The Egyptian Journal of Hospital Medicine (October 2019) Vol. 77 (5), Page 5742-5751

Cognitive Functions in Breastfed versus Artificially Fed in Preschool Children

Sara Hamed Ibrahim[1], Somaya Mohamed Abd El –Ghany[1], Tagreed Mohamed El Shafie[2] , Marwa El Hady[1]

Pediatrics[1] and Psychiatry[2] Departments, Faculty of Medicine for girls - Al–Azhar University

ABSTRACT

Background: Breastfeeding has been widely researched and reviewed in relation to cognitive performance in children, but early reviews have not provided compelling evidence linking breastfeeding to cognitive development

Objective: To assess the effect of breastfeeding duration and exclusivity on the cognitive development of a group of preschool Egyptian children.

Methods: The current study was a cross sectional comparative study that included 90 apparently healthy preschool Egyptian children aged 3 - <6 years who were classified into three equal groups according to their type of feeding in early infancy. Assessment of neurocognitive function and IQ was done using the following 3 tests: Stanford-Binet test 5th edition Arabic version (2003), Kaufman Assessment Battery for Children (2004), Illinois Test of Psycholinguistic Abilities (ITPA) (2001).

Results: There was significant increase in IQ detected by kauffaman test in breastfed group than either mixed or artificially fed, while no significant difference was found in IQ between mixed and artificial fed groups. There was significant increase in psycholinguistic age in breastfed group in comparison to artificially fed groups, while no significant difference was found between breastfed and mixed fed or mixed fed and artificially fed groups. Children who were breastfed had better scores in Total IQ than either artificially or mixed fed. Also, there was significant increase in total IQ scores in mixed than artificially fed groups. A significant positive relation was found between the total duration of breastfeeding and Binet total IQ score.

Conclusion: The effect of breastfeeding is dose-dependent, the longer the duration of breastfeeding, the more is the benefit, the strongest effect for cognitive function in breastfed children was more prominent in psycholinguistic age.

Keywords: Breastfed; Artificially fed, Egyptian Children.

INTRODUCTION

Cognitive development in childhood is vital for an individual's capacity to learn and take advantage of the opportunities available within a particular environment **(1).**

Individuals scoring higher on intelligence tests in early childhood are usually more successful in professional careers and achieve a higher level of education and better socioeconomic status, which may in turn positively affect their health status **(2).** Breastfeeding is recognized as the best source of nutrition for all infants, and the World Health Organization (WHO) recommends exclusive breastfeeding until 6 months of age. Long-term beneficial consequences of breastfeeding for a child's mental health result from the fact that maternal milk is a rich source of fatty acids and other bioactive components essential for the brain development of infants **(3).**

Despite the long-standing history of research concerning breastfeeding and cognitive ability, few well-controlled studies have examined the potential benefits of breastfeeding on specific cognitive processes **(4).**

Failure to account for partial versus exclusive breastfeeding or breastfeeding duration could lead to underestimation of the true effect of breastfeeding on child intelligence. Detailed data regarding breastfeeding exposure and adequate control for confounding factors are necessary for valid estimates of the relationship between breastfeeding and later intelligence **(5).**

AIM OF THE WORK

To assess the effect of breastfeeding duration and exclusivity on the cognitive development of a group of preschool Egyptian children.

SUBJECT AND METHODS

This cross sectional comparative study was carried out on 90 apparently healthy preschool children aged 3-<6 years who were classified into three equal groups according to their type of feeding in early infancy: **Group I:** included 30 children who were exclusively breast fed 4-6 months and continued breastfeeding with complementary feeding up to at least 18 months, **Group II:** included 30 children who were artificially fed and **Group III**: included 30 children who were mixed fed.

Cases were randomly selected from medium social class preschool nurseries from March 2015 to June 2017. All mothers enrolled in

Received:16/08/2019
Accepted:16/09/2019

the study were employed and had the same level of education.

Inclusion criteria

Apparently healthy children of either sex aged 3-<6 years, who were either exclusively breastfed (at least 4 months) or artificially fed or mixed fed.

Exclusion criteria

Factors that can affect cognitive function other than type of feeding including:

- Preterm babies < 37 week gestation.
- Presences of any chronic medical illness (cardiac, respiratory, GIT, hematological, renal, neurological, psychological, etc. ….).
- Illiterate or divorced mother.
- Children with neurodevelopmental disabilities
- Children with genetic, chromosomal abnormalities or congenital malformations
- History of maternal drug abuse
- Family disturbance
- Behavioral abnormalities.

Ethical consideration:

An informed consent was obtained from each child caregivers before enrollment in the study and confidentially of all data were ensured. **The study was approved by ethical committee of Faculty of medicine for Girls Al-Azhar University.**

All groups were subjected to complete history taking according to a predesigned questionnaire with stress on feeding type, thorough clinical examination to exclude any chronic illness or neurodevelopmental disabilities that can affect cognitive function as well as assessment of neurocognitive function and IQ using the following 3 tests: Stanford-Binet test 5th edition Arabic version (2003), Kaufman Assessment Battery for Children (2004), Illinois Test of Psycholinguistic Abilities (ITPA) (2001).

Statistical analysis

Data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 20 and the following were done:

Qualitative data were presented as number and percentage while quantitative data were presented as mean, standard deviation and ranges.

The student's t-test was used to compare the mean of two groups of quantitative data. The comparison between two groups with qualitative data were done by using **Chi-square test** and/or **Fisher exact** test was used instead of chi-square test when the expected count in any cell was found less than 5.

The comparison between more than two groups with parametric distribution were done by using **One way Analysis of Variance (ANOVA).**

Pearson correlation coefficients were used to assess the relation between studied parameters in the same group.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered ± significant as the following:

- P>0.05: Non-significant.
- P<0.05: Significant.

RESULTS

Table (1): Comparison between the three studied groups regarding sex.

Sex	Groups								Chi-Square	
	BF(n=30)		MF(n=30)		AF(n=30)		Total			
	N	%	N	%	N	%	N	%	X^2	P-value
Males	12	40.00	18	60.00	18	60.00	48	53.33	3.214	0.200
Females	18	60.00	12	40.00	12	40.00	42	46.67		
Total	30	100.00	30	100.00	30	100.00	90	100.00		

No statistically significant difference was found between the three studied groups regarding sex.

Table (2): Comparison between the three studied groups regarding age

Age(Years)	Groups			ANOVA	
	BF (n=30)	MF (n=30)	AF (n=30)	F	P-value
Range	3.2 - 5.9	3.1 - 5.9	3.2 - 5.9	1.514	0.226
Mean ±SD	4.527 ± 0.853	4.740 ± 0.951	4.330 ± 0.931		

No statistically significant difference was found between the three studied groups regarding age

Table (3): Comparison between the three studied groups regarding IQ detected by Kauffman Test:

Kauffman Test	Groups			ANOVA		TUKEY'S Test		
	BF(n=30)	MF(n=30)	AF(n=30)	F	P-value	B&M	B&A	M&A
Range	65.2 - 230	59 - 144.5	17 - 130	12.460	<0.001*	0.011*	<0.001*	0.119
Mean ±SD	117.280 ± 44.313	92.407 ± 20.118	75.620 ± 28.371					

There was significant increase in IQ detected by kauffaman test in breastfed group than either mixed or artificially fed, while no significant difference was found in IQ between mixed and artificial fed groups.

Table (4): Comparison between the three studied groups regarding phsycolungistic age detected by IllinoisTest:

Illinois Test	Groups			ANOVA		TUKEY'S Test		
	BF(n=30)	MF(n=30)	AF(n=30)	F	P-value	B&M	B&A	M&A
Range	3 - 5.7	2.1 - 5.6	2.1 - 5.4	3.665	0.030*	0.275	0.023*	0.484
Mean ±SD	4.327 ± 0.876	3.968 ± 0.934	3.700 ± 0.890					

There was significant increase in phsycolungistic age in breastfed group in comparison to artificially fed groups, while no significant difference was found between breastfed and mixed fed or mixed fed and artificially fed groups.

Table (5): Comparison between the three studied groups regarding Binet Fluid resoning(FR)

Binet FR Score	Groups			ANOVA		TUKEY'S Test		
	BF(n=30)	MF(n=30)	AF(n=30)	F	P-value	B&M	B&A	M&A
Range	81 - 140	87 - 135	73 - 135	11.624	<0.001*	0.458	<0.001*	0.003*
Mean ±SD	119.833 ± 15.868	114.333 ± 16.595	98.500 ± 20.557					
Binet VSscore								
Range	105 - 137	87 - 132	82 - 118	38.401	<0.001*	<0.001*	<0.001*	0.012*
Mean ±SD	120.500 ± 9.291	105.633 ± 11.663	98.000 ± 9.191					
Binet WMscore								
Range	100 - 137	76 - 121	66 - 110	61.892	<0.001*	<0.001*	<0.001*	0.004*
Mean ±SD	119.067 ± 9.370	97.900 ± 11.484	88.767 ± 11.473					
Binet KN score								
Range	86 - 135	10 - 124	65 - 110	9.774	<0.001*	0.004*	<0.001*	0.615
Mean ±SD	108.300 ± 9.696	93.967 ± 24.670	89.833 ± 12.739					
Binet QR								
Range	97 - 121	10 - 116	74 - 116	22.733	<0.001*	<0.001*	<0.001*	0.305
Mean ±SD	112.800 ± 6.094	96.167 ± 18.061	91.200 ± 11.972					
Binet NV								
Range	95 - 136	80 - 119	77 - 117	35.209	<0.001*	<0.001*	<0.001*	0.002*
Mean ±SD	118.933 ± 10.007	105.900 ± 8.628	96.500 ± 12.241					
Binet V								
Range	101 - 128	84 - 115	67 - 114	43.835	<0.001*	<0.001*	<0.001*	<0.001*
Mean ±SD	113.967 ± 6.896	101.533 ± 8.390	89.433 ± 13.821					
BinetTotal IQ								
Range	106 - 144	91 - 117	7 - 116	33.203	<0.001*	<0.001*	<0.001*	<0.001*
Mean ±SD	117.700 ± 8.154	103.900 ± 6.895	90.200 ± 19.961					

Children who were artificially fed had lower scores in Fluid resoning (FR) than either breastfed or mixed fed, while no significant difference was found between breastfed and mixed fed groups regarding the same test.

Children who were breastfed had better scores in Visual Spatial (VS) than either artificially or mixed fed. Also there was significant increase in VS scores in mixed than artificially fed group.

Children who were breastfed had better scores in working memory (WM) test than either artificially or mixed fed. Also, there was significant increase in WM scores in mixed than artificially fed groups.

Children who were breastfed had better scores in Knowledge (KN) than either artificially or mixed fed, while there was no significant difference between mixed and artificially fed groups in KN scores.

Children who were breastfed had better scores in Quantitative Reasoning (QR) than either artificially or mixed fed, while there was no significant difference between mixed and artificially fed groups in QR scores.

Children who were breastfed had better scores in Binet Non Verbal (NV) than either artificially or mixed fed. Also, there was significant increase in NV scores in mixed than artificially fed groups.

Children who were breastfed had better scores in Binet Verbal than either artificially or mixed fed. Also, there was significant increase in Verbal scores in mixed than artificially fed groups.

Children who were breastfed had better scores in Total IQ than either artificially or mixed fed. Also, there was significant increase in total IQ scores in mixed than artificially fed groups.

Table (6): Correlation between the IQ tests (Binet- Kauffman-Illinois) and other studied parameters of the breastfed group

BF	Binet Total IQ		Kauffman		Illinois	
	r	P-value	r	P-value	r	P-value
Duration of Exclusive breast feeding	0.158	0.405	-0.31	0.096	-0.15	0.417
Duration of breast feeding	0.523	0.003*	-0.015	0.936	0.126	0.507
Age	0.468	0.009*	0.348	0.060	0.668	<0.001*
Weight	0.384	0.036*	0.565	0.001*	0.852	<0.001*
Height	0.246	0.189	0.621	<0.001*	0.891	<0.001*
HC	0.240	0.201	0.404	0.027*	0.579	0.001*
Maternal age	0.100	0.601	0.141	0.456	0.090	0.637
Age at Introduction of solid food	-0.49	0.005*	-0.10	0.586	0.084	0.658

Regarding Binet test, there was significant positive correlation between total IQ score and each of total duration of breast feeding, age, weight, and a significant negative correlation with age of introduction of solid food. Regarding Kauffman test, there was significant positive correlation between IQ and anthropometric parameters (weight, height and HC). Regarding Illinois test, there was significant positive correlation between the psycholinguistic age and each of age and anthropometric parameters (weight, height and HC).

Table (7): Correlation between the IQ tests (Binet- Kauffman- Illinois) and the studied parameters of the mixed fed group

MF	Binet Total IQ		Kauffman IQ		Illinois IQ	
	r	P-value	r	P-value	r	P-value
Duration of breast feeding	0.240	0.202	0.015	0.937	0.107	0.573
Age	0.294	0.114	0.452	0.012*	0.806	<0.001*
Weight	0.240	0.201	0.460	0.011*	0.757	<0.001*
Height	0.253	0.177	0.452	0.012*	0.791	<0.001*
HC	0.079	0.678	0.317	0.088	0.368	0.045*
Maternal age	0.414	0.023*	0.010	0.959	-0.026	0.890
Introduction of solid food	-0.02	0.903	-0.038	0.843	-0.318	0.087

Regarding Binet test, there was significant positive correlation between total IQ scores and the maternal age. Regarding Kauffman test score, there was significant positive correlation between IQ and each of age, weight and height. Regarding Illinois test, there was significant positive correlation between psycholinguistic age parameters and each of age and anthropometric parameters (weight, height and HC).

Table (8): Correlation between the IQ tests (Binet- Kauffman- Illinois) and the studied parameters of the artificially fed group

AF	Binet Total IQ		Kauffman		Illinois	
	r	P-value	r	P-value	r	P-value
Age	-0.032	0.866	0.304	0.103	0.841	<0.001*
Weight	0.096	0.615	0.377	0.040*	0.816	<0.001*
Height	0.086	0.652	0.353	0.056	0.891	<0.001*
HC	0.108	0.571	-0.092	0.631	0.522	0.003*
Maternal age	0.291	0.119	0.197	0.296	0.637	<0.001*
Introduction of solid food	0.002	0.990	-0.147	0.439	0.242	0.197

Regarding Binet total IQ test, no significant correlation was found with any of the studied parameters. Regarding Kauffman test score, there was significant positive correlation between IQ and the weight.

Regarding Illinois test score, there was significant positive correlation between the psycholinguistic age and each of weight, height, HC and maternal age.

Table (9): Correlation between the IQ tests (Binet- Kauffman- Illinois) and duration of breastfeeding in breast fed versus themixed fed group

BF and MF	Binet Total IQ		Kauffman	
	r	P-value	r	P-value
Exclusive breastfeeding duration	0.158	0.405	0.310	0.096
Duration of breastfeeding	0.329	0.010*	0.260	0.045*

A significant positive correlation was found between the IQ and duration of breastfeeding in both Binet and Kauffman tests.

Table (10): Relation between exclusive breastfeeding duration and IQ test scores

		Exclusive breastfeeding duration			ANOVA	
		4 Months	5 Months	6 Months	F	P-value
Binet Total IQ %	**Range**	107 - 128	108 - 129	106 - 144	0.615	0.548
	Mean ±SD	115.125 ± 7.772	117.909 ± 7.077	119.364 ± 9.595		
Koffman	**Range**	65.2 - 230	73 - 156.9	90 - 230	1.644	0.212
	Mean ±SD	99.788 ± 55.695	112.273 ± 27.989	135.009 ± 46.063		
Illinos	**Range**	3 - 5.3	3.4 - 5.7	3.1 - 5.4	0.375	0.691
	Mean ±SD	4.173 ± 0.920	4.300 ± 0.955	4.501 ± 0.824		

Although non-significant, there was a positive relation between exclusive breastfeeding duration and IQ scores.

Table (11): The Relation between total breastfeeding duration and Binet total IQ scores

IQ Tests		Total Duration of breast feeding		T-Test	
		12-18 Months	19-24 Months	t	P-value
BinetTotal IQ	**Range**	106 - 122	108 - 144	2.298	0.029*
	Mean ±SD	114.286 ± 4.906	120.688 ± 9.343		

A significant positive relation was found between the total duration of breastfeeding and Binet total IQ score.

DISCUSSION

Nutrition plays an important role in the neurodevelopment of children. Infancy and early childhood are periods of additive neural development (increasing cells, neurons, synapses, etc.) especially rapid physical and mental development. Poor nutrition during early life can have considerable and long- lasting consequences on neurodevelopmentand cognitive functions [(6)].

Pollitt *et al.* [(7)] hypothesized that cognitive development is influenced by nutritional status, physical growth, motor development and activity, as well as interactions among them, and between children and their social and physical environments.

Breastfeeding has been widely researched and reviewed in relation to cognitive performance in children. **Nyaradi *et al.*** [(8)] reported a consistent positive association between breastfeeding duration and IQ with a difference between breastfed and non breastfed children.

When we investigated the influence of type of feeding on neurocognitive functions and IQ in our three studied groups there was significant increase in IQ detected by kauffaman test in breastfed group than either mixed or artificially fed one, while no significant difference was found in IQ between mixed and artificial fed groups.

This was supported by **Melanie *et al.*** [(9)] who assessed the influence of breastfeeding on the cognitive outcome and reported significant differences in test scores between breastfed children and those who did not receive any breast milk feedings with3.6 IQ higherpoints for overall intellectual functioning and 2.3 IQ points for verbal ability.

Regarding Illinois test, the present study showed significant increase in psycholinguistic age in breastfed group in comparison to artificially fed

groups, while no significant difference was found between breastfed and mixed fed or mixed fed and artificially fed groups.

Similarly, **Belfort *et al.*** [10] examined the relationship of breastfeeding duration and exclusivity with child cognitive function, and stated that longer breastfeeding duration was associated with higher age scores and greater age intelligence**.**

The age of attaining specific milestones reflect the intellectual potential and is incorporated in Binet's early test of child intelligence [11]**.**

Binet test asses the executive function which includes fluid reasoning (FR), visual spatial (VS) and learning abilities that consists of (knowledge (KN), quantitative reasoning (QR) and working memory (WM).

A striking aspect of Binet's tests was the role of verbal tests even at the youngest ages (3 years), and the comparison of mental and chronological ages implies that Binet's measure of intelligence reflect the speed of cognitive development to a large extent [12, 13, 14]**.**

Results of Binet test in our study revealedthatchildren whoreceived artificial feeding had lower scores in fluid reasoning (FR) than either breastfed or mixed fed but no significantdifferencewas found between breastfed and mixed fed regarding the same test. Also, children who were breastfed had better scores in Visual Spatial (VS) than either artificially or mixed fed, and those who were mixed fed had higher visualspatial (VS) scores than artificially fed group.

In agreement with the present study, **Rantalainen *et al.*** [15] who examined the association between breastfeeding and its duration in infancy on cognitive ability in young adulthood reported that breastfedgroup had higher cognitive ability especially in visuospatial subtest and its longer duration predicted higher total cognitive ability and visuospatial subtest scores.

As regard Binet working memory (WM) test, the present study revealed thatchildren who were breastfed reportedbetter scores than eitherartificially or mixed fed. Also, there was significant increase in working memory (WM) scores in mixed than artificially fed groups.

This was supported by **Cai *et al.*** [4] who assessed the association between early infant feeding and detailed measures of cognitive development in the first 2 years of life and found that the memory domain is better mainly in breastfed group than those in artificially fed group. Additionally mixed fed have better results than artificially fed.

In the present study, we assessed learning abilities of the studied children by applying Binet Knowledge (KN) and Quantative resonaing (QR) tests which represent the mathematics ability of these children. Their results revealed that children who were breastfed had better scores in Knowledge (KN) and Quantative resonaing (QR) than either artificially or mixed fed, while no significant difference was found betweenmixed fed or artificially fed in Knowledge (KN) and Quantative resonaing (QR) scores.

In the study of **Cesur *et al.*** [16] which was the first study to examine the effect of breastfeeding in infancy on young adult earning abilities, they reported that siblings who were breastfed have higher academic test scores.

Relatedly, **Belfield and Kelly** [5] who estimated the effect of breastfeeding on the child cognitive development, found that breastfeeding-induced cognitive benefits may increase academic achievement and educational attainment.

Regarding non- verbal intelligence of our studied children we found that children who were breastfed had better scores in Binet Non Verbal (NV) than either artificiallyor mixed fed. Also, there was significant increase in NV scores in mixed than artificially fed groups.

These results were supported by **Nyaradi *et al.*** [8] who examined the association of breastfeeding duration with non-verbal intelligence in children of age 6 years. They observed a significant positive association between breastfeeding duration and child IQ conferring an advantage of 0.32 (0.20 to 0.44) points for each additional month of breastfeeding.

As regard Binet Verbal scores in our study, children who were breastfed had better scores in Binet Verbal than either artificially or mixed fed. Also, there was significant increase in Verbal scores in mixed than artificially fed groups.

This was supported by **Girard *et al.*** [17] who investigated the potential impacts of breastfeeding on preschool children's cognitive ability andexpressive vocabulary. They found significant advantages for children who were breastfed who recorded higher intelligence scores compared with controls at age 6 years. The strongest effects were for verbal intelligence. This study offers the best support to date for a causal link between breastfeeding and cognitive development.

In the present study we assessed the total IQ scores by applying Binet total IQ test. Children who were breastfed had better scores in total IQ than either artificially or mixed fed. Also, there was significant increase in total IQ scores in mixed than artificially fed groups.

Kim *et al.* [18] examined the association between breastfeeding and learning abilities in preschool children and reported that breastfed children had an adjusted cognitive advantage of 3.15 IQ points compared to formula-fed children. This positive effect of breastfeeding on IQ was also observed in a randomized trial by **Kramer *et al.* [19]** which assessed whether prolonged and exclusive breastfeeding improves children's cognitive ability.They reported an average 7.5 IQ points increase in children who were allocated to breastfeeding promotion groups**.**

Regarding the correlation between the IQ tests (Binet- Kauffman-Illinois) and other studied parameters of the breastfed group the current study demonstrated significant positive correlation between Binet total IQ score and each oftotal duration of breast feeding, age, weight, and a significant negative correlation with age of introduction of solid food. RegardingKauffman test, there was significant positive correlation between IQ andanthropometric parameters (weight, height and HC), whileIllinois test demonstrated significant positive correlation betweenthe psycholinguistic age andeach of age and anthropometric parameters (weight, height and HC).

In mixed fed group, there was significant positive correlation between Binet total IQ scores and maternal age. This reflects the effect of increase ofthe maternal experiencewith age on the cognition.

Also, there was significant positive correlation betweenKauffman IQ score and each ofage, weight and heightof mixed fed children. While Illinois test showed significant positive correlation betweenpsycholinguistic age parameters and each of age and anthropometric parameters (weight, height and HC).

Regarding the correlation between the IQ tests (Binet- Kauffman- Illinois) and the studied parameters of the artificiallyfed group, while no significant correlation was found between Binet total IQ score and any of studied parameters, there was significant positive correlationbetween IQ andweight as regard Kauffman test score. RegardingIllinoistest score, there wassignificant positive correlation betweenthe psycholinguistic ageand each of weight, height, HC and maternal age.

In the present study, we evaluated the impact of the duration ofbreastfeeding on the IQ test scores in both breastfed and mixed fed group and foundpositivecorrelation between the IQ scores and the duration of breastfeeding in both Binet, Kauffman tests.

Moreover, we investigated relation between exclusive breastfeeding duration and IQ test scoresand found positive relation between the duration of exclusive breastfeeding and IQ scores although non-significant.

Also, we studiedthe relation between the totalbreastfeeding duration in general and Binet total IQ scores. A significant positive relation was found between them.

Similar results have been obtained by many researchers who evaluated the relationship between duration of breastfeeding and both the neurocognitivefunctions and IQ.

Oddy *et al.* [20] who assessed the effect of breastfeeding duration and academic achievement found that longer breastfeeding duration was significantly associated with better academic performance

Maria *et al.* [21]found the association between the duration of any breastfeeding and exclusive breastfeeding on cognitive development at age 5 years in UK, where they observed an association between prolonged breastfeeding and higher cognitive development scores, particularly in children who were born preterm. These improvements were apparent at a breastfeeding duration of 4 to 6 months in term children and a duration of 2 months in preterm children, in whom the rates of exclusive breastfeeding were relatively low.

Belfort *et al.* [10] found that a longer duration and greater exclusivity of breastfeeding were associated with better receptive language at age 3 and verbal and non-verbal IQ at age 7.

Brahma *et al.* 22 (2017) found a dose-response relationship between duration of BF and all measurements of intelligence quotient (IQ).

Similarly, **Furman 23 (2017**) demonstrated that the effect of breast milk is dose-dependent, with exclusivity and longer duration increasing benefits**.**

Also, **Rantalainen *et al.* [15]** foundthat neurodevelopmental advantages of breastfeeding and its longer duration persist into old age, and longer duration of breastfeeding may benefit aging-related change, particularly in verbal reasoning ability.

In conclusion, our data demonstrated that breastfeeding is associated withbetter cognitive function with main impact on the non verbalIQ domain. Thisobserved finding may be related to the following possible explanations: The first mechanism has been thought to be related to the prescence of high levels of long chain polyunsaturated fatty acids, including docosahexaenoic acid (DHA)and arachidonic acid (AA), which are not onlyneuronal structural

elements but also essential for brain maturation. DHA and AA comprise approximately 20% of the fatty acid content of the brain and are involved in early neurodevelopment, promoting neuronal growth, repair and myelination [(24)].

A second explanation for the better cognitive function in childrenwho were breastfed in infancy is that infants exhibit different gutmicrobial profiles than thatof formula fed ones a factorwhich is also related to brain development and functions.

The third explanation is related to the high sialic acid content of breast milkin comparisonto itslow content of in formula milk. Sialic acid (Sia), a family of 9-carbon sugar acids, occurs in large amounts in human milk oligosaccharides and is an essential component of brain gangliosides and sialylated glycoproteins, particularly as precursors for the synthesis of the polysialic acid (polySia) glycan that post-translationally modify the cell membrane-associated neural cell adhesion molecules (NCAM). Polysialylated NCAM and neural gangliosides both play critical roles in mediating cell-to-cell interactions important for neuronal outgrowth, synaptic connectivity, and memory formation.Thisearly stageof neurodevelopment in infants are crucial for establishing neural structures and synaptic connections that influence brain structure and cognitive functions well into adulthood.

CONCLUSION

From the current study we concluded that breastfeeding is significantly associated with higher cognitive functions in preschool children. The strongest effect for cognitive function in breastfed children was more prominent in psycholinguistic age. The effect of breastfeeding is dose-dependent, the longer the duration of breastfeeding, the more is the benefit.

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