

Original Article

Changes in muscle tone of the lower limbs in 181 high-risk premature infants in early intervention

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Abstract: Objective: To understand changes in muscle tone of the lower limbs in high-risk premature infants and the results after early intervention. Methods: Premature infants born from 1 July 2016 (with expected date of delivery on 1 October 2016) to 1 July 2017 (with expected date of delivery on 1 October 2017) with gestational age < 32 weeks were selected for monthly follow-up in the first 6 months of life and every 2 months from 6 to 12 months of age. Results of an intervention for dystonia were evaluated at 2, 4, 6, 8 and 12 months of age. Results: A total of 181 high-risk premature infants were included in our study population, among which 121 (66.9%) had experienced dystonia, which mainly manifested as hypertonia within the first 6 months of age and hypotonia beyond 6 months of age. All cases of dystonia significantly improved after intervention at 2 months of age. By 12 months of age, the improvement rate of hypertonia was 95%, while that of hypotonia was only 64.5%. Conclusions: The level of muscle tone is presented as a dynamic process in our study population. After early intervention, both hypertonia and hypotonia improved, with the level of improvement of hypertonia more significant.

Keywords: Premature infant, lower limbs, muscle tension, early intervention

Introduction

Currently, about 15 million premature infants are born each year in the world, and this number has been increasing every year [1, 2]. The incidence rate of premature birth in China is about 7.1%, and approximately 1.8 million premature infants are born each year [3]. Premature infants, especially high-risk premature infants with gestational age < 32 weeks, have significantly higher risk of mental retardation, developmental disabilities, coordination disorders, and other diseases [4-7]. Currently, there is a generalized consensus in the literature that early intervention can improve prognosis in premature infants [8, 9]. Muscle tone assessment has been an important part of infant neuromotor examination programs worldwide for screening and diagnosis of infants with a high risk of brain injury [10]. According to the literature, muscle tone and posture abnormalities, if not corrected as soon as possible, may be strengthened and solidified, which can lead to changes in the limb and muscle morphology, as well as cerebral palsy and limb disability [11-13]. In this study, we analysed changes in muscle tone of

the lower limbs in 181 high-risk premature infants in Ningbo following early intervention for dystonia.

Subjects and methods

Subjects

High-risk premature infants were selected who were born from 1 July 2016 (with expected date of delivery on 1 October 2016) to 1 July 2017 (with expected date of delivery on 1 October 2017), with gestational age at birth < 32 weeks, and were followed up at the Department of Child Care of Ningbo Women and Children's Hospital, while premature infants with purulent meningitis, congenital and genetic metabolic diseases, and chromosomal abnormalities were excluded from our study.

Methods

After 40 weeks of post-natal muscle tone intervention, infants were followed up for the first time in our department. The parents listened to a lecture "Early Intervention for 0-3 Months Infants" delivered by a professional rehabilita-

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tion doctor. The main content of the lecture involved the following infant behaviour: lying prostrate and raising the head, responses to images and sounds, tactile hand exercises, and correct cuddling posture. Follow-ups were performed monthly before 6 months of age and every 2 months from 6 to 12 months of age. Muscle tone was evaluated at 2, 4, 6, 8 and 12 months of age, and corresponding family training guidance was provided based on the results of the muscle tone assessment.

Twenty neuromotor test items were carried out, for which the quantitative and diagnostic criteria for muscle tone of the lower limbs were adductor and dorsiflexion angles of 40-80° and 60-70° as the normal ranges within 4 months, 70-110° and 60-70° at 6 months, 100-140° and 60-70° at 8 months, and 130-150° and 60-70° at 12 months, respectively.

To eliminate operational errors, all evaluations and instructions were completed by the first two authors. The conventional Bobath treatment approach was adopted and demonstrated to each parental unit so that they could master the treatment approach and establish a treatment plan.

Statistical analysis

Statistical analysis was performed using the SPSS statistical software. Enumeration data were expressed by frequency and percentage, and unordered enumeration data were analysed using χ^2 or Fisher's exact test, while ordered enumeration data were analysed using one-way ordered χ^2 test.

Results

Comparison of occurrence of various abnormal conditions among distinct months of age

A total of 181 high-risk premature infants were enrolled, including 80 girls and 101 boys. Muscle tone of the lower limbs was evaluated at 2, 4, 6, 8, 10, and 12 months of age. Muscle tone was normal in 60 cases for all evaluations, whereas the other 121 cases had experienced dystonia, with a detection rate of 66.9%. Five abnormal conditions of the lower limbs were identified-pure adduction hypertonia, pure increased dorsiflexion angle, pure adduction hypotonia, adduction hypertonia complicated by increased dorsiflexion angle, and adduction

hypotonia complicated by increased dorsiflexion angle.

Adduction hypertonia was identified at 2, 4 and 6 months of age, but the increase in muscle tone was most significant at 2 months of age ($P < 0.05$). Increased dorsiflexion angle was identified at 2, 4, 6 and 8 months of age, but the increase was most significant at 4 months of age ($P < 0.05$). Adduction hypotonia was identified at 4, 6 and 8 months of age, and the decrease in muscle tone was most significant at 6 months of age ($P < 0.05$). Adduction hypertonia with increased dorsiflexion angle was identified in 6 cases at 4 months of age but not at any other age. Adduction hypotonia with increased dorsiflexion angle was identified in 2 cases at 8 months of age, as shown in **Table 1**.

Comparison of occurrence of various abnormal conditions at distinct months of age

Adduction hypertonia and increased dorsiflexion angle were identified at 2 months of age as shown in **Table 2**, but the incidence of adduction hypertonia was significantly higher than that of increased dorsiflexion angle ($P < 0.05$). At 4 months of age, adduction hypertonia, increased dorsiflexion angle, and adduction hypotonia were present; however, adduction hypertonia was the most prevalent abnormal condition of the lower limbs at this age ($P < 0.05$). Increased dorsiflexion angle and adduction hypotonia were identified at 6 months of age; however, the incidence of adduction hypotonia was significantly higher than that of increased dorsiflexion angle ($P < 0.05$). At 8 months of age, adduction hypotonia and increased dorsiflexion angle were present; however, the incidence of adduction hypotonia was significantly higher than that of increased dorsiflexion angle ($P < 0.05$).

Comparison of improvement among various abnormal conditions at distinct months of age

All abnormal conditions improved significantly within 2-4 months, as shown in **Table 3**.

Outcomes of abnormal conditions at 12 months of age

The improvement rate of adduction hypertonia was 98.0%, in which only 1 case, identified at 2 months of age, did not show any improvement. The improvement rate of increased dorsiflexion

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Table 1. Comparison of occurrence of various abnormal conditions among various months of age

Months of age	Adduction hypertonia		Months of age	Months of age	Increased dorsiflexion angle		Months of age	Months of age	Adduction hypotonia	
	Months of age	P			P	P			P	
2 (34, 18.8%)	4 (14, 9.5%)	0.018	2 (11, 6.1%)	4 (26, 15.3%)	0.005	4 (9, 5%)	6 (19, 11.1%)	0.035		
4 (14, 9.5%)	6 (1, 0.8%)	0.002	4 (26, 15.3%)	6 (5, 3.5%)	0.001	6 (19, 11.1%)	8 (9, 5.9%)	0.098		

Table 2. Comparison of occurrence of various abnormal conditions at distinct months of age

Abnormal condition	2 months of age		Abnormal condition	4 months of age		Abnormal condition	6 months of age	
	Abnormal condition	P		Abnormal condition	P		Abnormal condition	P
A (34, 18.8%)	B (11, 6.1%)	0.001	A (14, 9.5%)	B (26, 15.3%)	0.084	B (5, 3.5%)	C (19, 11.1%)	0.011
A (34, 18.8%)	C (1, 0.5%)	0.001	A (14, 9.5%)	C (9, 5%)	0.112	A (1, 0.8%)	B (5, 3.5%)	0.001
C (1, 0.5%)	B (11, 6.1%)	0.001	B (26, 15.3%)	C (9, 5%)	0.001	C (19, 11.1%)	A (1, 0.8%)	0.001

A represents adduction hypertonia; B represents increased dorsiflexion angle; C represents adduction hypotonia.

Table 3. Comparison of months of age at the time of improvement among various abnormal conditions

Months of age	Adduction hypertonia			Months of age	Increased dorsiflexion angle			Months of age	Hypotonia		
	Treatment course	P	P		Treatment course	P	P		Treatment course	P	
2	0 (0, 0)	2 (24, 70.6%)	0.00001	2	0 (0, 0)	2 (5, 45.5%)	0.018	2	0 (0, 0)	2 (0, 0)	0.876
2	2 (24, 70.6%)	4 (5, 50%)	0.121	2	2 (5, 45.5%)	4 (5, 83.3%)	0.032	4	2 (0, 0)	4 (3, 33.3%)	0.521
2	4 (5, 50%)	6 (3, 60%)	0.214	4	0 (0, 0)	2 (14, 53.8%)	0.0001	6	0 (0, 0)	2 (11, 57.9%)	0.001
4	0 (0, 0)	2 (10, 71.4%)	0.00001	4	2 (14, 53.8%)	4 (10, 83.3%)	0.0001	6	2 (11, 57.9%)	4 (4, 50%)	0.022
4	2 (10, 71.4%)	4 (3, 75%)	0.163	6	0 (0, 0)	2 (1, 100%)	0.652	8	0 (0, 0)	2 (7, 77.8%)	0.001

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angle was 95.5%, with 2 cases in which no improvement was noted—one identified at 2 months of age and the other at 8 months of age. The improvement rate of adduction hypotonia was 64.5%, and the cases without improvement were distributed among all the months of age evaluated. The improvement rate of adduction hypertonia complicated with increased dorsiflexion angle was 100%; two cases of hypotonia complicated with increased dorsiflexion angle occurred at 8 months of age and without improvement at 12 months of age.

Discussion

Through the implementation of appropriate early intervention training, both abnormal sensory-motor patterns and abnormal postures can be corrected. The high plasticity and adaptability of the early infant brain can be fully utilized to stimulate the cerebral cortex and sub-cortical centre to form normal motor patterns, and thus establishing normal motor development [14]. Accurate evaluation of muscle tone in premature infants, timely detection of abnormalities, and informing parents of potential solutions can reduce the incidence of adverse prognosis in premature infants [15, 16]. Some studies have demonstrated that there is a high incidence of abnormal muscle tone in premature infants up to 18 months of age and that early truncal tone abnormalities are associated with a worse developmental outcome [17-20]. However, in our study, we focused on muscle tone of the lower limbs in premature infants.

We found that the main abnormality was adduction hypertonia within 6 months of age and adduction hypotonia after 6 months of age. Adduction hypertonia identified at 2 months of age had an improvement rate of 70.6% following 2 months of large-range, slow, passive movements of the lower limbs. At 12 months of age, the improvement rate was as high as 98%, and although the adductor muscle tone was still high in 1 case, the child was able to walk alone at 13 months of age without showing any abnormal postures.

At 4 months of age, the abnormal conditions were mainly adduction hypertonia and increased dorsiflexion angle, which is identified in a total of 40 cases. Three main causes of abnormalities were identified in this period. First, parents held their children from the axilla

to allow them to stand up and jump, which was the most frequent abnormality of the three that were identified. For this situation, parents should be told to reduce the number of times that they hold their children to stand up and, specifically, instruct the parents to refrain from holding their children from the axilla and to allow them to stand on their toes. Second, as the activities of children at this age are increasing, if parents place toys in front of their children's feet for the children to kick or stamp, it is easy to cause the children's legs to stretch significantly in order to contact the toys, which increases the muscle tone of the extensors of their lower limbs, thereby easily causing adduction hypertonia or increased dorsiflexion angle or both adduction hypertonia and increased dorsiflexion angle. Given this situation, parents should place the toys above their children's feet instead of in front of them and encourage the children to play with their feet up or to grasp their feet with both hands. Third, some parents discovered that their children's legs were often stiff and could not be opened when changing diapers at home. When the parents touched their children's legs with their hands, their children's legs would stretch forward with force, causing stress hypertonia but not affecting their independent activities. They could freely turn from the supine position to the prone position and could often raise their legs to play. Given this situation, parents should reduce the frequency of passive activities requiring the use of their children's lower limbs, with little or no touching. It is apparent that the abnormalities identified at 4 months of age were mainly caused by improper care methods performed by family members. These abnormalities demonstrated the greatest capacity for improvement, which could be achieved once the parents' care methods for their infants were modified.

At 6 months of age, there were 6 children with hypertonia due to the above-mentioned causes. By changing the parents' care methods, the infants' improvement rate reached 100% after 2 months.

At 4 months of age, hypotonia was identified and peaked at 6 months of age in 19 cases. At this age, it should be emphasized to parents that they should teach children to crawl on their hands and knees as soon as possible. During

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the re-examinations performed 2 months thereafter, 11 children had normal muscle tone and could crawl on their hands and knees. By the age of 12 months, 4 children showed no improvement. Nine cases of dystonia were identified at 8 months of age, and they were also taught to crawl with hands and knees. During the re-examinations performed 2 months thereafter, 7 cases were normal. By the age of 12 months, 2 cases still had no improvement. There were 4 cases that improved at the age of 10 months and only 1 showed improvement at 12 months of age. These results demonstrate that the improvement rate of hypotonia was 65.9% at 12 months of age, but the abnormalities identified at 6 and 8 months of age could be improved to a great extent after a large amount of crawling exercise with hands and knees, whereas those identified at 4 months and 10 months of age did not show a great capacity for improvement.

Conclusions

The muscle tone of the premature infants showed dynamic change and usually deviated from the normal ranges in most cases, with either an increase or decrease. However, dystonia mainly presented as hypertonia before 6 months of age and as hypotonia after 6 months of age. After proper intervention, the outcome of hypertonia was significantly better than that of hypotonia. Hypotonia was a condition that proved difficult to improve but could be partially improved after intervention. Understanding the changes in muscle tone of premature infants enable parents to make informed decisions regarding the care that they provide to their children and correct deviations in the development of the nervous system as early as possible to minimize the incidence of sequelae.

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Disclosure of conflict of interest

None.

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