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Kwashiorkor and Mental Development[1]

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UNTIL RECENTLY in the fight against malnutrition, survival was the main concern. Awareness and knowledge of the biochemical pathology of malnutrition and the availability of more efficient means for prompt diagnosis and treatment have reduced the immediate mortality among malnourished children. In direct proportion to our success in this regard is the grim possibility of an increasing pool of survivors who may be handicapped in a variety of ways and for variable periods of time.

In recent years the possible effect of protein malnutrition in early childhood on mental development has attracted considerable attention. Experiments with different species of animals have clearly shown that early protein malnutrition not only stunts growth but also impairs learning ability, memory, and behavior (1–4).

Investigation of the possible effect of early protein malnutrition in children has been attempted by a number of workers (5–8). The assessment of mental development unlike that of physical growth is beset with many difficulties. The techniques for the assessment of intelligence and mental functions that may be applicable to a particular community or cultural group may not be suitable for a different situation. Obviously, appropriate techniques for the assessment of mental functions have to be evolved for each cultural group, taking into account the special attributes of that particular group.

Although intelligence tests suitable and applicable for children have been developed in India, they have their limitations. The currently available tests can be administered only to children belonging to particular regions where the tests were originally standardized. In addition to cultural differences, regional-linguistic variations, rural-urban differences, and differences in levels of literacy and education call for the building of suitable tests for other groups.

METHODS AND MATERIALS

The first part of the study reported here relates to the evolution of suitable tests of mental development for children in the Telengana area of Andhra Pradesh taking into consideration the two different languages spoken (Telugu and Urdu) and the varied cultural environments of these two linguistic groups. Suitable tests were developed for children in the age group of 6–11 years. The tests included the following: (1) intelligence tests and (2) sensory development tests.

The second part of the study consisted in the application of these tests to children who had recovered from kwashiorkor and to "normal" children in the same community.

During the course of the last 8 years, after the Nutrition Research Laboratories were shifted to Hyderabad, our Clinical Unit had treated several hundred cases of kwashiorkor. Careful and complete records of these cases had been maintained. These provided an excellent opportunity for the study of the long-term effects of severe protein-calorie malnutrition on mental function.

Development of Tests

Intelligence tests. Two batteries of intelligence tests, one to cover the age group 6 and 7

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years and another to cover the age group 8–11 years were constructed.

It was obvious that the type of intelligence tests which could be considered for these largely illiterate communities were "performance tests" or other tests of intelligence that do not require reading and writing on the part of the subject. Types of tests that fall in the category of verbal tests of intelligence were practically ruled out, although a test which could be administered orally and be scored by means of an oral response on the part of the subject, as for example, the immediate memory test, could be included. It was clear that most of the tests should have as their basis the actual manipulation of varied concrete materials by the subjects. It was necessary that the tests should be individually applied to the subject.

The test items were so chosen as to test different mental functions like reasoning, organization of knowledge, memory, and different perceptual processes. Therefore some of the tests were object assembly tests, block design tests, memory tests with digits and objects, comprehension tests, and picture arrangement tests. Memory items in the tests were so constructed that they would involve testing the subject's auditory and visual imagery. Comprehension and arithmetic tests were included to measure the subject's abstract ability with regard to reasoning, concept formation, organization of knowledge, and mental alertness. Perceptual ability of the children was tested by inclusion of such items as picture completion (9) and simplified object assembly and block design (10). These tests were meant to test the subject's visual perceptual ability—analysis and synthesis, and also visual-motor integration. It should be noted that these tests were based purely on nonverbal performance so as to suit the illiterate group. The items in the intelligence test battery indicating scores for each item are given in APPENDIX I.

Standardization of intelligence tests. The whole battery of intelligence tests developed was based on a point scale devised for subjects ranging in age from 8 to 11 years. One continuous test was given to each subject irrespective of the age. Each subject was expected to work up to his maximum grade. For the purpose of scoring, various groups of items within the test and various items within each group were graded. The maximum score for the battery was 75.

These test items were administered to 50 children in the 8 to 11-year age group belonging to the low socioeconomic group around Hyderabad. The population chosen for standardizing the test battery belonged to the same cultural and socioeconomic class from which cases of kwashiorkor in our hospital were derived.

The mean scores obtained by the different age groups increased with increasing age and were 52, 68, and 82% for the 8 to 9-, 9 to 10-, and 10 to 11-year age group, respectively. The battery was, therefore, accepted as suitable.

Sensory development tests. Several studies made on learning (11, 12) indicate that the basic mechanisms involved in primary learning are probably the effective establishment and patterning of intersensory organization.

On the basis of this principle, Cravioto et al. (8) have studied the intersensory organization using eight different geometrical shapes. On similar lines, eight pairs of different geometrical shapes were prepared and were used in the present study also. The different sensory tests were visual, haptic, and kinesthetic. Haptic sense was measured through tactile, kinesthetic, and surface movement sensations from the subject's fingers and hands as in the active manual exploration of the test object. The kinesthetic sense measuring the sensory inputs obtained through arm movement was studied by the tester making the subject hold a stylus between his fingers and trace the outlines of the geometrical shapes.

The intersensory equivalence was studied by presenting a form to one sensory system (visual) and asking the subject to compare it with a form presented to another sensory system (haptic or kinesthetic). The order of presentation of standard and variable stimuli for testing intersensory functioning is given in APPENDIX II.

The combination of these factors resulted in three sets of comparative judging tasks. They were presented to the child in the following order: visual-haptic series, visual-kinesthetic series, and haptic-kinesthetic series.

APPLICATION OF TESTS

Nineteen children who had been admitted to our unit between 1959 and 1962 with classical signs of kwashiorkor and had been successfully treated were taken up for the study. Their ages at the time of admission were between 18 and 36 months. At the time of the follow-up assessment of these children, their ages were between 8 and 11 years.

Selection of Control Subjects

Any attempt to measure the influence of nutrition on mental performance must consider of necessity the role played by parental factors, such as parental care of the child in regard to physical and intellectual development and parental level of intelligence. The relative weightings to be given to these factors would also depend upon a series of other environmental conditions among which socioeconomic status and family size are important.

In selecting the control children for comparison with the experimental group, care was, therefore, taken that they were appropriately matched. For every one of these "experimental" children three matched controls were chosen taking into consideration age, sex, religion, caste, socioeconomic status, family size, birth order, and educational background of the parents. There were no obvious differences in either the general pattern of child care or the level of education of the mothers as between the experimental children and their matched controls. These controls were selected from the same locality and the same school where the experimental children were found. It was also ensured that the control children corresponding to a given experimental subject also belonged to the same class in the school. Such selection might have weighted the investigation against the demonstration of real differences between the groups. The demonstration of any difference between the groups under these conditions must, therefore, be considered particularly significant.

On an average, about 1 hr was needed to complete "intelligence" testing and about 45 min to examine the sensory development. These two tests were done on consecutive days. On such occasions when it was observed that the child was either not concentrating or was tired, the tests for the day were given up and the child retested on a subsequent day.

In addition to the intelligence test and sensory tests, anthropometric measurements of all the children were also recorded.

TABLE I

Performance of the kwashiorkor-treated children expressed as percentage of the control subjects

Age, Years	Number	Mean	Median
8–9	11	31.30	26.83
9–10	5	54.45	54.77
10–11	3	52.44	52.33

RESULTS AND DISCUSSION

There was a significant difference between the control subjects and subjects who had been treated for kwashiorkor with regard to the performance of the intelligence tests. The performance of the experimental subjects in the intelligence test, expressed as a percentage of the control subjects, ranged from 7.69 to 78.94 at different ages. The performance of the experimental group of children expressed as percentage of the control subjects is presented in Table I. The difference was particularly marked in the younger age group (8–9 years) and tended to diminish in the older age group (10–11 years) (Tables II and III).

In order to investigate in which of the abilities the experimental children differed from their controls, the whole battery of tests was split into four important abilities, namely, memory, perceptual ability, abstract ability, and verbal ability. The maximum score for the battery was 75; the breakdown for the different abilities was: memory, 17; perceptual ability, 32; abstract ability, 18; and verbal ability, 8.

The distribution of scores (expressed in percent) for the children according to different abilities is presented in Table II.

TABLE II. Average performance and anthropometric measurements in the 8 to 11-year-old children

Age, Years	Sex	Sample Size	Intelligence Test Score	Visual Haptic, Errors of		Visual Kinesthetic, Errors of		Haptic Kinesthetic, Errors of		Anthropometric Measurements		
				Equivalence	Nonequivalence	Equivalence	Nonequivalence	Equivalence	Nonequivalence	Height	Weight	Head Circumference
8–9	F	7 E	16.77	33.05	26.29	58.95	39.04	61.64	40.57	109.99	16.84	48.13
			(4.00–40.00)	(0.00–62.50)	(1.79–53.57)	(25.00–93.75)	(17.86–78.57)	(43.75–81.35)	(16.07–83.93)	(105.10–115.60)	(14.40–18.80)	(45.50–48.80)
		15 MC	57.08	10.00	7.86	30.04	14.41	28.42	14.28	113.95	16.93	48.90
			(50.67–68.93)	(0.00–18.75)	(5.36–12.50)	(12.50–37.50)	(10.72–18.75)	(18.75–56.25)	(7.03–20.54)	(108.20–119.90)	(16.00–18.87)	(47.80–50.45)
	M	4 E	17.53	14.06	16.97	53.13	35.71	40.63	34.82	103.35	14.38	48.25
			(10.67–20.67)	(0.00–31.25)	(8.93–25.00)	(43.75–62.50)	(25.00–48.21)	(31.25–50.00)	(17.85–53.57)	(99.50–111.30)	(12.50–17.40)	(47.70–48.80)
		12 MC	54.90	4.17	7.75	39.59	12.20	40.09	11.01	115.13	18.62	49.27
			(46.67–57.73)	(0.00–6.25)	(3.57–11.96)	(32.81–46.87)	(10.71–13.39)	(35.94–46.87)	(9.37–14.87)	(112.15–117.20)	(17.45–18.97)	(48.00–49.83)
9–10	M	4 E	36.00	28.12	14.73	42.19	16.43	62.50	18.76	120.70	18.65	48.98
			(26.67–50.67)	(6.25–56.25)	(0.00–26.79)	(18.75–62.50)	(7.14–27.42)	(56.25–75.00)	(5.38–33.93)	(106.60–128.80)	(14.00–22.40)	(46.40–51.00)
		13 MC	70.74	5.77	2.88	25.94	8.80	23.57	5.35	123.12	20.48	49.31
			(65.73–82.21)	(2.06–10.44)	(1.20–4.16)	(20.81–28.12)	(5.95–11.91)	(12.50–32.81)	(2.37–10.71)	(118.20–126.43)	(17.67–22.46)	(48.10–50.20)
	F	1 E	45.33	6.25	3.57	56.25	16.08	62.50	10.72	113.50	19.20	49.60
		2 MC	63.33	0.00	1.78	28.12	8.93	28.12	10.72	115.05	19.30	49.35
			(61.33–65.33)	(0.00–0.00)	(0.00–3.57)	(18.75–37.50)	(7.14–10.72)	(25.00–31.25)	(8.93–12.50)	(114.50–115.60)	(18.60–20.00)	(48.70–50.00)
10–11	F	3 E	40.44	8.33	17.26	37.50	35.12	37.50	25.59	121.25	19.73	48.76
			(33.33–50.67)	(0.00–18.75)	(8.93–26.79)	(25.00–50.00)	(30.36–42.86)	(25.00–62.50)	(21.43–28.57)	(114.30–128.30)	(16.80–22.70)	(48.20–49.40)
		8 MC	78.48	3.92	3.82	14.73	7.79	17.17	6.01	127.45	22.09	49.79
			(71.33–84.40)	(0.00–6.25)	(3.04–4.46)	(12.50–18.75)	(5.89–10.71)	(12.85–22.94)	(4.11–8.93)	(125.95–129.40)	(21.47–22.90)	(49.70–49.87)

All values are means with the range of values shown in parentheses. E = experimental. MC = matched controls.

TABLE III. Average percent scores obtained for different abilities in the intelligence test

Age, Years	Sex	Number of Observations		Memory		Perceptual Ability		Abstract Ability		Verbal Ability	
		Experi-mental	Matched control	Experimental	Matched control	Experimental	Matched control	Experimental	Matched control	Experimental	Matched control
8–9	F	7	15	18.48	47.50	17.42	62.56	14.30	65.20	16.08	36.60
				(0.0–29.4)	(38.2–57.1)	(3.1–56.2)	(39.1–74.1)	(0.0–27.8)	(44.4–88.9)	(0.0–50.0)	(25.0–56.3)
	M	4	12	22.03	46.10	17.20	58.60	19.43	62.90	3.13	40.66
				(17.6–35.3)	(41.2–51.0)	(6.3–28.1)	(53.1–70.9)	(11.1–22.2)	(47.2–74.0)	(0.0–12.5)	(25.0–56.3)
9–10	M	4	13	32.38	56.52	35.98	77.17	41.65	77.22	28.13	56.54
				(11.8–41.2)	(51.2–60.6)	(9.4–59.4)	(66.4–90.6)	(16.7–55.5)	(61.1–90.6)	(0.0–50.0)	(41.3–75.0)
	F	1	2	70.60	61.76	37.50	60.94	33.30	83.40	50.00	31.20
					(58.8–64.7)		(53.1–68.8)		(77.8–88.9)		(25.0–37.5)
10–11	F	3	8	37.26	65.21	38.56	83.95	46.26	83.48	50.00	73.30
				(29.4–41.2)	(54.7–72.9)	(31.3–53.1)	(76.6–87.5)	(44.4–50.0)	(63.9–92.8)	(25.0–62.5)	(62.5–91.3)

All values are means with range of values in parentheses.

In children who are mentally retarded for various reasons the perceptual and abstract abilities are reported to suffer the most (13, 14). Our observations in the children studied here are also in line with this, though it must be pointed out that the scores allotted for the different abilities were not equal.

It was also found that there was a close direct relationship between the intelligence scores and the performance in the intersensory tests. This relationship was observed both in the control and the experimental subjects.

It has been stated by Birch and Lefford (15), who developed the intersensory test procedures employed here, that its maximum effectiveness is reached by ages 8 and 9 and that this test has a greatly reduced capacity for discrimination once the children are over 10 years of age. It was observed in the present investigation, however, that even children who were past 10 years of age committed a considerable number of errors in the visual-kinesthetic and haptic-kinesthetic series. Also, the difference between the experimental and matched controls was still quite marked. The use of these tests, therefore, even beyond the age of 10 appeared to be justified.

The heights, weights, and head circumferences of the experimental children were generally similar to those observed in the matched controls, though the weights tended to be somewhat lower in the experimental subjects.

It has been reported that there is a correlation between head circumference and the intelligence scores (5). Of the other anthropometric measurements, height has been found to be a better indicator of intelligence of children (8). The present study also establishes the above observations in the 8 to 9-year-old control subjects. Significant correlations between the anthropometric measurements and the intelligence scores were not observed here in the other groups, probably due to the small sample size in the different experimental groups.

Although the differences between the performance of the control children and those who had suffered from kwashiorkor were clear-cut, the results of this study have to be interpreted with great caution.

Robles et al. (16) had not found evidence of depressed mental function of the magnitude observed here in their cases of kwashiorkor a few months after recovery. The question arises as to whether the marked differences seen here between the experimental and control groups are attributable to the earlier episode of protein-calorie malnutrition in the former, or to other factors. In this connection two important possibilities may be considered.

1) All the children of the experimental group had been hospitalized for a minimum period of 6 weeks when they were suffering from kwashiorkor. It is to be expected that for some weeks preceding and following this period of hospitalization these children were practically bedridden in their homes. In comparison with other children in the community who had not actually suffered from kwashiorkor, this prolonged immobilization would have resulted in a considerable loss of "learning time." In addition, the possible effects of other factors such as anxiety, fear, and emotional stress, incidental to hospitalization, also require consideration. It must be pointed out, however, that under the prevailing practice followed in the pediatric ward here, the mothers are always allowed to stay with, and attend to, their children during the entire period of hospitalization.

2) It is well known that among children of the poor communities subsisting on low protein, low calorie diets, only some children develop full-fledged kwashiorkor while others escape at least the acute and severe effects of protein-calorie malnutrition. It may be expected that an important factor which would determine the incidence of frank kwashiorkor in a poor community would be the level of intelligence, motivation, and resourcefulness of the parents. Children drawn from homes of parents who are particularly deficient in these qualities may be specially vulnerable as a result of lack of proper parental care. Under this circumstance, the poorer performance of these children may be a reflection of their environmental home situation. If this were so, then the very same factors which contributed to the development of kwashiorkor specially in these children, would have also contributed to their poor mental performance. The observation that the differences between experimental and the control children tend to narrow with increasing age may in fact be an expression of the beneficial effect of the exposure to an environment and influence outside their homes in their later years.

Although the differences in mental performance between the two groups of children investigated in this study are clear-cut, it is not easy at this stage to determine to what extent this is a result of the episode of kwashiorkor and to what extent it is due to the other factors mentioned earlier.

SUMMARY

Nineteen children successfully treated for kwashiorkor were followed up to see the effect of early malnutrition on growth and mental functions. These children were compared with appropriately matched controls selected from the same locality and the school from which the experimental children were derived. These controls were matched for age, sex, religion, caste, socioeconomic status, family size, birth order, and educational level of the parents and the subjects.

Suitable intelligence tests and sensory development tests were constructed and these tests were applied to both the experimental and control groups of children. In addition to these tests, anthropometric measurements were also taken on all children. The salient features of the study are:

a) There was a significant difference between the performance of the control and the experimental subjects with regard to the intelligence tests. This difference was particularly marked in the younger age group (8–9 years) and tended to diminish in the older age group (10–11 years).

b) Intersensory organization was poorer in the experimental subjects than in the control subjects. The performance in the intersensory tests was markedly poorer in the younger age group and tended to improve in the older age group (10–11 years).

c) The retardation was noticeable mainly with regard to perceptual and abstract abilities.

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APPENDIX I

Items in the Intelligence Test Battery	Scores for the Items	Points	Maximum Scores
Immediate memory test (with pictures)	7 Items and above	5	
	6 Items	4	
	5 Items	3	
	4 Items	2	
	3 Items	1	
	Less than 3	0	5
Knox cube test (auditory and visual memory test)	5 Tappings	3	
	4 Tappings	2	
	3 Tappings	1	3
Copying a diamond		1	1
Drawing designs from memory	All correct	3	
	3 Items, correctly reproduced	2	
	2 Items, correctly reproduced	1	
	Less than 2	0	3
Missing features (5 items)	1 Point each		5
Arranging pictures (7 items)	All correct	3	
	1 Error	2	
	2 Errors	1	
	Above 2 errors	0	3
Simple comprehension test	1st Problem	1	
	2nd and 3rd Problem	2 Each	5
Repeating digits	3 Digits	1	
	4 Digits	2	
	5 Digits	3	3
Repeating digits, reversed	3 Digits	1	
	4 Digits	2	
	5 Digits	3	3
Counting coins, 7 problems	1–4 Problems	1 Each	
	5–7 Problems	2 Each	10
Simple arithmetic test	1st Problem	1	
	2nd Problem	2	3
Naming the days	All correct	2	
	2 Correct	1	2
Giving the number of days, weeks, and months	All correct	2	
	2 Correct	1	2
Free association test	20–29 Words	1	
	30–39 Words	2	
	40–49 Words	3	
	50– And above	4	4
Picture construction test	1–3 Pictures		
	1 Min each	2	
	1–1.30 Min each	1	
	Above 1.30	0	
	4–6 Pictures:		
	2 min each	3	
	2–2.30 Min each	2	
	2.30–3 Min	1	
	Above 3 min	0	15
Block design test			
Test I	5 Min, all correct	2	
	5–6 Min, all correct	1	
Test II	8 Min, all correct	3	
	8–10 Min, all correct	2	
	8–10 Min	1	
Test III	10 Min, all correct	3	
	10–12 Min, all correct	2	
	10–12 Min, 1 error	2	8
		Total	75

APPENDIX II

Order of presentation standard and variable stimuli for testing intersensory functions

Standard Stimuli							
TRI	HEX	SQU	M.C.	CRO	DIA	STA	CIR
sq	st	st	cr	hx	di	tr	cr
ci	hx	tr	mc	di	cr	di	ci
di	cr	sq	tr	cr	mc	mc	mc
st	hx	di	ci	tr	ci	sq	hx
tr	ci	hx	mc	sq	hx	st	st
mc	sq	mc	st	ci	di	hx	ci
hx	di	sq	di	cr	tr	cr	sq
tr	mc	ci	sq	st	sq	st	tr
cr	tr	cr	hx	mc	st	ci	di

TRI, tr = triangle; HEX, hx = hexagon; SQU, sq = square; M.C., mc = modified form of cross; CRO, cr = cross; DIA, di = diamond; STA, st = star; CIR, ci = circle.