Association between Preschool Children Nutrition and Cognitive Performance

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Abstract

The present study is aimed to assess the nutritional status and cognitive performances of some preschool children (57.2-71.39 months). The study was performed on 39 children 51% were girls and 49% were boys with a mean age of 53.59±1.85 months. All children from cities Giza government. The obtained data showed that mean value body weight, height, body mass index (BMI), and mid upper arm circumference (MUAC) were 16.97±0.26 kg, 101.7±0.98 cm, 16.47±0.21kg/m^2, and 14.01±0.33 cm respectively. According to the food intake analysis, the mean value intake of total energy, protein, fat, and carbohydrate was 985.08±32.79 kcal, 33.74±1.12 g, 33.98±1.28 g, and 110.96±3.89 g respectively. The mean value intake of some minerals (Iodine, Iron, Selenium, and Zinc) was 81.64±5.49µg, 9.71±0.49 mg, and 42.79±2.67µg and 4.77±0.22 mg respectively. The mean value intake of some vitamins (Vitamin A, Vitamin B1, Vitamin B2, and Vitamin C) was 273.23±25.57 I.U, 0.45±0.06 mg, 0.49±0.03 mg, and 17.01±1.14mg respectively. Some biochemical analyses showed that the mean value urinary iodine was 159.55±3.08 µg/l, and blood hemoglobin was 11.5±0.10g/dl. The Wechsler tests were done to calculate student IQ, the mean value of verbal IQ was 103.23±1.18, the mean average of performance IQ was 76.23±2.78, and the mean of total IQ was 94.61±0.93. Finally, this study is importance due to the lack of studies in this stage of childhood and so we recommended that to more investigation need to done at this stage of childhood especially with the increasing interest of the Egyptian government in the healthy nutrition of children.

Key words: Nutrient intake, IQ children, Early childhood stage , Preschool children

Introduction

Early childhood constitutes the most vital period of life due to its essential role in cognitive, social, emotional, physical, motor development and cumulative lifelong learning **(Islam et al., 2016)**. Improving the health of preschool children is one of the substantial objectives of healthcare services in most developing countries (**Onifade et al., 2016**). United Nations Children's Emergency Fund (UNICEF) estimates that approximately half of all deaths in children fewer than five years are attributable to

under-nutrition (**Frison et al., 2016**). Nutrition is one of many elements that stimulus a child's development (**Florence et al., 2008**).

With two-thirds of child mortality attributable to malnutrition, Egypt stands as one of the 36 countries, where 90 percent of the global burden of malnutrition falls. The double burden of malnutrition is categorized by living of undernutrition along with overweight, obesity, or diet-related deficiencies within individuals. Children who are overweight are at risk of non-communicable diseases such as diabetes and coronary heart disease and micronutrient deficiencies due to a poor diet. The double burden of malnutrition (DBM) is a major challenge in Egypt, especially for overweight/obesity and stunting. Anemia is a disorder in which there is a deficiency of red cells or hemoglobin in the blood, resulting in paleness and fatigue; is also a major challenge in Egypt affecting 27.2 percent of children under-5. The concern about malnutrition is that it has a long series of upsetting effects on early childhood growth and development contributing not only to infant and child mortality but also, to physical, and cognitive developmental impairments among children if children survive (**Ministry of Health and Population, 2015**).

The relationship between nutrition and mental development and performance in children is equally important in terms of their attainment and productivity both in school and in later life (**Benton, 2010**). Cognitive development is influenced by the interaction between the brain and its environment (**Isaacs and Oates 2008**). Nutrition plays a vital role as one of the most important environmental factors influencing cognitive performance as it provides the building blocks for the neural formation and brain development (**Benton, 2008**).

Therefore, the objective of this study is to evaluate the nutritional status and its impact on health and cognitive development among preschool children.

Subject and Methods

Study Design: Thirty-nine healthy children of both sexes aging 53.59±1.85 months were recruited from the urban area of Giza governorate. They were attending in nursery schools. The personal data were collected by their mothers and their ages were assessed from the birth certificates if a physical or mental disability was present or ill children at the time of the study were excluded.

Data Collection and Field Work

Data collection took place through a home visit. An informed consent form was signed by the parent before participation in the study. The study was approved by the ethical committee of the National research center with registration numbers 18-105. Anthropometric measurements were conducted on the children while the parents were being interviewed and a questionnaire was filled by the investigator on some personal

data, socio-demographic background and 24-hour recall of their children. Subsequently, a cognitive assessment was conducted on the students one-to-one.

Anthropometric measurements

1- Age was assessed from birth certificates.

2- Body weight was assessed using a beam-type balance while the child wore very light clothes and was barefooted. This weight was taken to the nearest o.5 kg **(Jelliffe et al., 1989)** using a kilogram weighing balances ranging from 1-130 kilograms.

3- Body height was measured to the nearest 1 mm for children. Height measurements were taken, while the subject was standing position against a firm wall with a fixed scale. Height was taken with no shoes and recorded to the nearest centimeter **(Moussa, 1999)**.

4- Mid-upper arm circumference (MUAC): was measured to the nearest 0.1 cm with non-elastic tape over light clothing on the upper left arm. The children stood relaxed to the trained technician and the arm hanging freely at the side; the tape was passed around the arm at the level of the mid−point of the upper arm **(Mazicioglu et al., 2010)**.

5- Body Mass Index (BMI)= The body mass index (BMI) is the metric currently in use for defining anthropometric height/weight characteristics them into groups. It was done according to the equation weigh (kg)/ height^2 (m) (**Nuttall, 2015**)

Dietary intake

Triple 24-hour dietary recalls were administered to the children's mothers. Dietary data were translated into nutrient intake data using a specifically designed nutrient database, (The Egyptian Food Composition Tables and Nutrient Data Base Management System from National Nutation Institute, 2006).

Cognitive Tests

Cognitive and intellectual functioning was assessed through the application of the Wechsler Intelligence Scale for Children (WPPSI), the Arabic version (**Ismaiel and Kamal, 1999**).

It is designed to assess and measure the child's verbal, performance, and full-scale IQ through assessment of different functions (short- and long-term memory, comprehension, information, abstract thinking, problem-solving, and speed of information processing). Thorough application of (WPPSI), we can assess Verbal and Practical IQ as well as total IQ (**Kaufman et al., 2016**).

Biochemical analysis:

Blood Hemoglobin: Hemoglobin estimation was done according to **Shaklai et al (1977).** In a reagent solution, the ferrous ions of hemoglobin are oxidized to the ferric state by potassium ferricyanide to form methemoglobin.

Methemoglobin subsequently reacts with the cyanide ions provided by potassium cyanide to form cyanmethemoglobin.

Hemoglobin + Cyanide + Ferricyanide $\longrightarrow$ Cyamethemoglobin (Ion).

The amount of cyanmethemoglobin can be measured spectrophotometrically at a wavelength of 546 nm. The intensity of the color is directly proportional to hemoglobin concentration in the specimen.

Urinary Iodine: Urinary Iodine was determined according to (**WHO, 2013**). Urine samples were thawed and mixed thoroughly on a rot mixer before pipe ting. 250µl of urine were taken into 13X 100 mm scrolled test tubes then adding 1 ml of M ammonium per sulfate to each tube and the samples were hydrolyzed for 1 h at 100°C. After cooling the tubes to room temperature add 2.5 ml arsenious acid solution and mix well then incubate for 15 minutes. Add 300µl of ceric ammonium sulfate to each tube, and then incubate for 30 minutes. Readings were performed using a spectrophotometer (Thermo Fisher Scientific Genesys, USA) at 420 nm, within 30 minutes.

Statistical Analysis
All data were expressed as the arithmetic means with standard error. Data were analyzed using SPSS Version 20.0 for Windows (Statistical Package for the Social Sciences) (**Snedecor and Cochran, 1980**)

Results and Discussion

A suitable diet in childhood is considered to play a vital role in the physical, mental, and emotional development of children through to their later adult age. Anthropometry is a practical and immediately appropriate method for evaluating children's development patterns. Anthropometric indicators can be used as a screening device to identify individuals at risk of under-nutrition or over-nutrition, followed by a more elaborate investigation using other techniques (**Rysha et al., 2017**). In the present study, 39 children volunteered to assess their nutritional and cognitive status, 51% were girls and 49% were boys. They all live in the cities of Giza Governorate. Their ages were ranged from 57.2-71.39 months with a mean age of 53.59±1.85 months, when asking children mothers some questions about the method of delivery, birth weight, as well as breastfeeding it was found that only 26% of children were born in vaginally way and 74% in a cesarean way. 49% of children were breast feeding, 49% of children used artificial milk during infancy, 25% were used breast feeding and 26% used both artificial and Breast feeding during infancy. Only 18 % of children were playing sports. According to **Meireles and Machado, (2018)** were reported that a small difference was observed in cognitive performance of children born by instrumental vaginal delivery and non-planned cesarean section in comparison to those born by non-instrumental vaginal delivery or planned cesarean, nonetheless this should have a minimal impact on a child's future neurodevelopment. **Borra et al., 2012** reported that breastfeeding for four weeks is positively and statistically significantly associated with higher cognitive test scores, by around one-tenth of a standard deviation In this study we measure some anthropometric

measurements like weight, height, and mid-upper arm circumference (MUAC). The mean average weights of children were 16.97 ± 0.26 kg, the mean average heights of children were 101.7 ± 0.98 cm so the mean average body mass index (BMI) of children were 16.47 ± 0.21 kg/m^2 and MUR was 14.01 ± 0.33cm. These data were shown in figures (1, 2, 3, and 4) and table (1). Cesarean section is one of the most frequently performed surgical procedures in the world, representing the most executed major obstetrical intervention, with rates varying between 5-60%. Over the last decades, there has been a global rise in the rate of cesarean section, which is believed to have major contributors to the increase in maternal requests and changes in clinical practice. Furthermore, rates well above the World Health Organization's recommended 15% ceiling suggest a high number of unnecessary procedures.

Fig (1): Gender Presentage

Fig (2): Type of Preschool Delivery Presentage
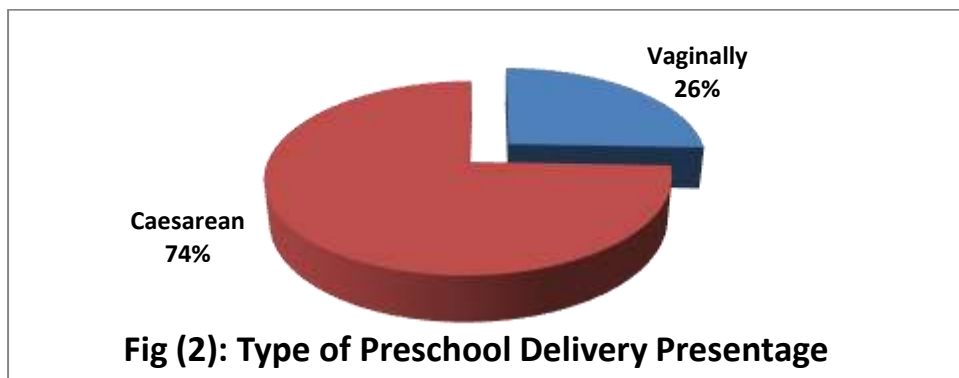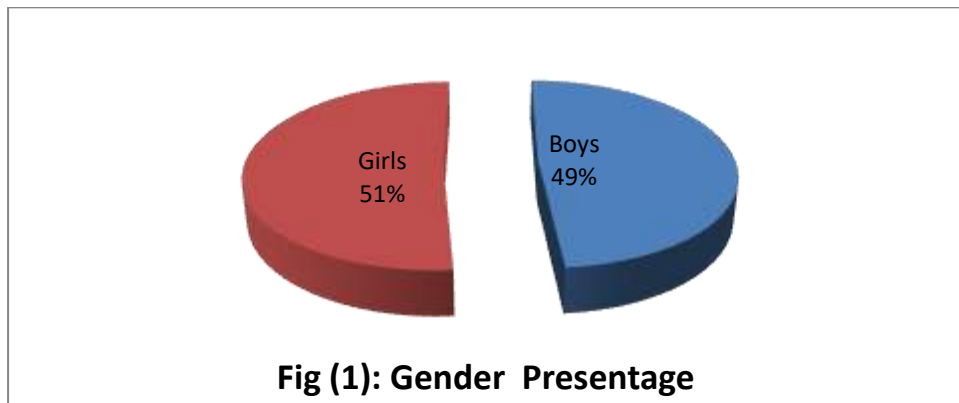
Parameters	Boys	Girls	Total Children average
Age (Month)	53.79±2.69	53.39±2.63	53.59±1.85
Weight (kg)	16.89±0.32	17.05±0.43	16.97±0.26
Height (cm)	101.87±1.48	101.55±1.34	101.7±0.98
BMI[*] (kg/m^2)	16.34±0.29	16.60±0.31	16.47±0.21
MUAC[**] (cm)	13.74±0.47	14.28±0.47	14.01±0.33
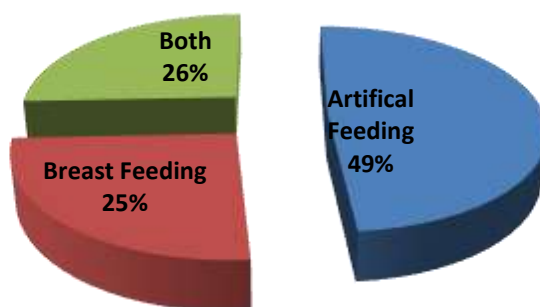
Fig (3) Feeding during Infancy Precentage

Fig (4): Precentage of doing phsical activity

Table (1):   Some Anthropometric Measurements for Preschool Children

[*]Body Mass Index
[**]Mid Upper Arm Circumference

Nutrition has a considerable in child health not only physical but also mental and emotional. Inadequate dietary intake can cause malnutrition whether over nutrition which may cause over weight and obesity or under nutrition which may cause stunting and adverse effect on the development of the organ (**Merkiel and Chalcarz, 2007**). Table (2) showed the Macro Nutrient that taken by preschool children that calculated from 24-hour recall sheets, the mean average intake from total calories among preschool were 985.08±32.79 Kcal /day, while the mean average

intake from protein was 33.74±1.12g /d, the mean average intake from fat were 33.98±1.28 g/d and finally, the mean average intake of total carbohydrates were 110.96±3.89 g/d.

Table (2): Total Calories and Macro Nutrient Intake among Preschool Children per day

Parameter	Energy		Protein		Fat		CHO*	
	kcal/d	%	g/d	%	g/d	%	g/d	%
Boys	1019.302±53.50	62.88	35.45±1.74	43.74	34.80±2.12	96.61	112.70±5.78	46.35
Girls	952.56±38.76	64.45	32.12±1.37	43.46	33.19±1.5	101.05	109.31±5.34	49.31
Total Children	985.08±32.79	63.57	33.74±1.12	43.55	33.98±1.28	98.68	110.96±3.89	47.74

*Carbohydrate

Several micronutrient deficiencies affect functional, particularly cognition and physical performance of children. Micronutrient deficiencies are a critical concern among children throughout the world. Approximately 30% of the world's population live in iodine-deficient areas and 25% of the world's children under age 3 y have iron-deficiency anemia, with higher rates in developing countries (**Black, 2003**).

According to Food and Nutrition Board, Institute of Medicine, National Academies the Estimated Average Requirements (EAR) from Iodine, iron, selenium, and zinc were 65µg/d, 4.1 mg/d, 23µg/d, and 4mg/d respectively. In the present study, we focused on the dietary actually intake from some minerals that may be related to brain development like iodine, iron, selenium, and zinc showed in the table (3). The mean average intakes of iodine in the present study were 81.64±5.49 µg/d so the percentage of the actual intake among preschool children was 125.6%. The mean average intake from iron among preschool student in the present study was 9.71±0.49 mg/d so the percentage of the actual intake among preschool children were 236.83%. The mean average intakes from Selenium in the present study were 42.79±2.67µg/d so the percentage of the actual intake among preschool children were 186.04% and finally the mean average intake from zinc among preschool student in the present study were 4.77±0.22 mg/d so the percentage of the actual intake among preschool children were 119.25%.

Zinc is a cofactor for more than 200 enzymes that regulate different metabolic activities in the body, including protein and DNA synthesis. Zinc is also found in high concentrations in synaptic vesicles of hippocampal neurons, which are centrally involved in education and memorial status (**Nyaradi et al., 2013**).

Iron has import role for children because of its critical impact on their development. Iron is an essential role in the normal anatomical development of the

fetal brain. Iron deficiency in early childhood is the most common micronutrient deficiency and can lead to irreversible damage to brain structure and cognitive function, regardless of therapies with iron supplements (**Cerami, 2017**).

Iodine is a vital trace element for the function of the organism. It is essential for the biosynthesis of thyroid hormones, necessary for normal increase, development and functioning of the metabolism throughout life. Iodine deficiency can cause irreversible brain damage and mental retardation (**Ghassabian and Trasande, 2018**).

Selenium is a mineral that has antioxidant action. It reduces free radicals as well as inhibits the manufacture of new ones in the organism since it is a critical element for GSH-Px, which is an enzyme with antioxidant activity. Selenium deficiency has been more associated with reduced immune system effect (innate and adaptative), precisely the activity of selenoproteins in the oxidative system that reduce the free oxygen radicals formed in the manufacture of thyroid hormones. Selenium deficiency is also related to the development of cretinism since it presents a direct relation with iodine in the organism during hormone conversion (**Ventura et al., 2017**).

Table (3): Minerals Intake among Preschool Children Per day

Parameters	Iodine		Iron		Selenium		Zinc	
	µg/d	%	mg/d	%	µg/d	%	mg/d	%
Boys	145.74±9.71	119.47	9.75±0.84	237.88	44.95±4.02	195.43	5.04±0.34	125.89
Girls	85.43±7.6	131.44	9.66±0.53	235.61	40.74±3.58	177.15	4.51±0.29	112.78
Total children	81.64±5.49	125.6	9.71±0.49	236.83	42.79±2.67	186.04	4.77±0.22	119.25

Vitamins as essential nutrients inevitably play a role in the initial development of the brain, and as co-enzymes influence metabolism throughout life (**Benton, 2012**). According to Food and Nutrition Board, Institute of Medicine, National Academies the Estimated Average Requirements for vitamin A, B1, B2, and C were 275 IU, 0.5mg/d, 0.5mg/d, and 22 mg/d respectively. Table (4) showed that the dietary actually intake from some vitamins.

The mean average intake from Vitamin A among preschool students in the present study was 273.23±25.57 IU/d so the percentage of the actual intake among preschool children was 99.27%. The mean average intake from Vitamin B1 among preschool students in the present study was 0.45±0.06 mg/d so the percentage of the actual intake among preschool children was 90%. The mean average intake from

Vitamin B2 among preschool students in the present study was 0.49±0.03mg/d so the percentage of the actual intake among preschool children was 98%. The mean average intake from Vitamin C among preschool student in the present study was 17.01±1.14mg/d so the percentage of the actual intake among preschool children were 77.32%.

Vitamin A deficiency was also connected to iron deficiency anemia, a risk factor for cognitive impairment. Epidemiological evidence from observational studies thus far suggests that those antioxidants in the diet, supplements, and serum may play a neuroprotective role (**Park et al., 2018**). B-vitamins, including thiamine, is vital for brain development and function through many mechanisms. They play a role in carbohydrate metabolism (which helps to provide the brain's energy supply), membrane structure and function, and synapse formation and function. Neurological symptoms typically characterize thiamine-deficiency disorders. In high-income countries, thiamine deficiency in infants has become a rare condition since food has been enriched with thiamine (**Butterworth, 2003**). Increasing proofs suggested that vitamin C has vital redox homeostatic factor in the central nervous system, relating to a poor dietary intake of Vitamin C to adverse effects on cognitive performance (**Tveden-Nyborg and Lykkesfeldt, 2009**). Several in vitro and in vivo experiments have supported an essential role for Vitamin C in the brain, both as a powerful antioxidant and scavenger of ROS, as well as a key factor in the recycling of other brain antioxidants (**Lykkesfeldt et al., 2007**).

Table (4): Vitamins Intake among Preschool Children Per day

Parameters	Vitamin A		Vitamin B1		Vitamin B2		Vitamin C	
	IU	%	mg	%	mg	%	mg	%
Boys	268.29±25.73	97.58	0.52±0.12	104.32	0.49±0.04	97.85	16.84±1.64	76.54
Girls	277.94±44.19	101.07	0.39±0.05	78.15	0.49±0.04	98.7	17.18±1.63	78.07
Total Children	273.23±25.57	99.27	0.45±0.06	90	0.49±0.03	98	17.01±1.14	77.32

The laboratory analysis used in the biochemical tests is shown in table (5)**.** The results show that the mean averages of urinary iodine were 159.55±3.08 µg/L, however the blood taken from children was used for hemoglobin analysis. The results show that the mean average blood hemoglobin was 11.5±0.10 g/dl. Its notice that there is no iodine deficiency or anemia among the preschool children, these results reflect the intake of food, especially iron and iodine. **Abdel-Rasoul et al., 2017** prevalence of iron deficiency anemia among preschool children was 52.2%., and higher in girls than in boys but did not reach a significant level. **Elsayed et al., 2015** reported that iodine deficiency (ID) (<100 µg/L) is present among 10 % of the studied

primary school children in seven governorates but there is no accurate data about iodine deficiency in preschool children in Egypt

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Table (5): Some Biochemical Analysis of Preschool Children

Biochemical	Boys	Girls	Total Children
Urinary Iodine	156.32±4.25	162.63±4.45	159.55±3.08
Blood Hemoglobin	11.63±0.15	11.38±0.13	11.5±0.10

The Wechsler IQ (WPPSI) tests for preschool children are the most frequently used individual IQ test used worldwide. These tests convert to scores that express the IQ of children. IQ results among the children in our study showed in table (6). This study showed that the Verbal IQ of children was 98.43±0.99, the performance IQ of children was 76.23±2.78 and the total IQ was 94.61±0.93. The results of IQ tests showed a normal range average in children's IQ (the average ranges were 90-109). From the previous results, it's childhood, while a healthy diet, associated with high intakes of nutrient-rich foods described normal to the children in the study to have a good IQ result**. Northstone et al., 2012** demonstrated that unhealthy or inadequate diet associated with high fat, sugar, and processed food content in early childhood may be associated with small reductions in IQ in later at about the time of IQ assessment may be associated with small increases in IQ**.**

Table (6): IQ Scale among Preschool Children

Parameter	Boys	Girls	Total
Verbal IQ	103.74±1.68	102.75±1.69	103.23±1.18
Performance IQ	76.21±4.28	76.25±3.68	76.23±2.78
Total IQ	95.47±1.52	93.8±1.14	94.61±0.93

Conclusion:

Big attention to proper nutrition for children has become of great interest to the Egyptian government. From the previous data, it was noted that the nutritional status in childhood and the cognitive performance of pre-school children in the present study needs further follow-up and data to know the level of the expected impact on the health and cognitive status for preschool children.

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