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The Impact of Undernutrition on Intelligence Quotient and Impulsivity Index

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ABSTRACT

Background: Undernutrition is the most common cause of growth retardation in developing countries. We aimed to assess the effect of undernutrition on cognition, intelligence quotient, and impulsivity index of 7-11 year-old children in Shiraz, southern Iran.

Objectives: Our objective was to determine the association between chronic moderate undernutrition and poor Intelligence Quotient and Impulsivity Index.

Patients and Methods: In this case-control study, two groups of school-aged children with the mean age of 9 ± 0.98 years were enrolled. After controlling the confounding variables, 24 children with moderately chronic undernutrition (group 1) were compared to 17 normal children (group 2). We selected children based on growth parameters, evaluation of intensity, history, and by excluding underlying diseases. Intelligence quotient and draw-a-person tests were performed. We described data as mean and standard deviations, and used the t test for independent groups. Data was analyzed using SPSS software, version 11.5. Significance level was considered as 5%.

Results: Only P5 (omissions) and P7 (relativities) parameters in the DAP test were significantly different. The Mean ± SD in the undernourished and normal groups were respectively 0.91 ± 0.28, 0.70 ± 0.46 for p5 (P = 0.030), and 0.64 ± 0.49, 0.35 ± 0.49 for p7 (P = 0.024), and 17.8 ± 1.89, 19 ± 1.80 (P = 0.050) for spelling .For verbal intelligence quotient, (VIQ) were 115 ± 9.7, and 113 ± 10.6 (P = 0.528). For performance intelligence quotient, (PIQ) were 117 ± 14.1, and 116 ± 11.3 (P = 0.864). For total intelligence quotient, (TIQ) were 117 ± 10.3, and 116 ± 10.2 (P = 0.715). For impulsivity index were 5.3 ± 2.8, and 4.3 ± 2.6 (P = 0.256).

Conclusions: Chronic and moderate malnutrition did not influence the cognitive function, the intelligence quotient, and the impulsivity index.

Keywords: Behavior; Child; Cognition; Malnutrition; Intelligence

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Implication for health policy/practice/research/medical education:
The implication of this article is related to intellectual capacity of undernourished children.

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1. Background

Undernutrition is the most prevalent nutritional problem in developing countries. While the absolute number of undernourished children has been globally increased, in some parts of the world, mainly Latin America and Eastern Asia, the rate of undernutrition has been considerably decreased. Half of the southern Asian children are undernourished. In Africa, one third of the children have body weights below the normal standards (1). Undernutrition is the most common cause of failure to thrive (FTT) in Iranian children referring to clinics (2). Intellectual capacity is specifically important for people's quality of life in developing countries, because economic development is restricted by the deficiencies of social sectors, which in turn may lead to unfavorable socioeconomic, sociocultural, intellectual, and nutritional conditions.

Undernutrition in the first few months of life (< 6 months) is not common. However, it may be associated with poor cognition and development in the first few years of life (3). Some studies suggest a link between malnutrition, and poor cognition (1, 4-6). In human beings, the "brain growth spurt" begins from 3 months before birth up to 2 years (7). Randomized interventional trials performed in different countries have confirmed the sensitivity of developing human's brain to nutrition, and the long-term effects of malnutrition on cognition (8, 9).

This is also the period for the development of general intelligence factor (g factor), measured by the intelligence quotient (IQ) test. Intelligence is affected by both environmental and biological factors. Environmental factors include the sociocultural, socioeconomic, familial, and educational status. Biological influences depend on nutrition, exposure to chemical toxins, and prenatal factors. Nutrition is one of the most important biological factors affecting the intelligence.

It was believed that prenatal malnutrition could lead to intellectual development deficit. A study on male infants, born during a wartime famine, showed that short term prenatal malnutrition had no effects on intellectual development (10). Some studies contradict the fact that the malnutrition-IQ link is eliminated after controlling psychosocial and environmental factors (11-13). Strauss and colleagues concluded that intrauterine growth retardation (IUGR) has little impact on intelligence, except when associated with serious deficiency in the head circumference (14).

2. Objectives

We aimed to assess and compare the impact of undernutrition on cognition, intelligence quotient and impulsivity index of two different groups of 7-11 year-old children in Shiraz, southern Iran.

3. Patients and Methods

900 School-aged children in the third educational district of Shiraz, southern Iran from different grades of primary school who were considered as undergrowth children by the health officers of those schools were examined. Their weight, height, head circumference (15), body mass index (16), and triceps skin-fold thickness (17) were measured. Children with inadequate growth were identified according to the percentiles prepared by the National Center for Health Statistics (NCHS) (18). The undergrowth children whose weights and heights were below the 50th percentile (greater or equal to 2 standard percentiles) were selected (24 children as group 1), and the intensity of growth retardation was determined according to the Waterlow (19) and Gomez's classification (20).

In the next stage, we asked their parents to provide sufficient history about their children's feeding habits and other variables. Written consent was obtained prior to the study from their parents. Included children had no history of special diseases (such as thyroid diseases, diabetes mellitus, and any chronic diseases), constitutional delayed growth and puberty, head trauma, epilepsy, drug use (such as iron supplementation), asphyxia, and premature delivery. Their parents did not indicate any history of alcohol consumption, cigarette smoking, and their heights were not below the fifth percentile. There were Positive history of late supplementary feeding, low caloric diet, anorexia, poor weight gain, decreased velocity of growth in the early years of life, meat consumption ≤ 2 times/week and in small amounts, and history of insufficient food intake in the early years of life continuing to school age in the undergrowth group.

Complete blood count, thyroid stimulating hormone (TSH), T3, urine analysis, stool OB/OP, blood urea nitrogen (BUN), liver function test, and bone age were measured to evaluate the underlying diseases. If the results were normal, we measured the IQ using the Wechsler Intelligent Scale for Children, third edition (WISC–III), and the impulsivity index using the Draw-A-Person (DAP) test, respectively (21). We also obtained enough information about the children's mathematics, spelling, and reading capabilities from their teachers. From the same schools in the third educational district of Shiraz, we selected 17 students with normal nutrition as group 2 and after controlling the confounding factors, we then compared them with the undernourished group (n = 24) to evaluate the impact of under nutrition on the IQ and the impulsivity index. Data was analyzed using the t and Pearson's correlation tests.

As all of the children belonged to the third educational district of Shiraz, they had similar sociocultural and socioeconomic status with respect to their parental education, jobs, number of family members, their residence, and income. Also, they were all right-handed. Data was described as the mean and standard deviations. We used the t test for independent groups and person's correlation coefficient for relation two variables. We used SPSS software, version 11.5. Significance level was considered as 5%.

Table 1. ComparisonBetween the Two Groups Based on the Anthropometric Measurements (T test)

Index	Group	Mean ± SD	P value
Height	Undernourished	125.54 ± 6.59	0.006
	Normal	130.53 ± 4.96	
Weight	Undernourished	20.08 ± 3.08	0.001
	Normal	26.88 ± 3.31	
BMI[a]	Undernourished	12.55 ± 1.07	0.001
	Normal	15.79 ± 1.12	
Head Circum-ference	Undernourished	51 ± 1.33	0.258
	Normal	51.24 ± 1.25	
Skin Fold Thickness	Undernourished	6.46 ± 1.47	0.001
	Normal	8.71 ± 0.99	

[a] Abbreviations: BMI, Body Mass Index

4. Results

The children's mean age was 9 ± 0.98 years. We enrolled 19 girls and 22 boys. *Table 1* shows the growth parameters of the children. Except the head circumference, the other parameters were significantly different.

Apart from the ratio related to breastfed children, the other factors (birth weight, age, sex, type of delivery, and socioeconomic status) were not significantly different (table 2). The VIQ, PIQ, TIQ, and P total did not show a significant difference between the two groups. The spelling, p5, and p7 scores in the DAP test differed significantly between the two groups (table 3). The Pearson's correlation test revealed a negative significant correlation between the P total and the children's height in the undernourished group (table 4).

There was a significant correlation between the mathematics/dictation and VIQ scores in the normal group, while no such correlation was found in the undernourished group. The P total, and VIQ showed a negative correlation in the undernourished group and no correlation in the normal group. However, there was a negative correlation between P total and dictation scores in the undernourished group.

Table 2. Comparing the Demographic FactorsBetween the Two Groups

Variable	Undernourished Group, n = 24	Normal Group, n = 17	P value
Birth Weight. g, Mean ± SD	2978.94 ± 346	3164 ± 278	0.087
Age Year Mean ± SD	8.92 ± 1.05	9.12 ± 0.86	0.517
Vaginal Delivery Ratio, %	62.5	76.5	0.344
Male ratio, %	58.3	41.7	0.537
Breastfed Ratio, %	87.5	100	0.007

Table 3. Comparison ofthe Mean (Standard Deviation) of Various Intellectual Tests Between the Two Groups

Variable	Undernourished Group, Mean ± SD, n = 24	Normal Group, Mean ± SD, n = 17	P value
VIQ[a]	115 ± 9.7	113 ± 10.6	0.528
PIQ[a]	117 ± 14.1	116 ± 11.3	0.864
TIQ[a]	117 ± 10.3	116 ± 10.2	0.715
P value Total (Impulsivity Index)	5.3 ± 2.8	4.3 ± 2.6	0.256
Spell	17.82 ± 1.89	19 ± 1.80	0.050
P5	0.91 ± 0.28	0.64 ± 0.49	0.030
P7	0.70 ± 0.46	0.35 ± 0.49	0.024

[a] Abbreviations: VIQ, verbal IQ; PIQ, performance IQ; TIQ, total IQ; P total, impulsivity index; P5,omissions; P7, relativity

Table 4. The Pearson Correlation Test Results

Variable	Spell	VIQ	TIQ	P value Total
Height	UNG[a]+ 0.037			UNG[a]- 0.033
Mathematics		NG[a]+ 0.036		
Spelling		NG[a]+ 0.048	NG[a]+ 0.038	UNG[a]- 0.033
P value total	UNG[a]- 0.033	UNG[a]- 0.041	UNG[a]- 0.022	

[a] Abbreviations: UNG, Undernourished group; NG, Normal group; (-), Negative correlation; (+), positive correlation

5. Discussion

Several studies contradict the fact that the malnutrition-IQ link is eliminated after controlling psychosocial and environmental factors (11-13). In a study by Ivanovic and colleagues, head circumference was the only anthropometric indicator of postnatal nutritional status that was significantly decreased in undernourished boys and girls. This study compared two groups of 16-year-old adolescents, in which one group had severe undernutrition in the early years of life (1). In the mentioned study, undernourished children had lower VIQ and PIQ than normal 16-year-old in both sexes. MRI findings showed that undernourished boys and girls had decreased brain volume, and corpus callosum parameters compared to the normal group, especially in boys. This study showed that in the brain tissue of undernourished children, the head circumference decreased and anatomical abnormality was evident.

The correlation of IQ with other parts of the brain has not been consistent in different studies. Andreasen and colleagues confirmed that IQ and cerebella size have a positively significant correlation (22). Reiss and coworkers reached a positive correlation between IQ and gray matter volume from the prefrontal cortex (23). Others have suggested that IQ correlates with the caudate nucleus (6). Studies involving sibling had less consistent findings in favor of the association between IQ and poor nutrition, although differences still exist in some siblings (3). There are some suggestions that transient and acute episodes of poor nutrition per se, may not be as important as severe chronic undernutrition, on brain development and IQ, especially when the critical period has ended and this may explain the more inconsistent findings in many studies. Teachers reported that malnourished children communicated poorly with others, had poor attention, and were more distractible. Some reports show that these children have less emotional control. It is likely that different cultures behave children differently which may explain some of the inconsistencies between the findings of different studies (3, 4).

Jianghong and colleagues showed that malnutrition at the age of three is associated with poorer verbal and full-scale cognitive ability without affecting the spatial IQ (4). If we evaluated these children again at the age of eleven, they would have shown poorer VIQ, spatial IQ, full scale IQ, reading ability, and school performance. Isac and colleagues compared two groups of adolescents (standard or high nutrient diet groups) in the postnatal weeks after preterm birth. The members of the group had similar birth status and neonatal course. CT scan and IQ tests were also obtained. The high nutrient group (especially the boys) had significantly larger caudate volumes and higher VIQ. Her study showed that the IQ and caudate volume were influenced by an early and high nutrient diet and had a selective association with VIQ in boys (6). Lucus and coworkers reached similar results (24). Different biological and environmental factors affect intellectual ability, and controlling them is sometimes very difficult. On the other hand, the intensity and duration of malnutrition are not the same; so these may yield different results in different studies. In our study, we tried to evaluate undernourished children. Influential factors such as age, sex, right-handedness, delivery type, and socioeconomic status were compared in both groups. The intensity of undernourishment was moderate. Breastfed children have better IQ at the age of three than infants fed with skim milk in either term or preterm infants (25). In our study, the percentage of breastfeeding was 87.5% in the undernourished group, compared to 100% in the normal group; however, the IQ had no significant difference.

Although the VIQ, performance IQ, total IQ, and P total had no significant differences in the undernourished group compared to the normal one, there were significant differences in the spelling, P5, and P7 parameters in the DAP test. The positive correlation at the 0.05 level between the VIQ and mathematics and spelling score in the normal children, and the negative correlation at the 0.05 level between the P total (Impulsivity index) and VIQ and the total IQ in the undernourished group, may indicate that if the malnutrition was severe in our case group, and nutritional recovery failed, it may lead to poor IQ and increased impulsivity score.

Liac and colleagues, showed that children with a short stature have more behavioral disorders (26). The correlation between height and P total was negatively significant at 0.05 levels in the undernourished group. Although growth standards - used in the NCHS - have been adopted from studies on western children, in this study we used the NCHS standards to determine the undernourished children because no evident differences exist between growth percentiles in Iranian and western children. One of the limitations of our study that can be addressed in further researches is the lower sample size compared to other reports. Another limitation was that we studied only one of the educational districts of Shiraz. Larger studies on all educational districts are recommended. Growth retardation due to long-term chronic and moderate malnutrition did not affect the cognitive function, IQ, and the impulsivity index of the children in our study. This might be explained by the fact that the children were breastfed in the first few years of life.

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None declared.

Authors' Contribution

Data were collected and manuscript was prepared by Mahnaz Haghighi. Psychological tests were performed by Gholamreza Chalabianloo and Maryam Afshar. Statistical analysis was performed by Mehrab Sayadi. Labratory tests were performed by Parvin Javad.

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