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AUTHOR Klein, Pnina S.; And Others
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ABSTRACT

This study investigated the specific learning abilities and general adjustment of 50 children, 5-14 years of age, who had pyloric stenosis (PS) in infancy, compared to 44 siblings and 50 matched control children. PS involves a period of brief starvation in early infancy, unrelated to socioeconomic conditions and is surgically correctable. The major questions posed by this study were: Does a defined period of starvation occuring within the first 3 months after birth have an effect on subsequent learning abilities and general adjustment? (2) If so, which specific abilities are most affected? All learning abilities measured were significantly correlated with the degree of starvation severity in infancy. Starvation causing a reduction of over 10 percent of the expected body weight in infancy was associated with poorer learning abilities, especially those involving short term memory and attention. (Author/CS)

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LONG TERM EFFECTS OF INFANT STARVATION ON LEARNING ABILITIES

Pnina S. Klein, Ed.D.

Gilbert B. Forbes, M.D.

Philip R. Nader, M.D.

University of Rochester and Educational Clinic, Queens College, CUNY

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ABSTRACT

The criterion of starvation in this study was the medical condition of Pyloric Stenosis (PS). PS involves a period of brief starvation in early infancy, unrelated to socioeconomic conditions and is easily correctable. Specific learning abilities and general adjustment of 50 subjects, 5 to 14 years old, who had PS were studied and compared to: a) 44 siblings; and b) 50 matched controls. All learning abilities measured were significantly correlated with the degree of starvation severity in infancy. Starvation causing a reduction of over 10% of the expected body weight in infancy was associated with poorer learning abilities, especially those involving short term memory and attention.

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Much of the interest in the relationship between malnutrition and learning abilities in both animal and human studies has focused on the existence of critical periods in brain growth early in life. Nutritional deficits occurring during these critical periods have been found to be associated with irreversible reductions in cell number and result in long term deficits in intellectual functioning.[1,2,3,4]

Malnutrition in early infancy, as it occurs in many parts of the world, including the U.S., has been reported to be associated with poor functioning on a variety of mental ability tests administered in later childhood.[5,6,7,8,9] Although no definite boundaries of these critical periods in infants can be drawn from the findings of previous studies, there is sufficient evidence to conclude that differences in the severity of malnutrition/starvation and the time of onset of the insult would likely determine the extent of brain impairment and consequent functioning. However, it has been difficult to isolate the effects of malnutrition on intellectual functioning of human subjects due to confounding socioeconomic and cultural variables.

Pyloric stenosis (PS), a naturally occurring condition of starvation during early infancy, is not associated with these confounding variables of social deprivation or poverty. With its onset between birth and 3 months of age and with a clinical severity ranging from mild dehydration through more extensive starvation and malnutrition, the conditic.. of pyloric stenosis offers an advantageous model in which to study the long term effects of a starvation/malnutrition insult to the developing infant's nervous system. Almost immediately upon surgical correction of this condition, the child resumes normal eating, in the same social and environmental milieu as his siblings. This clear termination of starvation provides definite boundaries of the starvation period. This study reports the specific learning abilities and general adjustment of 50 patients 5-14 years of age who had pyloric stenosis in infancy compared to 44 siblings and 50 matched control children.

The major questions posed by this study were as follows: Does a defined period of starvation occurring within the first 3 months after birth have an effect on subsequent learning abilities and general adjustment? If so, which specific abilities are most affected?

METHODS

In order to isolate starvation as the cause of differences among the subjects' test scores, the following variables known to affect intellectual development were controlled: age, sex, socioeconomic status, parental education, complications during pregnancy and delivery, birth weight, birth order, number of siblings, medical problems and surgical operations in the child's life history. In addition, conclusions were based only on those findings which were consistent across various analyses of the data.

Subjects

A total of 144 white children from Monroe County volunteered to participate in this study. The children were divided as follows:

1. Index cases. A group of 50 children, 44 boys and 6 girls, who had been treated for PS in infancy. The index cases were between 5 and 14 years old with a mean age of 9 years 2 months.

2. Sibling control group. A group of 44 subjects, each of whom was a sibling of an index case. Their ages ranged between 5 and 15 years with a mean age of 10 years and 1 month.

3. Matched control group. A group of 50 children, each of whom was matched by age, sex and father's level of education (in years) to the index cases. These subjects were drawn from a sample of 6,669 individuals who represented a random sample of the population of Monroe County, New York.

Subjects for whom there was reason to assume possible neurological damage due to conditions during pregnancy and birth or later injury were excluded from all three groups. Subjects who weighed less than 2.3 kg. or more than 4.1 kg. for boys and 4.3 kg. for girls were also excluded. No significant differences were found between the three groups of subjects with regard to: duration of pregnancy, mother's age, birth weight, birth order, number of siblings or number of surgical operations in the child's history.

Instruments

Rather than dealing with the global concept of intelligence, the present study focused on more functional concepts of learning abilities, especially those essential for "school learning." Specific tests were selected to measure different sensory channels of communication, as well as the different levels of cognitive organization. Verbal abilities were measured by the Peabody Picture Vocabulary Test (PPVT) and by the Vocabulary from the Wechsler Intelligence Scale for Children (WISC). Eye-hand coordination and speed and accuracy of learning a new code were measured by the Digit Symbol (coding) test from the WISC. Two measures of short term rote sequential memory were used: the Digit Span test from the WISC, which tests immediate recall for auditory stimuli (Auditory Memory) and the Visual Memory tests from the Hiskey-Nebraska Test of Learning Aptitude, which test recall for visual stimuli. Non-verbal reasoning and understanding of figural spatial relations were measured by the Raven Progressive Matrices. Achievement in reading and arithmetic were evaluated by the Wide Range Achievement Test (WRAT).

The parents of each subject were interviewed and asked to evaluate their children on the Parental Estimate of Development Scale (PEDS)[10] and on the Vineland Social Maturity Scale (VSMS).[11] The school teacher of each subject was asked to evaluate him on the Ottawa School Behavior Checklist (OSBCL).[12] The behaviors listed in the OSBCL were factor analyzed and yield scores for

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each of the following factors: Immaturity, Overactivity, Conduct and Personality.

The subjects' physical development was assessed by the measurements of head circumference and height and weight at the time of the testing.

Procedures

Three hospitals in Rochester, New York (Strong Memorial Hospital, Rochester General Hospital and the Genesee Hospital) submitted a list of all patients who had been treated for PS between the years 1959 and 1968. Of these, a total of 98 were identified as still residing in the Monroe County area. Fifty-nine families (57.3 percent of all families contacted) expressed their willingness to participate in the study. Nine subjects were excluded because of other confounding variables (low birth weight, complications during birth, and convulsions). Following the identification of the index cases, the matched control subjects were selected.

Psychological testing and measurements of each subject and parental interviews were carried out individually. Each subject was randomly assigned to one of three trained psychometricians. Each index case and his sibling were tested simultaneously. Testing of each child lasted one and a half to two hours. The OSBCL was sent to the teachers with an enclosed return envelope.

The medical records of the index cases were examined independently by the two pediatrician authors. Based on their evaluation, the onset, duration and severity of starvation were recorded. The severity of starvation was determined by relating the infant's body weight on admission to the hospital to his or her expected weight, as extrapolated from the weight at birth. This weight deficit was expressed as a percentage of the expected weight for this age. Based on the percent of weight deficit the index cases fell into the following groups of starvation "severity":

a. Low severity, weight deficit of 0 to 10 percent of expected weight for age

b. Moderate severity, weight deficit of 11 to 20 percent of expected weight for age

c. High severity, weight deficit of 21 to 41.9 percent of expected weight for age.

The analysis included two parts: an intergroup comparison of the index cases, siblings, and matched controls; and an intragroup analysis dealing with index cases who suffered from various levels of starvation at different periods of time during infancy.

RESULTS

Effects of starvation on learning abilities

No significant differences were found between siblings and matched control subjects on all tests of learning abilities (Table 1). However,

--- Table 1 about here ---

significant correlations were found between the learning ability tests and the subjects' severity of starvation (Table 2). More severe starvation was associated with lower scores on the learning ability tests.

--- Table 2 about here ---

The index cases in the "low severity" of starvation group, i.e., those who had an estimated weight deficit of 10 percent or less, did not differ from both their siblings and their matched control subjects on all tests of learning abilities, with the exception of Auditory Memory (Table 1). Higher levels of starvation, 11 percent weight deficit or greater, did result in lower performance on several tests. As indicated in Table 1, the Auditory Memory and Coding scores were found to be consistently lower for the index cases when compared to their siblings and their matched control subjects in the high severity of starvation group. Although index cases in all three levels of severity were found to have lower Auditory Memory scores compared to siblings and controls, significant differences ($F = 3.86$, $df = 2.40$, $P < .05$) were found between the Auditory Memory scores of the index cases in the three levels of starvation severity.

Because of the congitive tasks involved in the visual memory tests, comparisons of test scores could only be carried out between the index cases and their matched controls. Poorer visual memory was found in index cases, in both the high ($p < .05$) and moderate ($p < .01$) severity groups when compared to

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their control subjects.

The findings reported in Table 1 for the PPVT, the Raven Progressive Matrices, the Vocabulary and the Reading and Arithmetic tests were not consistent throughout the comparisons. Thus, no conclusions could be drawn when: 1) differences were found between the index cases in a lower severity group and their control groups but not between the index cases in a higher severity group and their control groups; 2) differences were found between the index cases and one of the two control groups but not between them and the other control group.

<u>Effects of starvation on general adjustment</u>

Parental evaluation of the index child's overall development (Parental Estimate of Development Scale) indicated that the higher the degree of severity, the lower the parental estimation of their child's development and predicted potential ($r = .0367$, df 49, $p < .01$).

However, neither the teacher's evaluation of subjects' behavior on the Ottawa School Behavior Checklist (OSBCL) nor the parental evaluation on the Vineland Social Maturity Scale (VSMS) was found to be significantly correlated with the index of severity of starvation.

In the comparison between the index cases <u>within</u> each level of severity and the respective control groups, a low severity of starvation was not found to affect <u>any</u> of the measured aspects of behavior. Yet, high severity of starvation was associated with a lower social maturity score on the VSMS when compared to either siblings or matched controls.

Effects of starvation on physical development

The distribution of height, weight and head circumference of the index cases was not found to be significantly different from that of their parents, siblings or matched controls. In addition, no differences were found between the groups of index cases who suffered from high, moderate or low severity of starvation. Early motor development of the index cases (based on the history of the date of starting to walk) was found to be significantly correlated with the severity of starvation experienced by the subjects ($r = .400$, $df = 49$, $p < .01$). In other words, a higher degree of starvation was associated with this measure of slower motor development.

Effects of the time of onset of the starvation

An analysis of variance was carried out for the scores on each test in order to compare test scores of index cases for whom starvation onset occurred at either one of the following periods: 1-20, 21-30 and 31-60 days of life. No significant differences were found between these groups on any of the learning abilities measured, nor on the measures of general adjustment reported by the parents.

The time of starvation onset was found interestingly, to affect the scores on the OSBCL. Those index cases for whom starvation onset was between 21 and 30 days of age had significantly more problems related to immaturity, overactivity and conduct as compared to the two other groups of starvation onset (Table 3).

--- Table 3 about here ---

DISCUSSION

Pyloric stenosis, even though severe in infancy, did not result in measurable effects on gross physical development as reflected by head circumference, height or weight, although an indication of possible slow motor development was suggested.

However, even a brief period of moderate starvation caused by pyloric stenosis was found to have a long-lasting effect on learning abilities and general adjustment measured at 5 to 14 years of age. A weight deficit greater than 10 percent, especially a deficit of 20 percent or higher, was found to be associated with poorer scores on tests of learning abilities and social maturity (VSMS). Most consistent findings were observed for the scores on the Coding and Auditory Memory tests. These findings, supported by the findings for the Visual Memory test, suggest that short term memory and attention are affected by starvation occurring within the first three months of life.

Pyloric stenosis starvation onset between 21 and 30 days of age was significantly related to school problems involving immaturity, overactivity, and conduct problems as measured by the OSBCL. The items representing these factors on the above checklist depict behaviors that are related to the child's inability to control his behavior in the classroom and to attend to one task for a defined period of time. This suggests that basic mechanisms necessary for control of such abilities to attend are developed early in infancy. It is interesting also to note that this period of between 21 to 36 days was isolated in a study attempting to relate developmental biology and psychoanalysis as one of the critical periods in the development of anxiety.[13] The upper boundaries of the critical period identified in the present study (21 to 30 days) can not be clearly determined because there was only one subject for whom starvation onset occurred after 60 days of age.

Subjects who had suffered from starvation in the present study had also undergone surgery in infancy. It could be argued that the surgical operation and insult rather than the starvation itself affected the subjects' subsequent learning abilities and behavior. However, these variables were controlled by the design of the intragroup comparisons. Thus, all subjects had surgical treatment for PS, but differed with regard to the severity of starvation and its time of onset. The differences found between these groups of index cases could not therefore stem from the treatment procedures, but more likely from the variations in starvation.

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IMPLICATIONS

This study again calls attention to the more subtle long term effects of insults to the developing human nervous system. In addition it represents an example of a naturally occurring childhood condition which lends itself to a human model for extending basic animal research on the relationship between nutrition and learning.

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REFERENCES

1. Winick, M. and Noble, A.: Cellular response in rate during malnutrition at various ages. Journal of Nutrition, 89:300-306, 1966.

2. Winick, M. and Noble, A.: Cellular response with increased feeding in neonatal rats. Journal of Nutrition, 91:179-182, 1967.

3. Winick, M., Fish, J., and Rosso, P.: Cellular recovery in rat tissues after a brief period of neonatal nalnutrition. Journal of Nutrition, 95:623-626, 1968.

4. Dobbing, J.: Undernutrition and the developing brain. American Journal Diseases of Children, 120:411-415, 1970.

5. Birch, H.G., Pineiro, G., Alcalde, E., Cravioto, J.: Relation of Kwashiorkor in early childhood and intelligence at school age. Pediatric Research, 5:579-585, 1971.

6. Chase, H.P. and Martin, H.P.: Undernutrition and child development. New England Journal of Medicine, 282:17, 1970.

7. Cravioto, J. and Robles, B.: Evolution of adaptive and motor behavior during rehabilitation from Kwashiorkor. American Journal of Orthopsychiatry, 35:449, 1965.

8. Latham, M.C. and Cobos, L.F., Rueda-Williamson, R., and Stare, F.J.: Nutritional and ecological factors in intellectual development of Colombian children. Proceedings VIII International Congress of Nutrition, Prague, 1969.

9. Pollitt, E. and Granoff, D.: Mental and motor development of Peruvian children treated for severe malnutrition. Revista Interamericana de Psicologia, 1:93, 1967.

10. Heriot, J.T., Tavormina, J.B., Vautrain, R.L., and Culhane, B.R.: Parent and teacher estimates of pre-school development. Psychodiagnostic Laboratory, Department of Pediatrics, University of Rochester, 1972, unpublished.

11. Doll, E.A.: Vineland Social Maturity Scale. Circle Pines, Minnesota: American Guidance Service, Inc., 1965.

12. Pimm, J.B. and McClure, G.: Ottawa School Behavior Check List. Ottawa, Canada: Pimm Consultants, 1969.

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TABLE I

VALUES OF t FOR COMPARISONS BETWEEN INDEX CASES, SIBLINGS AND MATCHED CONTROLS

Level of Severity	Comparison between	PPVT	Vocabulary	Coding	Auditory Memory	Visual Memory	Raven	Reading	Arithmetic
High N=13	Index -- Sibs	1.2	1.3	-3.7**	-2.6*		1.4	1.1	2.2*
	Index-- Controls	1.5	-2.8**	-3.6**	-2.8**	-2.0*	1.7	-2.0*	1.1
Moderate N=18	Index-- Sibs	1.4	-2.1*	1.6	-3.4**		-3.5**	-2.3*	-1.9*
	Index-- Controls	-1.9*	1.4	1.5	-5.3**	-2.7**	-2.5*	1.7	0.7
Low N=13	Index-- Sibs	0.6	1.6	1.0	-3.0**		0.7	0.7	1.5
	Index-- Controls	0.3	1.3	0.8	-1.9*	0.8	0.2	-1.9*	0.2
N=44 N=44	Sibs Controls	0.2	0.4	1.5	0.9	0.9	0.3	1.0	1.7

* $p < .05$ one tailed
** $p < .01$ one tailed

TABLE 2

CORRELATION BETWEEN TESTS OF LEARNING ABILITIES AND DEGREE OF STARVATION

Name of Test	Correlation Coefficient	Level of Significance
PPVT	−0.323	$p < .05$
Vocabulary	−0.253	$p < .05$
Coding	−0.315	$p < .05$
Auditory Memory	−0.431	$p < .01$
Visual Memory	−0.258	$p < .05$
Raven Progressive Matrices	−0.383	$p < .01$
Reading	−0.362	$p < .01$
Arithmetic	−0.359	$p < .01$

TABLE 3

VALUES OF t FOR THE COMPARISONS BETWEEN THE OSBCL SCORES OF THE THREE GROUPS OF STARVATION ONSET

Comparison Between	df	Immaturity	Overactivity	Conduct Factor	Personality Factor	OSBCL
1-20 & 21-30	31	-3.019**	-2.930**	-2.024**	1.689	-2.754**
1-20 & 31-60	31	0.852	0.691	0.674	0.291	0.595
21-30 31-60	30	+2.156*	+2.212*	+2.491**	+2.491**	+2.094*

* $p < .05$ (one-tailed test)

** $p < .01$ (one-tailed test)