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Original article

Effect of early intervention on premature infants' general movements

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Abstract

This study is to investigate the characteristics of premature infants' general movements (GMs) and the effect of early intervention on their GMs.

Methods: The survey was carried among 285 premature infants. (1) Before intervention, the correlation between the gestational age/ birth weight and the GMs was evaluated. (2) The cases were divided into early intervention group ($n = 145$) and control group ($n = 140$), each group was divided into <32 weeks, 32–34 weeks and >34 weeks group according to gestational age. The early intervention was begun at the 3rd day after birth to 54th week gestational age. The rate of GMs among each group was compared after intervention.

Results: (1) Before intervention, gestational age/birth weight was negatively correlated with the rate of cramped-synchronized (CS) ($r = -0.988$, $r = -0.95$, $p < 0.01$), while no correlation with the rate of poor repertoire (PR) ($r = 0.122$, $r = 0.168$, $p > 0.05$). (2) After intervention, for the writhing movement, there was no significant difference ($\chi^2 = 0.509$, 1.401, 0.519, $p > 0.05$) between the early intervention group and the control group. Nevertheless, for the fidgety movement, there was significant difference ($\chi^2 = 7.921$, $\chi^2 = 5.763$, $p < 0.05$) between the two groups, especially in <32 weeks group ($\chi^2 = 5.578$, 4.067 $p < 0.05$) and in >34 weeks group ($\chi^2 = 5.757$, $p < 0.05$).

Conclusions: (1) It shows that the lower birth weight or the younger delivery gestational age, the more abnormal GMs in premature infants. (2) Early intervention could improve the fidgety movements of premature infant.

Keywords: General movements; Early intervention; Premature infants; Gestational age; Birth weight

General movements (GMs) assessment was a reliable and valuable tool to predict the brain function of infants, and it could make accurate and effective prediction on later neurodevelopmental outcome especially more accurately to predict cerebral palsy (CP) before the infants were 4–5 months [1]. Previous studies have shown that the sensitivity of GMs with regard to later CP was 100% with 95% credibility interval (0.73, 1.00) and the specificity was 98% with 95% credibility interval (0.91, 0.99) [2]. In China, Yang concluded that the sensitivity of GMs with regard to later CP was 83% and the specificity was 78% during writhing period, while the sensitivity was 75% and the specificity was 98% during fidgety movement [3]. In addition, it was found the presence of poor repertoire (PR) general movements at 1 month post-term seemed to predict lower neurodevel-

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opmental scores at 2 years especially in the domain of eye and hand coordination [4]. Abnormal fidgety (AF) movements was an early marker for complex minor neurological dysfunction at puberty [5]. More study indicated that cramped-synchronized (CS) general movements and absence of fidget movement (F^{-}) strongly predict the development of CP [1,2], Therefore, the GMs might serve as an objective and feasible tool for early prediction of neurodevelopmental outcome in high risk infants.

With the rapid development of perinatal and neonatal emergency medicine, the mortality of high risk infants, especially premature infants were reduced greatly, but the damage of central nervous system with different degree of disability rate gradually increased [6]. In recent years, the premature infants suffered severe neurological behavior have changed about 10–15%, with mild nerve behavior have changed about 50% [7]. Therefore, it was very important to take effective measures to promote the growth and development of premature infants, to improve development quotient, and to reduce the incidence of complications as well as the degree of dysfunction [8]. A growing number of research shows that early intervention can improve the growth of nervous system and reduce the incidence of developmental delay or CP effectually [9–11]. Therefore, people were always trying to find the most effective early intervention in these years. Recently, those interventions were confirmed effective as follows: the Newborn Individualized Developmental Care and Interventions Program (NIDCAP), which was a developmental supportive care intervention starting soon after birth and has shown long-time positive effects on behavior and mother–child interaction [12]. The Infant Behavioral Assessment and Intervention Program (IBAIP), a post-discharge intervention could improve the mental, motor, and behavioral outcomes of very low birth weight (VLBW) infants at 6 months corrected age [13], and that found long-time positive effects on children's mobility in daily activities [14]. The qualities of early social interaction seemed to impact the child's language skills, cognitive, social and emotional development [15,16]. However, to date, few studies have been reported about the effects of early intervention on GMs quality. Therefore, this study aimed to investigate the effect of early intervention on premature infants' general movements during writhing period and fidgety period, to guide the preterm infants to carry on early intervention, and to improve their neurodevelopmental outcome and reduce the incidence of CP.

1. Method

1.1. Participants

The study contained 285 premature infants (gestational age < 37 weeks). They were recruited from neonatal intensive care unit (NICU) from Sep 2011 to Dec 2012. The mean delivery gestational age is 33.73 weeks (standard deviation, 2.15 weeks), minimum delivery gestational age is 28 weeks and 2 days, maximum delivery gestational age is 36 weeks and 5 days. The mean birth weight is 2.60 kg (standard deviation, 0.59 kg), the lowest birth weight is 970 g and the highest birth weight is 2850 g. Central nervous system infection, genetic and metabolic disease, chromosomal disease, congenital abnormality, brain malformation and tumors of the central nervous system were excluded.

According to gestational age, all the cases were divided into: <32 weeks group ($n = 29$), 32–34 weeks group ($n = 97$) and >34 weeks group ($n = 159$), according to the birth weight, they were divided into: <1500 g group ($n = 20$), 1500–2000 g group ($n = 90$) and >2000 g group ($n = 175$). And then, all the infants were randomized to one of two groups: early intervention group and control group. The randomization was implemented by sealed envelopes using computer-generated random numbers balanced in groups of eight. Group assignments were generated by the study statistician and unsealed by an individual not involved in data collection. This study was approved from ethics committee of Qilu Hospital of Shandong University and the Affiliated Hospital of Bin Zhou Medical College. All parents of the subjects consented to participate in the study and signed the informed consent in the context of the book.

1.2. Early intervention

The early intervention was carried from the 3rd day after birth to 54th week gestational age. The frequency and maintain time of each intervention would be adjusted according to physical endurance of the infants. The intervention consisted of hospital intervention and family intervention. The infants with stable vital signs in neonatal intensive care unit (NICU) were given hospital intervention, including: (1) auditory stimulation; (2) visual stimulation; (3) tactile stimulation, for 1–2 times a day, 10–15 min each time, performed by a nurse. The infants who leaved NICU and followed up in children health care rehabilitation clinic were given family intervention. These infants would be companied by parent to go to the hospital once a week and accepted neural development evaluation by professional doctor of child development. Then, the parents would be taught the intervention methods by the doctor. The intervention including: (1) auditory stimulation; (2) visual stimulation; (3) tactile stimulation; (4) vestibular motion stimulation; (5) pediatric gymnastics; (6) hydrotherapy. (1)–(5) were performed 2–3 times a day by parents, 15–25 min each time. (6) was performed once a day, 15–30 min each time. Detailed intervention methods: (1) auditory stimulation: talking to the baby, singing and playing music, hearing sound of nurse or mother,

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heart and sound recording; (2) visual stimulation: letting the children see various removable visual card and the nurse or their parent's face; (3) tactile stimulation: buckling body passively, touching, massaging and transforming an infant's position; (4) vestibular motion stimulation: giving appropriate, oscillatory shaking. (5) pediatric gymnastics: Firstly, baby lying on the back, the parents massaging baby gently, with friendly words talking with them. After baby's muscle being relaxed, they being performed the chest expanding exercise, stretching exercise, lifting and downing leg exercise, bending leg movement by their parents. (6) hydrotherapy: The parents putting the baby in the warm water, and touching them softly, with relaxed, pleasant communication to them. So that the baby can relax their shoulder, elbow, knee, ankle, wrist and hip. At the same time, the baby also can swim freely in the water. These exercises can promote children's motor development, sensory integrative ability, and strengthen the development of skeletal and muscular. The intervention would be canceled if the baby cannot tolerate or ill. The case of stopping intervention for more than 1 week would be weed out the experiment.

The control group was only given the same feeding, care and infant health guidance as the intervention group.

1.3. Assessment of general movements [17,18]

There were two distinct patterns of general movements observed: writhing movement and fidgety movements. Writhing movements, the best observed time of which was from the 3rd day after birth to 44 weeks gestational age, was slow to moderate speed of small to moderate amplitude movements. Large, fast, elliptical extensor movements may occasionally break through, particularly in the arms of the normal. Abnormal movements were defined as follows: Poor repertoire general movements (PR), was monotonously sequenced successive movements that did not occur with the complexity seen in normal general movements. Cramped-synchronized general movements (CS), was rigid movements without a normal smooth and fluent character, with the limbs and trunk contracting and relaxing almost simultaneously. Fidgety movements, the best observed time was from 49 weeks to 55 weeks gestational age, was small-amplitude movements of moderate speed and variable acceleration of the neck, trunk, and limbs in all directions, continual in the normal awake infant. Abnormal of fidgety movements were absent fidgety movements (F^{-}) and abnormal fidgety movements (AF), the former was characterized by an absence of fidgety movements but the presence of other movements, the latter was fidgety-like movements with moderately or greatly exaggerated amplitude, speed, and jerkiness.

All infants were video recorded while partially dressed in active wakefulness. Each recording lasts for 1 h (writhing movement) or 12 min (fidgety movements). For the analysis, 3 or 4 episodes of general movements were selected from each recording, excluding periods of crying. A collection of the general movement video recordings at the two ages was compiled, stored in a separate file for each infant, and anonymized for study analysis. A general movement trajectory was described for each infant from the assessments at 3 time points: the first recording time is the 3rd day after birth, which recorded writhing movement before early intervention; the second recording time is 43 weeks gestational age, in this phase, the baby has accepted the intervention for several weeks; the last recording time is 54 weeks gestational age, which recorded fidgety movement after early intervention. If the result was abnormal (PR, CS, F^{-}or AF), the infant should be rerecorded after 3 days, until the results reached to two consistent conclusions. Additionally, if the infant fevered, he or she should be recorded again after the temperature returned to normal. If the infant was hypoglycemia condition, a rerecording also needed after blood sugar stable. The latest recording time could not more than 1 week after the prescribed time. The quality of general movements was assessed independently by 2 observers who were blinded to the participants' group assignments, all cases were reassessed by another experienced trainer of general movement assessment. In cases of disagreement, the video recordings were reassessed and agreement was reached after discussion. All the observers had successfully participated in a 4-day basic course and one of them had also taken part in a 4-day advanced training course of GMs.

1.4. Statistical analysis

The statistical analysis was performed by using the "Statistical Package for Social Sciences" (SPSS, Version 17.0). Normal test and students *t*-test were used in comparisons of delivery gestational age, birth weight between the two groups. Chi-square test was used in comparisons of gender, rate of different GMs result and so on between the two groups. Spearman rank correlation coefficient (r) was used to study the correlations among general movement assessments and birth weight, delivery gestational age.

2. Results

2.1. Comparison of the writhing movement

Table 1 shows the comparison of the writhing movement in each group according to delivery gestational age before early intervention. The younger the gestational age, the less the rate of normal writhing movement,

Table 1
Compare of the writhing movement in each group according to gestational age.

Group	*N* (ratio)	PR (ratio)	CS (ratio)
<32 weeks ($n = 29$)	5(17%)	9(31%)	15(52%)
32–34 weeks ($n = 97$)	49(51%)	35(36%)	13(13%)
>34 weeks ($n = 159$)	98(62%)	53(33%)	8(5%)
χ^2	19.89	0.332	48.532
p	0.000	0.847	0.000

N, normal; PR, poor repertoire; CS, cramped-synchronized. This table shows the comparison of the number (n) and ratio (%) of writhing movement when the infants were divided into <32 weeks, 32–34 weeks and >34 weeks groups according to gestational age. The significant changes occurred in the ratio of normal writhing movement as well as the ratio of CS ($p < 0.001$). The PR% is not changed significantly ($p > 0.05$).

and the difference is statistically significant ($\chi^2 = 19.89$, $p < 0.001$). The younger the gestational age, the higher the ratio of CS, and the difference is statistically significant ($\chi^2 = 48.532$, $p < 0.001$). The PR ratio changes little, and the difference is not statistically significant ($\chi^2 = 0.332$, $p > 0.05$) among the groups.

From Table 2, it shows the comparison of the writhing movement in each group according to birth weight before early intervention. It can be seen that the lower weight, the less the rate of normal writhing movement and the difference is statistically significant ($\chi^2 = 20.494$, $p < 0.001$). The lower weight, the more the rate of CS and the difference is statistically significant ($\chi^2 = 67.271$, $p < 0.001$). The PR ratio changes little, and the difference is not statistically significant ($\chi^2 = 2.761$, $p > 0.05$) among the groups.

Spearman's rank correlation analysis between writhing movement and delivery gestational age/birth weight before early intervention shows that gestational age is negatively correlated with CS% ($r = -0.988$, $p < 0.01$), no correlation with PR% ($r = 0.122$, $p > 0.05$); Birth weight is negatively correlated with CS% ($r = -0.95$, $p < 0.01$), no correlation with PR% ($r = 0.168$, $p > 0.05$); It is shown in Table 3.

Table 2
Compare of the writhing movement in each group according to birth weight.

Group	*N* (ratio)	PR (ratio)	CS (ratio)
<1500 g ($n = 20$)	2(10%)	4(20%)	14(70%)
1500–2000 ($n = 90$)	43(48%)	35(48%)	12(14%)
>2000 g ($n = 175$)	107(61%)	58(33%)	10(6%)
χ^2	20.494	2.761	67.271
p	0.000	0.251	0.000

N, normal writhing movement; PR, poor repertoire; CS, cramped-synchronized. This table shows the comparison of the number (n) and ratio (%) of writhing movement when the infants were divided into <1500 g, 1500–2000 g and >2000 g groups according to birth weight. The significant changes occurred in *N*% as well as CS% ($p < 0.001$). The PR% is not changed significantly ($p > 0.05$).

Table 3
Correlations of GMs results and delivery gestational age, birth weight.

	CS%	PR%
Gestational age	−0.988[a]	0.122
Birth weight	−0.95[a]	0.168

The spearman's correlation coefficient of gestational age, birth weight and CS%.
[a] $p < 0.01$.

2.2. Effect of early intervention on premature infants' general movements

The demographic backgrounds of all children are shown in Table 4. The difference is not statistically significant between the two groups in gestational age, birth weight, sex, small for gestational age, Apgar score, hypoxic-ischemic encephalopathy (HIE), periventricular lucency (PVL), intraventricular hemorrhage (IVH) grade and so on. The two groups are well balanced and comparable ($p > 0.05$).

Table 5 shows there is no significant difference ($\chi^2 = 0.509$, 1.401, 0.519, $p > 0.05$) between the two

Table 4
The demographic backgrounds of all children.

	Intervention group ($n = 145$)	Control group ($n = 140$)
Gestational age, weeks, mean (SD)	33.93 (2.61)	33.49 (1.89)
<32 weeks, n (%)	16 (11.0)	13 (9.2)
32–34 weeks, n (%)	50 (34.4)	47 (33.5)
>34 weeks, n (%)	79 (54.4)	80 (57.1)
Birth weight, mean (SD)	2.64 (0.61)	2.52 (0.56)
Male, n (%)	74 (51.0)	75 (53.5)
SGA, n (%)	29 (20.0)	24 (17.1)
Apgar:1 min, mean (SD)	7.65 (2.60)	7.39 (2.17)
5 min, mean (SD)	8.65 (2.45)	8.72 (2.61)
IVH grade1–2, n (%)	5 (3.4)	6 (4.2)
IVH grade3–4, n (%)	2 (1.3)	0 (0)
HIE, n (%)	21 (14.4)	16 (11.4)
PVL, n (%)	11 (7.6)	9 (6.2)
Fetal distress, n (%)	32 (22.1)	29 (20.7)
Intracranial hemorrhage, n (%)	14 (9.6)	11 (7.5)

SGA, small for gestation age. IVH, intraventricular hemorrhage, a bleeding into the brain's ventricular system, where the cerebrospinal fluid is produced and circulates through towards the subarachnoid space. IVH is often described in four grades: Grade 1 – bleeding occurs just in the germinal matrix; Grade 2 – bleeding also occurs inside the ventricles, but they are not enlarged; Grade 3 – ventricles are enlarged by the accumulated blood; Grade 4 – bleeding extends into the brain tissue around the ventricles. IHE, hypoxic-ischemic encephalopathy, a condition in which the brain does not receive enough oxygen. PVL, periventricular lucency, a form of white-matter brain injury, characterized by the necrosis (more often coagulation) of white matter near the lateral ventricles. The two groups were well balanced and comparable. The differences between the groups were not significant ($p > 0.05$).

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Table 5
Comparison of writhing movement between the intervention group and the control group.

Group	Total			<32 weeks			32–34 weeks			>34 weeks		
	N (ratio)	PR (ratio)	CS (ratio)	*N* (ratio)	PR (ratio)	CS (ratio)	*N* (ratio)	PR (ratio)	CS (ratio)	*N* (ratio)	PR (ratio)	CS (ratio)
Intervention group	82(57%)	52(36%)	11(7%)	5(31%)	7(44%)	4(25%)	25(50%)	20(40%)	5(10%)	52(66%)	25(32%)	2(2%)
Control group	85(61%)	41(29%)	14(10%)	3(23%)	4(31%)	6(46%)	27(57%)	16(34%)	4(9%)	55(69%)	21(26%)	4(5%)
χ^2	0.509	1.401	0.519	0.24	0.513	1.421	0.54	0.368	0.064	0.155	0.563	0.667
p	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

N, normal; PR, poor repertoire; CS, cramped-synchronized. In total, there is no significant difference between the two groups in *N*%, PR% and CS%. Each gestational age group also has no significant difference in these two groups.

Table 6
Comparison of fidgety movement between the intervention group and the control group.

Group	Total			<32 weeks			32–34 weeks			>34 weeks		
	N (ratio)	AF (ratio)	F^- (ratio)	*N* (ratio)	AF (ratio)	F^- (ratio)	*N* (ratio)	AF (ratio)	F^- (ratio)	*N* (ratio)	AF (ratio)	F^- (ratio)
Intervention group	139(96%)	1(0.6%)	5(3.4%)	13(81%)	1(6%)	2(13%)	48(96%)	0(0%)	2(4%)	78(99%)	0(0%)	1(1%)
Control group	121(86%)	4(3%)	15(11%)	5(39%)	2(15%)	6(46%)	42(89%)	1(2%)	4(9%)	74(93%)	1(1%)	5(6%)
χ^2	7.921	1.941	5.763	5.578	0.645	4.067	1.594	1.031	0.849	3.671	0.163	5.757
p	<0.05	>0.05	<0.05	<0.05	>0.05	<0.05	>0.05	>0.05	>0.05	>0.05	>0.05	<0.05

N, normal fidgety movements, AF, abnormal fidgety movements, F^-, absence of fidgety movement. After a longer period of intervention, the effect is appeared in <32 weeks group and in >34 weeks group obviously. but, no significant difference in 32–34 weeks group.

groups of writhing movement. Also, there is no significant difference ($p > 0.01$) between the two groups after the case was divided into 3 groups according to gestational age.

In Table 6, the rate of normal fidgety movement in early intervention group is more than the control group ($\chi^2 = 7.921$, $p < 0.05$), while the rate of F^- is fewer significantly ($\chi^2 = 5.763$, $p < 0.05$), especially in <32 weeks group, normal fidgety movement of early intervention group is increased more significantly than the control one ($\chi^2 = 5.578$, $p < 0.05$). On the contrary, the rate of F^- is obviously lower than that of the control group ($\chi^2 = 4.067$, $p < 0.05$). In 32–34 weeks group, there is no significant difference ($\chi^2 = 1.594$, 1.031, 0.849, $p > 0.05$) in fidgety movement between the two groups. In >34 weeks group, the rate of F^- in early intervention group is higher than another one ($\chi^2 = 5.757$, $p < 0.05$); while no significant difference in the rest ($\chi^2 = 3.671$, 0.163, $p > 0.05$).

3. Discussion

In recent years, mortality of premature infants has decreased significantly, but approximately 10–20% of survivors have neurological sequelae in different degrees, such as CP [7]. The risks associated with preterm birth increase as the gestational age decreases, and vulnerability remains in preterm infants [19]. The prevalence of developmental delay for preterm infants is twofold compared with full term infants [20], the cognitive outcomes are slightly lower in intelligence quotient (IQ) and poorer in neurodevelopmental as well as psychomotor outcomes [21,22]. However, these results are inconsistent [23]. Gross motor development for the group of preterm infants seems also to be negatively affected [24]. Therefore, further research is necessary to discuss the relationship between different delivery gestational age and neurodevelopmental & psychomotor outcomes of preterm infants.

CP is one of the most serious complications of premature infants. The diagnosis mainly depends on medical history and physical examination. Early detection and early intervention were extremely important. Computed tomography (CT), brain stem auditory and evoked potential, cranial ultrasound and magnetic resonance imaging (MRI) are effective inspections in the diagnosis of CP, but some of them, the sensitivity scans were clearly lower than that of assessment of general movements of a fidgety character, such as cranial ultrasound [25]. Studies have shown that GMs as a new neurological assessment tool is an early predictor of severe neurobehavioral defects such as CP. It has important significance in the diagnosis of developmental disorders or CP. Up to now, few studies have been reported the relationship between delivery gestational age, birth weight and general movements during writhing period. This study found the lower birth weight or the younger delivery gestational age, the more heaviest abnormal GMs the preterm infants have just as CS. This result is identical to Vries' research [26]. The immaturity brain of the lower birth weight or the younger delivery gestational age infants might be the mainly reason lead to fetal brain developmental disorders.

Early intervention could affect the rapidly growing brain and also improve and change the developing neural pathway [10].Some interventions took place soon after birth, others during the hospital-home transition and some post-hospital discharge. In this study, intervention was started from the 3rd day after birth, but unfortunately, we found that early intervention have no significant effect on writhing movement. The reasons might be: (1) The intervention time was shorter. The intervention started from the 3rd day after birth to 43 weeks gestational age for the second recording, last for 6–15 weeks, and only 6–11 weeks for most premature infants, thus we could hardly see any change in a relatively short period of time. (2) The sleeping time of infants was too long. Baby slept for general 18 h one day, so little time was used for intervention according to the early intervention principles. Fortunately, the improvement of quality of GM appeared in fidgety movements phase. After a long time of intervention (17–27 weeks), the rate of normal fidgety movements of intervention group was significantly higher than control group, while the rate of F^- decreased significantly. It prompted that early intervention can effectively change the motor pattern of the infant and significantly improve the recovery effect of the nervous system. This conclusion was consistent with the research that early intervention can reduce the incidence of CP. In the 32–34 weeks group, there was no significant difference in fidgety movement between the early intervention and the control group. The possible explanation was that the basis disease of the infants may play an important role, or the infants may have stronger self-repair ability in this age or other reasons still unknown. So we still needed further study on this assumption. There was no significant difference in the two groups in AF movements, which probably because limited data couldn't meet statistics requirements in this study.

GMs generated from central pattern generator located in the brainstem, which might be regulated by corticospinal tract or reticulospinal tract. If central pattern generator was damaged, the quality of GMs might be affected [17]. Preterm infants' brain was immature but with strong plasticity, so early intervention might improve the quality of GMs by reducing or preventing injury of the central pattern generator, corticospinal tract or the reticulospinal tract.

In short, the quality of writhing movement was significantly associated with birth weight and delivery gestational age. In order to reduce the incidence of

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abnormal nervous system sequelae, it is important for premature infants to be given early screened, early intervention after birth. In our study, this early intervention started from NICU, including massage, touch, multisensory stimulation, was a very simple, economical, effective and feasible measures in improving premature infant's normal fidgety.

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