ORIGINAL ARTICLE

The role of multisensory intervention combined with aEEG in the maturation and evaluation of brain and neural development in premature infants of different gestational ages

Huimin Li*

Department of Pediatrics, Genertec AMHT – Baogang Hospital, Baotou, Inner Mongolia, China

Received: July 12, 2024 **Accepted:** October 10, 2024 **Online Published:** October 18, 2024
DOI: 10.5430/dcc.v10n4p14 **URL:** https://doi.org/10.5430/dcc.v10n4p14

ABSTRACT

Objective: To explore the combined effects of multisensory intervention and amplitude integrated electroencephalogram monitoring on the maturation and evaluation of brain and neural development in premature infants of different gestational ages.
Methods: The controlled trial was carried out in 62 premature infants from January to February of 2023 in Genertec AMHT – Baogang Hospital. The premature infants were divided into two groups according to the gestational age: 32-33^{+6W} (Group A) and 34-36^{+6W} (Group B). By use of random number table method, each group was subdivided into the control group and the experimental group. The control group was monitored with aEEG within 1 day and the following 7 days after birth. The experimental group was monitored with aEEG within 1 day and the following 7 days after multisensory intervention (MS) to observe the change of aEEG parameters, in order to explore the effect of MS intervention on brain development maturity. The Neonatal Behavioral Neurological Assessment (NBNA) score was performed at 40 weeks of corrected gestational age in both groups.
Results: The amplitude voltage, the total aEEG score and the sleep-wake cycle score in the experimental group were higher than those in the control group ($p < .05$). The total NBNA score in the experimental group was higher than that in the control group.
Conclusions: The multi-sensory intervention is a simple and feasible method of development support nursing, it can improve the total NBNA score of premature infants, which can promote the brain development in premature infants and improve their neurodevelopmental behavior.

Key Words: Amplitude integrated EEG, Premature infants, Multi-sensory intervention, Neural development

1. INTRODUCTION

Premature birth is a major global health problem, and the social and economic burden associated with chronic sequelae of brain injury in premature infants (e.g., growth retardation, behavioural and social problems) is considerable.[1] The World Health Organization (WHO) estimates that about 15 million babies are born prematurely worldwide each year.[2]

In China, with the release of the two-child and the three-child policies, the incidence of premature babies has shown an increasing trend year by year, and the data show that[3] the birth

*Correspondence: Huimin Li; Email: 441689958@qq.com; Address: No. 20, Shaoxian Road, Kundulun District, Baotou, Inner Mongolia 014010, China.

rate of premature babies in China has risen to about 7%. With the improvement of neonatal treatment, the survival rate is increasing year by year, and the neurodevelopmental prognosis of premature infants has become the most characteristic and challenging work in the current and future neurological care in Neonatal Intensive Care Unit (NICU). The guidelines of healthcare services for premature infants[4] pointed out that the hospital should provide multiple developmental support care for premature infants in the NICU. The multisensory intervention (MS) is one of support care methods, and it is an intervention method for more than two stimuli such as tactile, auditory, visual vestibular function in premature infants. Previous studies have shown that MS intervention can reduce pain in premature infants, accelerate the progression of oral feeding and promote the neurological behavior.[5,6] However, whether the MS intervention can promote brain maturation and improve the outcome of brain development in premature infants remains to be unclear. Therefore, this study aims at the exploration of EEG characteristics in the combination of amplitude integrated EEG (amplitude integrated Electroencephalogram, aEEG) monitoring and the MS intervention, and the effects of MS intervention in the improvement of the brain maturation in the premature infants, with the aim to improve the survival quality. Now it is reported as follows.

2. Data and methods

2.1 General information

A total of 62 premature infants delivered in the Genertec AMHT – Baogang Hospital from January 2023 to February 2024 were selected as the research objects, and the premature infants were divided into two groups by gestational age: 32-33^{+6W} (Group A); 34-36^{+6W} (Group B). Each group was then subdivided into the control group and the experimental group. The approval number for this research issued by Ethics Committee is 2022MER-031.

Inclusion criteria are as follows: the gestational age was more than 32 weeks but less than 37 weeks; the vital signs were stable; the guardians had signed the informed consent forms.

Exclusion criteria are as follows: the premature infants with scalp hematoma, scalp edema, scalp damage, etc. greater than 3*3 cm; the premature infants diagnosed as neonatal asphyxia, convulsions, intracranial infection, hypoxic-ischemic encephalopathy, etc.; the premature infants who needed to be sedated and analgesic.

Exclusion criteria: the premature infants with chromosomal diseases or genetic diseases that can cause brain damage; the premature infants discharged from the hospital within 1 week; the premature infants who were unable to complete 3-4 hours of aEEG monitoring due to other reasons.

Comparison of general information

There were no significant differences in gestational age, birth mode, gender, Apgar score, birth weight, and pregnancy complications between Group A and Group B ($p > .05$). A comparison of general information is shown in Tables 1-2.

Table 1. Comparison of general information in Group A

Group	n	Gestational Age ($x \pm s$, day)	Birth Weight ($x \pm s$, kg)	Male/Female (n%)	Vaginal/cesarean section (n%)	Apgar score M (P25, P75, score)	Pregnancy complications (Y/N, n%)
Control Group	11	231±2.15	1.82±0.08	6/5 (54.55%)	5/6 (45.45%)	9 (9, 8)	9/2 (81.82%)
Experimental Group	11	231±2.30	1.85±0.10	5/6 (45.45%)	3/8 (27.27%)	8 (8, 7)	9/2 (81.82%)
χ^2/t value		-0.79	0.04	0.42	0.22	-1.32	0.36
p value		0.50	0.78	0.59	0.69	0.51	0.61

Table 2. Comparison of general information in Group B

Group	n	Gestational Age ($x \pm s$, day)	Birth Weight ($x \pm s$, kg)	Male/Female (n%)	Vaginal/cesarean section (n%)	Apgar score M (P25, P75, score)	Pregnancy complications (Y/N, n%)
Control Group	20	251±7.25	2.32±0.32	11/9 (55.00%)	12/8 (60.00%)	9 (9, 8)	9/2 (81.82%)
Experimental Group	20	252±6.48	2.28±0.23	12/8 (60.00%)	13/7 (65.00%)	10 (10, 9)	9/2 (81.82%)
χ^2/t value		-0.27	0.13	0.32	0.22	-1.25	0.30
p value		.58	.65	.53	.63	.56	.72

2.2 Research methods

The SA9800 EEG machine (Nanjing Vishee Medical Technology Co., Ltd.) was used in tis research, and aEEG monitoring was performed on Day 1 and Day 7 after enrollment. The international 10-20 lead standard system was adopted during this process, the recording time was 3-4 hours, and the interference operation was reduced during the monitoring period, and the brain development of the premature infants was qualitatively evaluated by a professionally trained pediatrician according to aEEG graphic background activity, sleep-wake cycle, and convulsive seizures,[6] premature infants were scored by use of the aEEG comprehensive scoring system, which was created by Burdjalov et al. in 2003. It can be used to respectively measure the continuity, lower boundary amplitude, bandwidth and sleep-wake cycle of aEEG background activity were assessed, and the total aEEG score was calculated in accordance with these four items, ranging from 0 to 13 points, with higher scores indicating more mature brain development.

2.3 Intervention method

2.3.1 *The control group*

The premature infants in the control group were given conventional treatment and care, with no MS intervention.

2.3.2 *The experimental group*

The experimental group was given MS intervention on the basis of the treatment in the control group, 2 times/d, 15 minutes/time, and MS intervention was performed in 30 minutes before feedings. The intervention protocol is as follows: Feeling: Rubbing, touching or massaging: Seven-step handwashing method was implemented to wash hands, applied an appropriate amount of baby skin oil with hands warm, use an appropriate force to perform 3-min oral massage and 7-min front chest-abdomen-limbs massage (the order can be adjusted) for the premature infants in the supine position, and the listening intervention was performed simultaneously. Listening: Within 24 hours after admission to the hospital, the mother's voice (or previous recording) can be recorded with a special voice recorder, or the voice was processed by the software and imported into the self-prepared voice recorder; within 15-30 min before feeding, put the recorder in the sleeping incubator 15-20 cm away from both ears of premature infants, with a volume of 45-55 dB for at least 5 min. Vision: When the premature infants were awake, the red ball, black and white card or face-to-face method can be used to attract the premature infants' gaze at a distance of about 20 cm from the eyes in the slow movement in the horizontal or anterior-and-backward directions. It was performed after the feeling intervention for 1-3 min. Vestibular function: Slowly picked up the premature infant, placed one hand on the back and buttocks, and holded the head with the other hand, and supported the lower body so that the body was in a straight line, slowly and horizontally swaying for 1-3 min.

2.4 Indicator observation

2.4.1 *Information comparation*

The gestational age, gender, birth weight, birth mode, Apgar score and pregnancy complications were compared between groups.

2.4.2 *aEEG monitoring*

The monitoring was performed 1 day before intervention and 7 days after intervention. Evaluation indicators were as follows: aEEG amplitude voltage: recording the changes in aEEG amplitude voltage during active sleep (AS) and quiet sleep (QS); aEEG score: evaluating the aEEG values from premature infants in different gestational ages, including graphic continuity (Co), sleep-wake cycle (Cy), lower boundary value (LB), bandwidth (B) and total score. The sum of the points of the four items is the Burdjalov total score.[7]

2.4.3 *Newborn behavioral neurological assessment (NBNA)*

Professor Bao Xiulan's grading method was applied,[8] the score includes 6 items of neonatal behavioral ability, 4 items of passive muscle tone, 4 items of active muscle tone, 3 items of primitive reflexes, and 3 items of general assessment. 0-2 points for each item, 0-40 points for the total table, the higher the score, the better the nerve function.

2.4.4 *Statistical methods*

SPSS 25.0 software was applied to statistical analysis, and the measurement data fitting to normal distribution was represented by $x \pm s$, with t-test applied. The measurement data not fitting to normal distribution was represented by nonparametric rank sum test. The categorical data was represented by n [%], and the chi-square test was used in the comparison of categorical data. $p < .05$ was considered as a standard to judge whether the difference was of statistical significance.

3. RESULTS

3.1 aEEG amplitude voltage

After 7 days of intervention, the amplitude voltages of QS and AS phases in the experimental group were higher than those in the control group, and the difference was statistically significant ($p < .05$). See Tables 3-4 for details.

3.2 aEEG score

According to the aEEG scoring system, after 7 days of intervention, the sleep-wake cycle score, bandwidth score and total aEEG score of the experimental group were higher than those of the control group, and the difference was statistically significant ($p < .05$). See Tables 5-6 for details.

3.3 NBNA score

After 7 days of intervention, the total NBNA score of Group A and Group B was higher than that of the control group, and the difference was statistically significant ($p < .05$). See Table 7 and Table 8 for details.

Table 3. Comparison of aEEG monitoring results from premature infants in Group A (score, $x \pm s$)

Group	n	AS lower boundary voltage				QS bandwidth			
		Before intervention	After intervention	*t* value	*p* value	Before intervention	After intervention	*t* value	*p* value
Control Group	11	7.15±0.11	12.98±1.26	-16.69	.00	4.83±0.12	16.57±0.21	-94.53	.00
Experimental Group	11	7.52±0.36	15.09±0.88	-14.95	.00	4.97±0.69	17.27±0.16	-90.86	.00
t value		-3.32	-4.17			-1.42	-3.97		
p value		.87	.57			.19	.00		

Table 4. Comparison of aEEG monitoring results from premature infants in Group B (score, $x \pm s$)

Group	n	AS lower boundary voltage				QS bandwidth			
		Before intervention	After intervention	*t* value	*p* value	Before intervention	After intervention	*t* value	*p* value
Control Group	20	8.15±0.62	16.68±1.02	-12.69	.00	5.63±0.19	17.23±0.19	-92.21	.00
Experimental Group	20	8.82±0.18	16.09±0.63	-11.68	.00	6.07±0.21	18.07±0.23	-96.18	.00
t value		-4.67	-5.06			-1.98	-4.65		
p value		.73	.52			.12	.02		

Table 5. Comparison of aEEG score from premature infants in Group A (score, $x \pm s$)

Group	n	Graphic continuity	Sleep-wake cycle	Lower boundary amplitude	Bandwidth	Total score
Control Group						
Before intervention	11	0.88±0.09	2.48±0.13	1.62±0.09	2.98±0.15	7.87±0.08
After intervention	11	1.30±0.12	2.94±0.16	1.92±0.09	3.25±0.16	8.58±0.10
t value		-7.47	-8.36	-12.2	-8.49	-11.71
p value		.01	.001	0	0	.001
Experimental Group						
Before intervention	11	1.09±0.08	2.59±0.14	1.60±0.07	3.01±0.13	7.83±0.07
After intervention	11	1.45±0.10	3.47±0.11	1.90±0.08	3.32±0.12	8.73±0.10
t value		-3.96	-13.38	-11.03	-11.62	-13.68
p value		.003	.002	.002	0	.001
*t*1 value		-4.32	-2.16	0.46	-0.17	-0.73
*p*1 value		.05	.06	.66	.87	.48
*t*2 value		-1.58	-6.93	0.68	0.51	-1.63
*p*2 value		.07	.11	.51	.62	.13

Table 6. Comparison of aEEG score from premature infants in Group B (score, $x \pm s$)

Group	n	Graphic continuity	Sleep-wake cycle	Lower boundary amplitude	Bandwidth	Total score
Control Group						
Before intervention	20	1.38±0.25	2.95±0.22	1.93±0.15	3.06±0.19	8.71±0.11
After intervention	20	2.24±0.33	3.89±0.18	2.64±0.18	3.82±0.25	10.16±0.15
t value		-3.21	-4.62	-11.7	-7.41	-10.05
p value		0	.001	0	0	.001
Experimental Group						
Before intervention	20	1.48±0.08	2.82±0.20	1.79±0.10	3.28±0.08	8.96±0.09
After intervention	20	2.76±0.13	4.17±0.08	2.90±0.08	4.11±0.13	10.55±0.16
t value		-3.21	-10.17	-9.32	-10.05	-11.73
p value		0	.002	0	0	0
*t*1 value		-4.75	-1.97	0.52	-0.96	-1.23
*p*1 value		.07	.06	.56	.06	.33
*t*2 value		-2.31	-5.82	1.04	1.11	-0.79
*p*2 value		.06	.16	.32	.41	.11

Table 7. Comparison of NBNA score from premature infants in Group A

Group	n	NBNA			
		Before intervention	After intervention	*t* value	*p* value
Control Group	11	34.81±0.75	36.02±0.26	-10.02	.00
Experimental Group	11	35.15±0.38	38.20±0.42	-9.83	.00
t value		-1.24	-2.41		
p value		.32	.01		

Table 8. Comparison of NBNA score from premature infants in Group B

Group	n	NBNA			
		Before intervention	After intervention	*t* value	*p* value
Control Group	20	35.17±0.31	37.92±0.38	-8.05	.00
Experimental Group	20	35.95±0.66	39.02±0.12	-7.26	.00
t value		-1.86	-3.18		
p value		.27	.12		

4. DISCUSSION

Studies have shown[9] that more than half of the surviving premature infants have different severity degrees of neurodevelopmental problems, about 50% of ultra-premature infants have learning difficulties, about 17% have cerebral palsy, and about 3% have hearing impairment, especially early social and behavioral problems, such as attention, social skills, logical thinking, personality, language and other neurobehavioral problems. These problems have aroused widespread concern of pediatric medical staff and parents, so it is extremely important to evaluate the brain neurobehavioral development of premature infants.

At present, there are a variety of neurobehavioral development assessment methods commonly used in clinical practice, and aEEG is the most commonly used and convenient neurophysiological testing tool in neonatal wards, which is non-invasive, convenient, and safe, and has a high value for the evaluation of neonatal brain development. It mainly assesses brain function through indicators such as background activity, amplitude voltage, sleep-wake cycle, etc.[10] Studies[11] have shown that aEEG has become a routine monitoring method for the later neurological assessment of high-risk neonates, and has a strong predictive effect on the neurodevelopmental behavior. The results of this study showed that the sleep-wake cycle, continuity, lower boundary amplitude and bandwidth and total aEEG score in the experimental group were higher than those in the control group, and the

differences were statistically significant (all $p < .05$), which was basically consistent with the results obtained by Yuan Wenjie et al.[12] It is also suggested that MS intervention can promote the maturation of aEEG background activity in premature infants. The possible reasons for the analysis are that the thalamus is the main starting point for human brain electrical activity, and it is also the most important intermediate station for sensory stimuli to enter the cerebral cortex, which can form a thalamic-cortical loop, thereby regulating the excitation of cortical neurons and the level of brain electrical activity. This study is to provide premature infants with a variety of sensations such as touching, hearing, vision and vestibular stimulation, which are transmitted into the thalamus to further stimulate the continuous proliferation of synapses of brain neurons, and simultaneously promote the activity of brain neurons, so as to establish and repair intersynaptic connections, form a powerful neural network, continuously optimize brain structure and promote brain function development, and enrich the emotional, cognitive and neurobehavioral growth in premature infants.[13,14]

The neonatal sleep-wake cycle mainly includes QS and AS. Practice has shown that sleeping is essential for the maturation of brain development, and it is a key process in neurodevelopment, especially during the QS phase.[15] This study showed that the average time of QS phase in the experimental group was longer than that in the control group after 7 days of MS intervention ($p < .05$), indicating that MS intervention could increase the quiet sleep time in premature infants, promote the sleeping state, and thus promote brain development. Yan et al.[16] showed that music can also prolong quiet sleep period for the premature infants, reduce pain and stress, play a soothing and sedative role, and promote the secretion of neurotransmitters, ultimately promoting the development of the cerebral cortex in premature infants. After years of clinical practice, NBNA, as the most commonly used method for neonatal behavioral neurological examination, can comprehensively reflect the neonatal neurological development and brain function status, and can detect mild brain injury in clinical practice.[17,18] This study showed that the NBNA scores of the experimental group were higher than those of the control group, and the difference was statistically significant, suggesting that MS intervention could improve the brain maturity and reduce the degree of brain injury in premature infants.

5. Conclusion

In summary, the results of this experiment showed that MS intervention plays a positive role in the brain development and maturation in premature infants at 32-37 weeks, and could be combined with aEEG as a method for neurodevelopmental assessment of premature infants, which is of great significance for improving the life quality of premature infants in the later period.[19] In addition, MS intervention is a type of developmental support nursing, which is simple and easy to learn without trauma and worthy of widespread clinical promotion.

Funding

Baotou Hygiene Scientific and Technological Program (wsjkk2022082).

Conflicts of Interest Disclosure

The author declares no conflicts of interest.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

REFERENCES

[1] Liu M, Dai X, Hua J. Neurobehavioral development of 25254 children with different gestational ages at birth in three cities of China. Chinese Journal of Contemporary Pediatrics. 2020; 22(9): 931-935.

[2] Deng K, Liang J, Mu Y, et al. Preterm births in China between 2012 and 2018: an observational study of more than 9 million women. Lancet Glob Health. 2021; 9(9): e1226-e1241. https://doi.org/10.1016/S2214-109X(21)00298-9

[3] Mi Y, Ying H. Infection during pregnancy and preterm birth. Chinese Journal of Practical Gynecology and Obstetrics. 2023; 39(12): 50-53.

[4] General Office of the National Health and Family Planning Commission. Guidelines for health care services for preterm infants [EB/OL]. (2017-03-03) [2022-11-15]. Available from: http//www.nhc.gov.cn/fys/s3585/201703/d5656db4e43a49ff9d14470864b0fb16.shtml

[5] Teng X, Liang J, Tan J, et al. A Randomized Controlled Study of Multisensory Interventions in Promoting Brain Function Development in Premature Infants. Chinese General Practice. 2023; 26(2): 168-174.

[6] Pineda R, Roussin J, Heiny E, et al. Health care professionals' perceptions about sensory-based interventions in the NICU. Am J Perinatol. 2019; 36(12): 1229-1236. https://doi.org/10.1055/s-0038-1676536

[7] Perinatal Professional Committee of the Pediatric Branch of the Chinese Medical Association. Expert consensus on the clinical application of neonatal amplitude integrated EEG. Chinese Journal of Neonatology. 2019; 34(1): 3-7.

[8] Burdjalov VF, Baumgart S, Spitzer AR. Cerebral function monitoring: a new scoring system for the evaluation of brain maturation in neonates. Pediatrics. 2003; 112(4): 855-861. https://doi.org/10.1542/peds.112.4.855

[9] Wang N, Li X. Progress in neurodevelopmental assessment of premature infants. Chinese Journal of Child Health Care. 2023; 31(4): 404-407.

[10] Tandircioglu UA, Güzoglu N, Gucuyener K, et al. Influence of Intensive care unit enlightenment on premature infants on functional brain maturation assessed by amplitude-integrated electroencephalograph. Am J Perinatol. 2019; 38(4): 357-362. https://doi.org/10.1055/s-0039-1697681

[11] Chen Y, Dong S, Chen Z, et al. Predictive effect of aEEG on long-term neuro-behaviour about neonates with hypoxic-ischemic encephalopathy. Chinese Journal of Birth Health & Heredity. 2020; 28(1): 4.

[12] Yuan W, Wu M, Xu Y, et al. Value of aEEG combined with AOPP and sLOX-1 in the early diagnosis of brain injury in premature infants. Journal of Clinical Pediatrics. 2020; 38(11): 842-846.

[13] Pittet-Metrailler MP, Almazrooei AM, Tam EWY. Sensory assessment: neurophysiology in neonates and neurodevelopmental outcome. Handb Clin Neurol. 2020; 174: 183-203. https://doi.org/10.1016/B978-0-444-64148-9.00014-4

[14] Provasi J, Blanc L, Carchon I. The importance of rhythmic stimulation for preterm infants in the NICU. Children (Basel). 2021; 8(8): 660. https://doi.org/10.3390/children8080660

[15] BoureL-Ponchel E, Hasaerts D, Challamel MJ, et al. Behavioral-state development and sleep-state differentiation during early ontogenesis. Clin Neurophysiol. 2021; 51(1): 89-98. https://doi.org/10.1016/j.neucli.2020.10.003

[16] Yan K, Ji FT, Yuan H, et al. Musical intervention increases quiet sleep time of preterm infants: a randomized controlled trial. Chinese Journal of Evidence-Based Pediatrics. 2020; 15(4): 269-273.

[17] Du H, Xue L, Wen J. Study on the correlation between craniocerebral ultrasonography and neonatal neurobehavioral scores and brain injury in premature infants. Chinese Clinical Doctor. 2019; 47(6): 732-733.

[18] Zhang X, Liu Y, Xia L, et al. Role of Neonatal Behavioral Neurological Assessment combined with magnetic resonance diffusion tensor imaging in evaluating white matter development in preterm infants. Chinese Journal of Contemporary Pediatrics. 2021; 23(9): 916-921.

[19] Zheng L, Su W, Huang H, et al. A research of the effect of early intervention program on physical and neuropsychological development for premature small for gestational age infants. Chinese Journal of Rehabilitation Medicine. 2021; 36(5): 559-563, 569.