Malnutrition and Environmental Enrichment by Early Adoption

Development of adopted Korean children differing greatly in early nutritional status is examined.

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Numerous studies conducted in several different countries have demonstrated that malnutrition during the first two years of life, when coupled with all the other socioeconomic deprivations that generally accompany it, is associated with retarded brain growth and mental development which persist into adult life (*1–3*). What is not clear is the contribution of the malnutrition relative to that of the other social and cultural deprivations. When malnutrition has occurred in human populations not deprived in other ways the effects on mental development have been much less marked (*4*). Animal experiments have shown that early isolation results in the same type of persistent behavioral abnormalities as does early malnutrition (*5*). A stimulatory environment has been shown to counteract the untoward behavioral effects of early malnutrition in rats (*6*). These observations have led to the hypothesis that malnutrition and environmental deprivation act synergistically to isolate the infant from the normal stimulatory inputs necessary for normal development (*6*). In addition, they suggest that enriching the environment of previously malnourished children might result in improved development. To test this hypothesis, we have examined the current status of a group of Korean orphans who were adopted during early life by U.S. parents and who had thereby undergone a total change in environment.

Experimental Sample

The sample was drawn from records of children who had been admitted to the Holt Adoption Service in Korea between 1958 and 1967. The following criteria were established for inclusion in the sample:

1) The child must be female. This was decided in order to eliminate sex differences; and because many more female than male infants were brought to the agency they provided a larger adoptive sample to choose from.

2) Date of birth and results of physical examination at the time of admission to Holt care, including height and weight, must be available on the records.

3) The child must have been less than two years old when first admitted to Holt care and less than three years old when adopted.

4) The child must have been reported to be full term at birth.

5) The physician's examination at time of initial contact must have revealed no physical defect or chronic illness.

6) The child must have been followed by the adoption service for at least six years and must be currently in elementary school (grades 1 to 8).

7) The child must have a current mailing address in the United States.

Table 1. Number of cases in each group.

Group	Total number	Number measured for: Current height	Current weight	IQ	School achievement
1	42	41	41	36	40
2	52	50	51	38	38
3	47	47	47	37	37

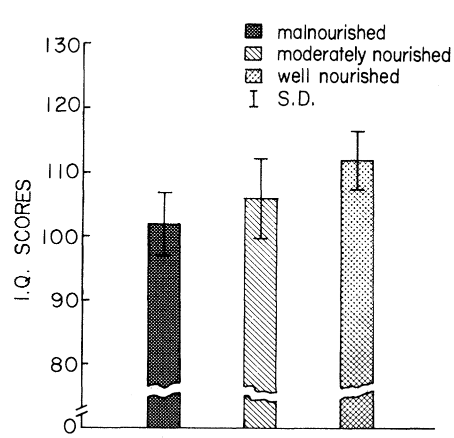

Fig. 1. The IQ's of the three nutrition groups—means and standard deviations (S.D.).

From 908 records chosen at random 229 children were found who met all these criteria. We divided these 229 into three groups, as follows, on the basis of how their height and weight at time of admission to Holt related to a reference standard of normal Korean children of the same age (*7*): group 1, designated "malnourished"—below the 3rd percentile for both height and weight; group 2, "moderately nourished"—from the 3rd through the 24th percentile for both height and weight; group 3, "well-nourished" or control—at or above the 25th percentile for both height and weight.

There were 24 children, randomly distributed through the three groups, whose height and weight were not in the same percentile grouping. These were eliminated from the sample. The remaining 205 consisted of 59 children in group 1, 76 in group 2, and 70 in group 3.

A letter was sent by the Holt Adoption Service to the parents describing the general objectives of the study and asking their cooperation. It was followed by a letter from us explaining the study in more detail and asking for permission to request information about the child from the school. Where possible, the parents were called by telephone so that any questions they had about the study could be answered. For various reasons, 64 children could not be followed—17 in group 1, 24 in group 2, and 23 in group 3. Most of this loss resulted from inability to reach the parents, from an inadequate response, or from parental refusal. The final sample thus consisted of 141 children—42 in group 1, 52 in group 2, and 47 in group 3.

Information on health, growth and nutrition, and family socioeconomic background was obtained from the families of these 141 children by means of a checklist questionnaire (*8*). Information about scores on standardized tests of intelligence and school performance for the years 1971 to 1973 was requested from the schools on a mailed form constructed for this purpose.

The outcome data presented here consist of current height, which was obtainable for 138 children; current weight, obtainable

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for 139; current IQ (*9*), for 111; and current achievement scores, for 115. Table 1 shows the number of children in each group about whom these data were obtained.

Results

As may be seen in Tables 2 and 3, all three groups have surpassed the expected mean (50th percentile) for Korean children in both height and weight. There is a tendency for the children in groups 1 and 2 to be smaller and lighter than in group 3, but the differences are statistically significant only between the mean heights of children in groups 1 and 3 (Table 2). Although all three groups are heavier and taller than would be expected if they had remained in Korea, their means all fall below the 50th percentile of an American standard.

The mean IQ of group 1 is 102; of group 2, 106; and of group 3, 112 (Fig. 1). Only the difference between groups 1 and 3 is statistically significant ($P \leq .005$). All the groups have reached or exceeded mean values of American children. When the data are converted to stanines (Table 4) the results are the same as with the IQ scores.

Results for achievement scores (Table 5) are similar to those for IQ's. All the groups have achieved at least to stanine 5 (the mean for U.S. school children of the same age). There is a highly statistically significant difference between group 1 and group 3 ($P \leq .001$). Differences in achievement between groups 1 and 2 just reach the level of statistical significance. All the groups are doing at least as well as would be expected from an average U.S. population.

Table 2. Current height (percentiles, Korean reference standard): comparison of the three nutrition groups. *F* prob. is the probability that the calculated *F* ratio would occur by chance.

Group	*N*	Mean percentile	S.D.	*F* prob.	Contrast groups	*t*-test *t*	*t*-test *P*
1	41	71.32	24.98	0.068	1 vs. 2	−1.25	0.264
2	50	76.86	21.25		1 vs. 3	−2.22	0.029*
3	47	82.81	23.36		2 vs. 3	−1.31	0.194
Total sample	138	77.24	23.41				

*Statistically significant.

Table 3. Current weight (percentiles, Korean reference standard): comparison of the three nutrition groups. *F* prob. is the probability that the calculated *F* ratio would occur by chance.

Group	*N*	Mean percentile	S.D.	*F* prob.	Contrast groups	*t*-test *t*	*t*-test *P*
1	41	73.95	24.60	0.223	1 vs. 2	−1.24	0.218
2	51	79.94	20.78		1 vs. 3	−1.61	0.111
3	47	82.11	22.66		2 vs. 3	−0.49	0.624
Total sample	139	78.91	22.68				

Table 4. IQ stanines: comparison of the three nutrition groups. *F* prob. is the probability that the calculated *F* ratio would occur by chance.

Group	*N*	Mean percentile	S.D.	*F* prob.	Contrast groups	*t*-test *t*	*t*-test *P*
1	37	5.25	1.32	0.005	1 vs. 2	−1.42	0.160
2	38	5.74	1.62		1 vs. 3	−3.45	0.001*
3	37	6.46	1.66		2 vs. 3	−1.91	0.061
Total sample	112	5.82	1.61				

*Statistically significant.

Table 5. Achievement stanines: comparison of the three nutrition groups. *F* prob. is the probability that the calculated *F* ratio would occur by chance.

Group	*N*	Mean percentile	S.D.	*F* prob.	Contrast groups	*t*-test *t*	*t*-test *P*
1	40	5.07	1.51	0.002	1 vs. 2	−2.12	0.038*
2	38	5.79	1.47		1 vs. 3	−3.60	0.001*
3	37	6.48	1.89		2 vs. 3	−1.80	0.080
Total sample	115	5.76	1.72				

*Statistically significant.

Discussion

In the studies referred to earlier which showed persistent retardation in children malnourished during the first two years of life (*1–3*), after successful nutritional rehabilitation the children were sent back to the environment from which they came. Even by comparison with nonmalnourished siblings or other children from similar socioeconomic environments their growth and development were retarded (*3*). Thus severe malnutrition itself during the first two years of life appears to exacerbate the developmental retardation that occurs under poor socioeconomic conditions. What happens to the child from a high socioeconomic background who becomes malnourished early in life? In the few such cases that have been studied (children with cystic fibrosis or pyloric stenosis) the children have shown a much smaller degree of retardation in growth and development and have tended to catch up with time (*4*). What has not been determined yet and what is a much more important practical problem is the fate of a malnourished child from a poor socioeconomic background who is subsequently reared in the relatively "enriched" environment of a higher socioeconomic stratum.

In a few instances attempts have been made to modify the subsequent environment either by keeping the child longer in the hospital in a program of environmental stimulation or by sending the child home but enrolling him or her in a special preschool program designed to provide a variety of enriching experiences. Improvement in development has been noted with both these approaches but there have been reversals as soon as the special program was discontinued (*10*). The data suggest that if a severely malnourished child is subsequently to develop adequately, any program of environmental enrichment must be of long duration. In the present study, severely malnourished children were compared with moderately malnourished and well-nourished children after all had undergone a radical and permanent change in their environments by being adopted into primarily middle-class American homes. (The adoptive parents had no knowledge of the previous nutritional status of the child, and the distribution of these children into their adoptive homes was entirely random.) The results are in striking contrast to those obtained from similar groups of children returned to the environments from which they came (*1, 2*). Even the severely malnourished adopted Korean children have surpassed Korean norms of height and weight. Moreover, the marked initial size differences between the malnourished and the well-nourished infants have almost entirely disappeared, leaving only a small difference in height. None of the groups reach mean values for American children of the same age. This may reflect either genetic size differences between Korean and American children or the effects of chronic undernutrition extending for several generations in developing countries such as South Korea.

Perhaps even more striking and less in accord with previously reported experience is the fact that the mean IQ of the severely malnourished children is 102 and slightly skewed to the right. It is about 40 points higher than that reported in similar populations that were returned to their early home environments (*1*, *3*). In addition, achievement in school for the severely malnourished group is equal to that expected of normal U.S. children. However, the stigmata of malnutrition had not entirely disappeared by the time these children were studied. There are statistically significant differences between the previously malnourished and well-nourished children in IQ and achievement scores. Whether these are permanent differences it may be too soon to judge. It should be noted, however, that the initially well-nourished children attained a mean IQ and achievement score higher than that of middle-class American children. It may be that these attainments (and those of the other two groups as well) reflect the select character of adoptive parents and of the environment they provide to their adopted children.

In this study all the children came to their U.S. homes before the age of three—the mean age was 18 months. Thus they spent a major portion of their early developmental years in their adoptive homes. It would be important both theoretically and practically to determine whether adoption at later ages produces similar results. Such studies are being planned.

References and Notes

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11. Acknowledgment is made to the Agency for International Development and the Grant Foundation for support of this research. We thank J. Justman and M. Sontag for consultations on how to evaluate the school data, L. Burrill for help with converting the IQ and achievement scores into standard stanines, B. Miller for technical assistance with the sampling and mailing, and G. Raabe and B. Milcarek for computer programming.

NEWS AND COMMENT

Recombinant DNA: NIH Sets Strict Rules to Launch New Technology

La Jolla, Calif. The signal to proceed with slow motion was given here on 5 December to a new technology whose ultimate benefits and potential risks may prove comparable in extent to those of harnessing the atom. Guidelines drawn up during a tensely argued 2-day meeting of a National Institutes of Health (NIH) committee will allow researchers to experiment with a new technique of genetic manipulation which because of its potential hazards has been under almost complete embargo for the last 18 months.

The technique involves the use of recently discovered enzymes to cut and splice the hereditary material of living organisms with unprecedented and possibly undreamed-of precision. A DNA segment carrying one or more genes can be excised from a chromosome and tacked onto another segment which may come from a quite different organism. The ability to construct recombinant DNA molecules, as they are known, is of both heuristic and practical significance. It offers in principle the means of obtaining a complete set of the genetic plans of any organism, including man. Biologists are already describing the technique in terms such as "revolutionary" and "one of the most significant advances of 20th century biology."

The practical applications so far envisaged range from equipping crop plants with nitrogen-fixing genes to make nitrogen fertilizer unnecessary, to the construction of microorganisms capable of synthesizing some of the products now obtained from oil. The recombinant DNA technique offers man power over nature in a more fundamental way than that of any other technology, because it is the power to intervene in evolution, to design and create combinations of genes in ways radically different from the slow reshufflings by which new organisms are created in nature.

Despite its promise, the new technique has been voluntarily forsworn by the scientific community because of theoretical hazards which most biologists consider to be extremely remote. The hazards stem from the fact that the properties of many recombinant DNA's likely to be constructed cannot always be predicted and may be deleterious. Should the addition of new genes confer a selective advantage on a virus or bacterium harmful to man or other forms of life, the outcome could be a catastrophe of possibly epidemic proportions.

Such horror scenarios, however incredible, are made more conceivable by the circumstance that the standard laboratory microorganism which will serve as the host for many recombinant DNA's is *Escherichia coli*, a common inhabitant of the human gut and throat. Laboratory workers often get infected by the organisms they handle, and through this means, if not by direct escape, a recombinant-containing bacterium might become established in the population at large. What cannot yet be excluded is the possibility that whatever genes have been built into the recombinant might be switched into action and interfere with the metabolism of those infected by the escaped bacterium.

This risk attaches in particular to one of the technique's most immediate uses, the so-called "shotgun" experiment, in which the total DNA of an organism is cut into segments and inserted into bacteria so that each segment may be grown in bacterial clones. Several of these segments are likely to contain harmful genes, such as those specifying any toxins the organism may