shown in table (5). Apparently, thinking problem solving and intelligence were mostly affected as shown by the significant correlation with each of the dietary intake and anthropometric measurements. Though the correlations were significant, yet they were not strong as shown from the low *p* values. Albumin is the only indicator of protein status that showed weak negative correlation with attention. Similarly Gupta et al. [24] and Guzman et al. [25] showed that intelligence was significantly correlated with nutritional status, in particular caloric intake. Freeman et al. [26] found that children who received high protein-caloric supplement and whose mothers were as well supplemented during pregnancy were more likely to score high in cognitive tests. Body weight and height were shown in previous studies to be correlated with some cognitive parameters. This was shown in the study of Lasky [27], where he found that body weight and height of infants were the best predictors of infant mental and motor scores. Similar observation on preschoolers in USA showed that the mean IQ differed significantly from the lowest to the highest quartiles of stature [28,2].

Multiple regression analysis of the different variables on intelligence is shown in table 6, where age, height, prealbumin and caloric intake entered the regression equation. However, as indicated from the value of R-square only 19.6% of the variation in intelligence could be explained by the significant variability in height and prealbumin levels. The impact of the variables of this study on thinking and problem solving is shown in table (7).

Age and height contributed by 31.6% of the variation in thinking and problem solving. For attention none of the variables apart from age showed significant relation to attention with 17.4% of the variation in attention could be explained by age variation. Memory and learning were the only behavioral parameters that were not affected by any of the variables studied.

In this regard, multiple regression analysis demonstrated the extent of contribution of the various nutritional parameters on behavior. This finding, though preliminary, yet it confirms the previous view that nutritional status significantly contributes to cognitive development. Extensive work in this regard need to be planned for different age groups and with a variety of age standardized tests.

References

1- HOROWITZ, F.D.: Child development for the pediatrician, symposium on behavioral pediatrics. Pediatric Clinics of North America, Vol. 29, No. 2, April, 1982.

2- JOHNSTON, F.E.; LOW, S.M.; BAESSA, Y. and MAC VEAN, R.: Interaction of nutritional and socioeconomic status as determinant of cognitive development in disadvantaged Urban Guatemalan children. Am. J. Physic. Anthropol., 73: 501-506, 1987.

3- POLLITT, E.; HATHIRAT, P.; KOTCHABHAKD, N.J.; MISSELL, L. and VALYASEVI, A.: Iron deficiency and educational achievement in Thailand. Am. J. clin. Nutr., 50 (3): 687-96, 1989.

4- CALVO, B.B. & GNAZZO, N.: Prevalence of iron deficiency in children aged 9-24 mo. from large urban area of Argentina. Am. J. Clin. Nutr., 52 (3): 534-40, 1990.

5- LOZOFF, B.: Iron and learning potential in childhood. Bull. N.Y. Acad. Med., 65(10): 1050-66, 1989.

6- FAIRCHILD, W.; MAAS, J.D.; HABICHT, J.P.: Iron deficiency and behaviour: Criteria for testing causality. Am. J. Clin. Nutr., 50 (3): 568-74, 1989.

7- Food and Nutrition Board of NAS-NRC: Nutrition review, Vol.31, No. 8; Aug. 242-246, 1973.

8- National Academy of Sciences: Food and Nutrition Board, Recommended dietary allowances, National Research Council (ed). Washington D.C., 1980.

9- TANNER, J.M. and WHITEHOUSE, R.H.: Revised standard of triceps and subscapular skinfolds in British children. Arch. Dis. Child., 50:142, 1975.

10- DOUMAS, B. T. ; WATSON, W. A. and BIGGS, H.G.: Albumin standard and the measurements of serum albumin with bromocresol green. Acta, 31:87, 1975.

11- MACINI, G.; GARBONARA, A. O. and HEREMANS, J.F.: Immunochemical quantitation of antigens by single radial immunodiffusion. Immunochem., 2:235, 1985.

12- RAVEN, J.C.; COURT, J.H. and RAVEN, J.: Manual for Raven's progressive matrices and vocabulary scales. The coloured progressive matrices ed. J.C. RAVEN LTD publisher H.K. Lewis and Co LTD London, 1971.

13- WECHSLER, D.: Manual for the Wechsler Intelligence scale for children revised. David Wechsler; Psychological Corporation, New York, 1974.

14- MC CARTHY, D. : Manual for the Mc Carthy scales of children's abilities ed. Darothea McCarthy, publisher the psychological corporation, New York, 1972.

15- POLLITT, E. : Behavioral tests battery methods for the evaluation of the impact of food and nutrition programs, edited by Sahen D.E.; Lockwood R. and Scrimshow N.S. The United States University, pp 198, 1984.

16- National Center For Health Statistics: NCHS growth curves for children birth - 18 years. United States. Washington D.C. and Welfare. (Vital and Health Statistics Series 11) DHEW publication.

17- FRISANCHO, A.R. : Triceps skinfold and upper arm muscle size norms for assessment of nutritional status. Am. J. Clin. Nutr., 27: 1052-1057, 1974.

18- JOHNSTON, F.E. & BELLER, A.: Anthropometric evaluation of the body composition of black and white Puertorican newborn. Am. J. Clin. Nutr., 29: 61-65, 1976.

19- MARTORELL, R.; YARBROUGH, C.; LECHTIG, A.; DELGADO, H. and KLEIN, R.E.: Upper arm anthropometric indicators of nutritional status. Am. J. Clin. Nutr., 29: 46-53.

20- SHETTY, P. S.; WATRASIEWDZ, K. E.; JUNG, R.I. and JAMES, W.P.T.: Rapid-turnover transport proteins: An index for subclinical protein energy malnutrition. Lancet, 2: 230-232, 1979.

21- KATHRYN, G. D.: Nutrition survey in Tabasco, Mexico: Nutritional status of preschool children. Am. J. of Clin. Nut., 37: 1010-1019, 1983.

22- BARBARA, A.; UNDERWOOD & ABRAHAM. STIKEL: Measuring impact using laboratories methodologies, in methods for the evaluation of the impact of food and nutrition programs. (David, E., Richard Lockwood and Nevin Scrimshaw, eds) United National University.

23- JAMES, W.P.T.; DAVIES, H.L.; BAILES, J. and DAUNCEY, M.J.: Elevated metabolic rates in obesity. Lancet, I: 1122-25.

24- GUPTA, S.; DHINGRA, D.C.; SINGH, M. V. and ANAND, K.: Impact of nutrition on intelligence. Indian Pediatr., 12: 1079-82.

25- GUZMAN, V.; GUTHRIE, H.A. & GUTHRIE, G.M.: Physical and intellectual development in Philippine children fed five different dietary staples. Am. J. Clin. Nutr., 29: Nov. 1242-1251, 1976.

26-FREEMAN, H.E.; KLEIN, R.E.; TOWNSED, J.W. and LECHTIG, A.: Nutrition and cognitive development among rural Guatemalan children. Am. J. Publ. Health, 70: 1277-1285, 1980.

27- LASKY, R. E.; KLEIN, R. F.; YARBROUGH, C.; ENGLE, P.L. and LECHTIG, A.: The relationship between physical growth and infant behavioral development in rural Guatemala. Child Development, 52: 219-226.

28- POLLITT, E. and MUELLER, W.: The relation of growth to cognition in a well nourished preschool population. Child Dev., 53: 1157-1163, 1982.