Neurophysiological Development of The Brain in Young Children with Natural and Artificial Feeding

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Abstract

This article discusses the neurophysiological development of the brain in infants who received different types of feeding (breast milk and infant formula). The psychosomatic status, in the form of sleep-wake rhythms, was assessed using electroencephalography, and the average duration of sleep during the day, as well as the progress of both nighttime and daytime sleep according to the norms of age groups, and the number of daytime and nighttime awakenings, was evaluated. The following differences were found between the groups: in groups 1 and 3, the average duration of a sleep episode was 3-4 hours. Whereas infants and group 2 had an average daytime sleep episode duration of 1.5-2 h. The results obtained were significant (p≤0.05).

Keywords: Sleep, electroencephalography, natural and artificial feeding.

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1. Introduction

The diet of infants and young children is a fundamental factor determining their subsequent health and lifespan. Of particular importance in this context are nutrients, which have been shown to promote intellectual development and positively impact behavior [7]. Changes in a child's intestinal microflora occur under the influence of the external environment, primarily due to their diet. This emphasizes the importance of paying attention to the mother's intestinal microflora and its impact on the child, as it serves as the primary source for the formation of their own microflora [5,6]. Numerous studies have now established the structural and functional impairments of organs and systems that arise from an irrational, unbalanced diet. These impairments gradually disrupt adaptation mechanisms, regulate homeostasis, and, as a consequence, disrupt the structure and function of many internal organs. Parameters such as the quality and quantity of food consumed have evolved through the process of determining the processes of restructuring and maintaining a constant composition at all levels of the body's organization. At birth, the deep structures of the infant's brain are already well developed, and the areas responsible for information perception are almost fully mature. This means that the development of cognitive abilities and the nervous system are closely linked. A stable and harmoniously functioning nervous system lays the foundation for the full development of higher mental functions in a child [1]. Understanding the EEG is fundamental: it serves not only as a diagnostic tool but also as an indicator of the neurophysiological maturity of the central nervous system, as L.R. Zenkov emphasizes. The dynamics of brain activity formation during individual development are closely linked to genotype, and with maturation, the EEG reflects an increasingly complex and diverse array of organizational forms. Numerous scientific studies have revealed that the structure of the cerebral cortex has unique, age-specific characteristics [2,3,4,5].Цель исследования.

To establish a dynamic relationship between the formation of a harmonious psychosomatic status in the form of sleep-wakefulness and normal intestinal microflora in young children with natural and artificial feeding.

2. Methods

The clinical study was conducted at a family clinic in the Almazar district. A total of 122 infants (62 boys and 60 girls) were observed for one year. They received various feeding methods (breast milk and infant formula).

Group 1 (n=22) included breastfed infants; Group 2 (n=50) were fed milk-based formula without probiotics (the first experimental group); Group 3 (n=50) included infants receiving infant formula with probiotics (the second experimental group) (see Figure 1).

Psychosomatic status, expressed as sleep-wake rhythms, was assessed using EEG, along with average daily sleep duration, sleep progression at both night and day according to age group norms, and the number of daytime and nighttime awakenings.

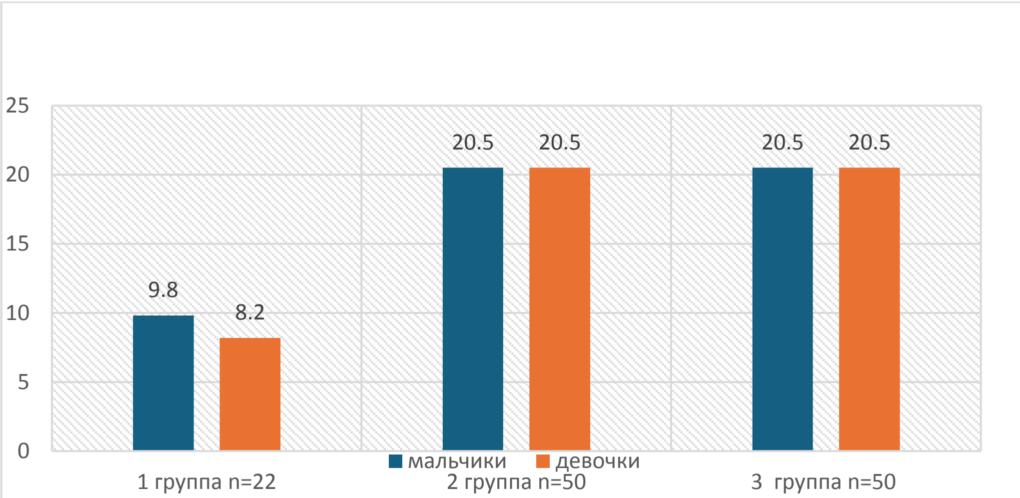

Figure 1. Distribution of examined children by age.

The probiotic used was IRID B, a pre-sorbed probiotic containing bifidobacteria of the class Bifidumbacterium longum 17x and Propionibacterium avidum I. Each sachet weighs 700 mg. A single dose contains at least 109 live bifidobacteria and 107 propionic acid bacteria.

3. Results

Our study showed that in all three groups, EEG parameters in newborn infants at one month of age were within the age norm (Table 1), with statistically significant data ($p \leq 0.01$).

In our study, an electroencephalographic sleep study was conducted in infants at one month of age. The EEG was recorded during daytime nap monitoring. Daytime nap recording duration varied from one to two hours. To assess overall sleep EEG and to make prognostic predictions from one to 12 months of age, we used the typological classification of EEG types.

EEG parameters and their prognostic value were assessed by calculating the duration and cyclicity of sleep phases. Recordings were conducted at one month of age, with repeat EEG examinations conducted at six and 12 months of age.

Table 1.

Distribution of alpha index values by age of the entire group.

Age	Group 1		Group 2			Group 3			
	M	m	M	m	P	M	m	P	P1

1 month	4,95±0,22	4,70±0,14	>0,05	3,99±0,10	<0,001	<0,001
6month	15,86±0,63	8,31±0,25	<0,001	16,01±0,44	>0,05	<0,001
P2	<0,001	<0,001		<0,001		
12 month	24,25±1,18	15,19±0,49	0,00	24,95±0,61	>0,05	<0,001
P2	<0,001	<0,001		<0,001		

Note: P - reliability of differences in relation to group 1; P1 - in relation to group 2; P2 - in relation to the previous research period.

Our observations showed that newborns show a tendency toward an increasing alpha wave index from the first month of life. When comparing alpha index values in children at 6 months, we found that during this period, the alpha wave index in children in the second group was significantly lower (p≤0.05). Compared to children in the first and third groups, the alpha index at this age was statistically significantly higher (p≤0.005), reaching 15.3±1.5% in the second group. Furthermore, in the 6- to 12-month age group, children in the third group showed differences, with an alpha wave index increase of 1.5-2 times. Thus, in the first group, the average value was 24.2±1%, while in the third group, it was 15%.

Theta and delta index values vary with age. It has been found that for people, as they grow older, the delta index normally has a gradual decrease (see Table 4.2), for example, at the age of 1 month it is equal to 70+2.1%, then by 6-7 months its values are equal to 50.8±1.5%.

Table 2

Distribution of the delta index value by age group.

Age	Group 1		Group 2			Group 3			
	M	m	M	m	P	M	m	P	P1
1 month	79,80±3,16		80,02±2,46		>0,05	78,98±2,32		>0,05	>0,05
6month	64,88±2,73		71,33±1,70		>0,05	66,01±2,21		>0,05	>0,05
P2	<0,001		<0,01			<0,001			
12 month	23,17±0,96		38,22±1,03		<0,001	22,83±0,65		>0,05	<0,001
P2	<0,001		<0,001			<0,001			

Note: P - reliability of differences in relation to group 1; P1 - in relation to group 2; P2 - in relation to the previous period of the study

According to the reliability values (p<0.001) in the compared groups, some age groups with the required value of change in the delta index can be distinguished: 1 month - 79.8%, 80.02%, 78.98% (>0.05); at 6 months - 64.8%, 71.3%, 66.01% (>0.05); and at 12 months - 23.17%, 38.22%, 22.83% the degree of variation indicators are reliable (p<0.05). In children in all three groups, a decrease in the delta index indicators with age is noted on the EEG (see Table 2).

Table 3

Distribution of theta index values by age of the entire group.

Age	Group 1		Group 2			Group 3			
	M	m	M	m	P	M	m	P	P1
1 month	15,26±0,69		15,45±0,41		>0,05	16,98±0,48		<0,05	<0,05
6 month	19,23±0,73		20,40±0,50		>0,05	17,95±0,41		>0,05	<0,001
P2	<0,001		<0,01			>0,05			
12 month	52,55±2,11		46,61±1,53		<0,05	52,15±1,24		>0,05	<0,01
P2	<0,001		<0,001			<0,001			

Note: P - reliability of differences in relation to group 1; P1 - in relation to group 2; P2 - in relation to the previous period of the stud

Theta rhythm amplitude values in subjects in Groups 1 and 3 also show a decrease in progression with age. The average theta rhythm amplitude in the first month of life is 130.3 ± 1.2 μV, while at 7-12 months it is 93.2 ± 1.2 μV. This may develop due to the dominance of the alpha rhythm in parallel to the theta rhythm, as in the first months of life, and a decrease in the theta rhythm after an increase in the alpha rhythm. According to our data, delta wave amplitude in Groups 1 and 3 decreased on average by 66.7 ± 2.1 to 54.4 ± 4.1 μV by 6-7 months, and in Group 2, by 80.3 ± 2.9 to 75 ± 3.1 μV.

Daytime sleep duration also did not differ between groups at 1 month of life. A study was conducted to determine the dynamics of daytime sleep duration. The results are presented in Table 4.

Table 4.

Daytime nap duration

Age (months)	Total duration of daytime sleep (hours)		Duration of daytime sleep in children of group 1 (average)		Duration of daytime sleep in children of group 2 (average)			Group 1	Group 2
	M	m	M	m	M	m	P	P2	
1 month	5,00±0,13		5,22±0,19		4,99±0,13		>0,05	P>0,05	P>0,05
6 month	3,50±0,06		3,70±0,17		3,41±0,10		>0,05	P>0,05	P>0,05
12 month	2,21±0,05		2,21±0,09		2,51±0,08		<0,05	P>0,05	P<0,01

Note: P - reliability of differences in relation to group 1; P1 - in relation to group 2; P2 - reliability of differences in relation to the norm

Daytime sleep progression is proportional to nighttime sleep (Table 4.6). Across all study groups, the greatest amount of daytime sleep was recorded between 0 and 3 months of age, with an average of 3-4 daytime sleep episodes.

The following differences were found between groups: in Groups 1 and 3, the average duration of a sleep episode was 3-4 hours. In contrast, in infants and Group 2, the average duration of a daytime sleep episode was 1.5-2 hours. The results were significant ($p \leq 0.05$).

4. Conclusion

Thus, a comparison of electroencephalographic sleep parameters, in particular sleep cycle formation and phase duration, revealed that in Group 1 and, especially, Group 3, children receiving infant formula with probiotics had significantly ($p \leq 0.05$) more organized sleep cycles compared to Group 2.

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