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Effect of Neonatal Developmental Intervention Program (NDT) on Motor Development and Growth in Premature Infants

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Purpose: The aim of this study was to identify the effects of neonatal developmental intervention program (NDT) in promoting motor development and growth and to determine the usefulness of Hammersmith Neonatal Neurological Examination (HNNE) and Neonatal Behavioral Assessment Scale (NBAS) in premature infants.

Methods: We performed NDT on selected premature infants (PI, n=42) and compared them with the full term control group (FC, n=20). NDT protocol and development assessment (HNNE, NBAS) were manipulated by the physical therapist in the neonatal intensive care unit. The data of this study were collected prospectively.

Results: The PI with GA <34 weeks (VPI) subgroup showed a more use of mechanical ventilator and surfactant, severe bronchopulmonary dysplasia and intraventricular hemorrhage, and patent ductus arteriosus treated surgically than the PI with GA ≥34 weeks but less than 37 weeks (LPI) subgroup. The average scores improved significantly in the PI group between the 1st, 2nd, and 3rd assessment by repeated measure ($P=0.000$). Also, the PI group showed significantly higher total scores and average score at 40 weeks postmenstrual age, $P=0.000$, respectively than in the FC group. The LPI subgroup showed more weight gain and change in the head circumference between the 1st and 3rd assessment by repeated measure, respectively, $P<0.05$. The PI group showed no apnea, bradycardia and late sepsis associated with intervention and assessment.

Conclusion: The NDT might be a safe and useful intervention to promote motor and growth outcomes in premature infants. Also, the HNNE and NBAS might be safe and useful tools for assessing neurodevelopment in premature infants.

Key Words: Infant, Premature, Early intervention (education), Growth & development, Outcome assessment

Introduction

Because of advances in treatment modalities in newborn medicine, the survival rate of premature infants has steadily increased. Premature born infants have a high chance of neurodevelopmental delay as compared to the full term born infants. The neonatal intensive care unit (NICU)

environment is rather dangerous than safe due to the noise from many machines and lights, thus leading to infants' stress¹⁾. Exposure to excessively harmful stimulations in the NICU can lead to the risks of physiological instability, neurobehavioral delay and so on. Therefore, a lower gestational age (GA) is associated with a increased probabilities of these risks²⁾.

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Previous studies have shown that avoiding direct contact with premature infants was desirable for unstable infants³⁾. But, recent studies have shown that absence of adequate physical contact leads to increased instability in premature infants, and suggested that direct contact by the interventions was needed to provide the premature infants in the NICU with the proper stimulations to compensate for the intrauterine stimulations^{4, 5)}. Also, with regards to neurodevelopmental assessment in premature infants, the Hammersmith Neonatal Neurological Examination (HNNE) and the Neonatal Behavioral Assessment Scale (NBAS) have already been used in premature infants^{6, 7)}.

There have been studies on the effects of sensory stimulation (tactile, auditory, visual, vestibular) on neurodevelopment^{1, 8)}. As compared to reports from western countries, there are fewer reports on the effects of early intervention in motor development in Korea.

With this background, we investigated the effects and efficiency of performing neonatal developmental intervention program (NDT) on motor development and growth, and the usefulness of HNNE and NBAS for assessing neurodevelopment in premature infants.

For this purpose, we performed the NDT for motor development and growth in premature infants.

Materials and Methods

1. Patients' characteristics and sample size of the study

The premature intervention (PI) group included 42 premature infants with stable vital signs, without any congenital and chromosomal abnormalities. The full term control (FC) group included 20 healthy full term infants. A preliminary study was conducted in February 2009 for 1 month, to calculate the sample size. This study had a power of at least 90% for detecting 14% difference in the increment between the PI and FC groups in average of the total score (sum of the scores of the HNNE and the NBAS) at 40 weeks' postmenstrual age (PMA) using independent samples two-tailed *t*-test with a type I error rate of $\alpha=0.05$. The required sample

size was found to be 35 in the PI group, 14 in the FC group, and the total required sample size was 49. We conducted this study with 42 premature infants in the PI group, 20 healthy full term infants in the FC group for a total of 62 infants, after receiving an informed consent from parents of the infants enrolled in the study.

Data on premature infants born in Busan St. Mary's Medical Center, Korea were prospectively collected during the period between March 2009 and October 2009. Inclusion criteria for the PI group were: (1) body weight (BW) below 2,500 g, (2) GA below 37 weeks (3) no chromosomal, metabolic, and musculoskeletal abnormality (4) no cyanotic heart disease (5) informed consent (6) stable vital signs judged by the neonatologist of the NICU. Exclusion criteria for the PI group were: (1) opportunities for intervention and the following assessment missed because of unstable vital signs. Inclusion criteria for the FC group were: (1) healthy full term babies born at Busan St. Mary's Medical Center and at Good Moon-Hwa Hospital, Korea (2) infants appropriate for gestational age (AGA).

Premature infants in the PI group were subdivided into 2 subgroups: infants with less than 34 weeks of GA (VPI) subgroup and infants with more than 34 weeks but less than 37 weeks of GA (LPI) subgroup. Collectively, this study was conducted with 14 infants in the VPI subgroup, 28 infants in the LPI subgroup, a total of 42 infants in the PI group and 20 infants in the FC group. The assessment at 40 weeks' PMA was conducted in 12 infants from the VPI subgroup and 24 infants from the LPI subgroup, thereby a total of 36 infants from the PI group. We did not analyze data of 6 infants from

Fig. 1. Study population. Abbreviation: GA, gestational age.

the PI group (VPI subgroup: 2 infants, LPI subgroup: 4 infants) at 40 weeks' PMA because of the delay in the time of the 3rd assessment (Fig. 1).

2. Procedure of the neonatal developmental intervention program (NDT)

NDT comprised of oral stimulation and positional intervention (supine, prone, side-lying positions). This program had the following aims: (1) To promote symmetry and midline (2) To encourage head symmetry (3) To strengthen neck and trunk flexors (4) To encourage hand to mouth movements (5) To strengthen leg flexors (6) To promote rotation (7) To promote the experience of movements (8) To prevent contractures. NDT was performed at PMA of 35.6 ± 0.8 weeks in the PI group and 36.1 ± 0.6 weeks in the FC group. The intervention session was performed for 15 minutes per day, 5 days per week for a period of 2 weeks. The physical therapist in the NICU performed this intervention in the infant's incubator while keeping a watch on the vital signs displayed on the monitors. Intervention was discontinued when the infants' vital signs became unstable [cyanosis, tachycardia ($>180/\text{min}$), tachypnea ($>80/\text{min}$), significant apnea with bradycardia ($<100/\text{min}$), high-grade fever ($>38^\circ\text{C}$)].

3. Motor development outcome measures

The infants' motor functioning was assessed using the HNNE and the NBAS before starting the intervention (1st assessment), re-assessed after 2 weeks of the intervention (2nd assessment) and at 40 weeks' PMA (3rd assessment). The HNNE and the NBAS assessment were performed by the physical therapist in the NICU. The HNNE assessment comprised of 6 clusters (34 items): (1) posture and tone (posture, arm recoil, arm traction, leg recoil, leg traction, popliteal angle, head control 1, head control 2, head lag, ventral suspension) (2) tone pattern (flexor tone 1, flexor tone 2, leg extension tone, neck extensor tone, increased extensor tone) (3) reflexes (tendon reflex, suck/gag, palmar grasp, plantar grasp, placing, moro reflex) (4) movements (spontaneous movement : quantity, spontaneous movement

: quality, head raising prone) (5) abnormal signs/patterns (abnormal hand or toe postures, tremor, startle) and (6) orientation and behavior (eye appearances, auditory orientation, visual orientation, alertness, irritability, consolability, cry). The NBAS scores comprised of 8 clusters (53 items): (1) habituation (2) social interaction (3) motor system (general tone, motor maturity, pull-to-sit, defensive, activity level) (4) state organization (5) state regulation (6) autonomic system (tremulousness, startles, lability of skin color) (7) supplementary items (quality of alertness, cost of attention, examiner facilitation, general irritability, robustness/endurance, state regulation, E's emotional resp.) (8) reflexes. Individual item scores were re-coded and the cluster scores were calculated.

To avoid the overlapping of items between the HNNE and NBAS, total HNNE and only 3 clusters (motor system, autonomic system, supplementary items) and 15 items of the NBAS were included in the assessment. We calculated the total scores and the average scores of HNNE and NBAS at the 1st, 2nd, and 3rd assessment. Higher scores indicated a better response to the therapy.

4. Growth development outcome measures

Body weight, head circumference (HC), height were measured when motor functioning was assessed. The change in body weight, HC, and height between each measurement was assessed.

5. Definition and measurement of prognostic factors

The total score was the sum of scores of all the items in the NBAS and the HNNE, and the average score was the average of the total score. The primary outcome variables investigated, included the total and average scores of HNNE and NBAS at 40 weeks' PMA and the change in the total and average scores of HNNE and NBAS between the 1st, 2nd, and 3rd assessment and the change in BW, HC, height between the 1st, 2nd, and 3rd assessment. The secondary outcome variables included the occurrence of late sepsis since performing the NDT, length of stay in the NICU, the interval between gavage feeding and oral feeding.

6. Statistical analysis

Independent T test was used for continuous variables and Chi-square test (Pearson and Fisher's exact test) was used for categorical variables. A two-way mixed repeated measures ANOVA was used to analyze the cluster scores of the NBAS and HNNE during the 1st, 2nd, and 3rd assessment. Multiple linear regression models were used for predicting the independent factor of the total score. Bivariate correlation was used for determining the relationship between the total scores and other variables. All analyses were conducted by using SPSS 17.0. The statistical significance level was chosen to be $P < 0.05$.

Results

1. Characteristics of patients

The characteristics of the infants and their mothers are

presented in Table 1. The GA was $30.57 (\pm 2.03)$ weeks in the VPI subgroup, $35.31 (\pm 0.78)$ week in the LPI subgroup and $39.30 (\pm 0.83)$ weeks in the FC group. The PI group showed a significantly lower GA, Apgar score, BW, HC and height, and higher multiple birth rate, and Cesarean section rate when statistically compared with the FC group. There were no small for gestational age (SGA) infants, twin infants, pregnancy induced hypertension mothers and mothers who were smoking and drinking during pregnancy in the FC group. Among the PI group, the VPI subgroup showed statistically significant lower GA, BW, Apgar scores at 1 minute and at 5 minutes, and rate of antenatal steroid use when compared with the LPI subgroup. The risk factors for the infants are presented in Table 2. The VPI subgroup showed a statistically frequent use of mechanical ventilator and surfactant when compared with the LPI subgroup. The VPI subgroup showed severe BPD, severe IVH, severe ROP, PDA treated medically and surgically than that seen in the LPI

Table 1. Characteristics of the Infants and Their Mothers

	PI			FC	
	VPI (GA <34 wk) Mean (SD or %)	LPI (GA ≥34 wk) Mean (SD or %)	P-value	Mean (SD or %)	P-value
Number of infants	14	28		20	
Infant					
Gestational age (week)	30.57 (± 2.03)	35.31 (± 0.78)	0.000	39.30 (± 0.83)	0.000
Apgar score at 1 min	4.29 (± 1.86)	5.93 (± 1.67)	0.006	7.65 (± 0.75)	0.000
Apgar score at 5 min	6.21 (± 1.81)	7.54 (± 1.53)	0.017	8.95 (± 0.22)	0.000
Birth weight (kg)	1.47 (± 0.43)	2.17 (± 0.35)	0.000	3.07 (± 0.26)	0.000
Height at birth (cm)	39.95 (± 3.44)	45.25 (± 2.77)	0.000	48.63 (± 1.89)	0.000
Head circumference at birth (cm)	28.11 (± 2.37)	31.69 (± 1.49)	0.000	33.71 (± 1.43)	0.000
Birth at any other hospital	2 (14.3%)	8 (28.6%)	0.451	19 (95.0%)	0.000
Male infants	6 (42.9%)	15 (53.6%)	0.513	10 (50.0%)	1.000
SGA	2 (14.3%)	4 (14.3%)	0.358	0 (0%)	0.153
Cesarean section	9 (64.3%)	19 (67.9%)	0.817	8 (40.0%)	0.047
Multiple birth	3 (21.4%)	12 (42.9%)	0.172	0 (0%)	0.002
Mother					
Age	29.86 (± 4.72)	32.04 (± 5.04)	0.179	30.92 (± 2.66)	0.791
Placental biopsy			0.330		
Mild, moderate chorioamnionitis	9 (64.3%)	11 (39.3%)	0.011		
Severe chorioamnionitis	1 (7.1%)	1 (3.6%)			
Antenatal steroid					
Complete use	3 (21.4%)	10 (35.7%)	0.608		
Incomplete use	4 (28.6%)	0 (0%)			
Maternal PIH	1 (7.1%)	1 (3.6%)	0.608	0 (0%)	0.321
Drinking and smoking during pregnancy	1 (7.1%)	1 (3.6%)	0.608	0 (0%)	0.321

Abbreviations: PI, preterm intervention; FC, full term control; GA, gestational age; SGA, small for gestational age; PIH, pregnancy induced hypertension.

subgroup.

2. Primary outcome – motor development outcome

The interventions were conducted 9.36 ± 0.76 times in the VPI subgroup and 9.11 ± 0.50 times in the LPI subgroup. The time of the 3rd assessment in the VPI subgroup, the LPI subgroup and the FC group GA was 39.94 ± 0.34 , 39.92 ± 0.30 , and 39.00 ± 1.07 weeks, respectively. There were no significant difference between the body weight of infants in the VPI subgroup, the LPI subgroup and the FC group at 40 weeks' PMA, at the time of the 3rd assessment (Table 3).

Table 2. Risk Factors for the Premature Intervention Group

	PI		P-value
	VPI (GA <34 wk) Mean (%)	LPI (GA $\geq$ 34 wk) Mean (%)	
Early respiratory support			0.001
O ₂ inhalation	2 (14.3%)	12 (42.9%)	
Nasal CPAP	3 (21.4%)	10 (35.7%)	
Mechanical ventilation	9 (64.3%)	2 (7.1%)	
Surfactant	9 (64.3%)	2 (7.1%)	0.000
BPD			0.000
Mild	3 (21.4%)	0 (0%)	
Moderate	3 (21.4%)	0 (0%)	
Severe	3 (21.4%)	0 (0%)	
IVH			0.004
Grade I/II	4 (28.6%)	1 (3.6%)	
Grade III/IV	3 (21.4%)	0 (0%)	
Severe ROP	1 (7.1%)	0 (0%)	0.049
PDA Tx.			
Medication	5 (35.7%)	0 (0%)	0.179
Surgery	1 (7.1%)	0 (0%)	0.330

Abbreviations: PI, preterm intervention; GA, gestational age; BPD, bronchopulmonary dysplasia; IVH, intraventricular hemorrhage; ROP, retinopathy of prematurity; PDA, patent ductus arteriosus.

The total scores of all the clusters (HNNE, NBAS) and the average scores were significantly improved in the VPI and LPI subgroups between the 1st, 2nd, and 3rd assessment by repeated measure ($P=0.000$) (Table 4). The average scores at the time of 3rd assessment were higher in the PI group than in the FC group (Fig. 2). The total scores and the average scores at 40 weeks' PMA were higher in the LPI subgroup than in the VPI subgroup. Also, the PI group had higher total scores and average scores of the sum of HNNE and NBAS at 40 weeks' PMA, respectively than the FC group ($P=0.000$) (Table 5). Controlling for the time of the 3rd assessment, sex, GA, and Apgar score at 1 minute and at 5 minutes, there was still a significant difference in the total scores between the PI and FC groups using a multiple regression model ($P=0.000$). Also, our study showed a negative relationship between the total score and the use of the early respiratory support and surfactant, BPD, IVH, ROP, PDA and GA based on the Pearson correlation tests at 0.05 significance levels (Table 6).

3. Primary outcome – growth outcome

Body weight gain improved between the 1st and 3rd assessment in both the VPI and LPI subgroups (Table 7). The LPI subgroup showed more weight gain and change in the HC between the 1st and 3rd assessment by repeated measure ($P<0.05$) (Table 8). The LPI subgroup showed a tendency for more body weight gain than the VPI subgroup between the 2nd and 3rd assessment (45.96 ± 22.12 g/day vs. 32.66 ± 14.43 g/day, $P=0.068$) (Table 7).

Table 3. Intervention and Assessment

	PI			FC	
	VPI (GA <34 wk) Mean (SD)	LPI (GA $\geq$ 34 wk) Mean (SD)	P-value	Mean (SD)	P-value
Number of interventions	9.36 (± 0.76)	9.11 (± 0.50)	0.202		
Time of the 1st assessment (week)	35.61 (± 0.80)	36.05 (± 0.63)	0.058		
Time of the 2nd assessment (week)	37.65 (± 0.87)	37.99 (± 0.66)	0.166		
Time of the 3rd assessment (week)	39.94 (± 0.34)	39.92 (± 0.30)	0.910	39.00 (± 1.07)	0.000
Interval between 1st and 2nd assessment (day)	14.43 (± 1.22)	13.46 (± 1.23)	0.021		
Interval between 2nd and 3rd assessment (day)	15.25 (± 4.25)	13.58 (± 3.54)	0.421		
Body weight at the time of the 3rd assessment (kg)	2.92 (± 0.49)	3.05 (± 0.44)	0.280	3.05 (± 0.30)	0.676

Abbreviations: PI, preterm intervention; FC, full term control; GA, gestational age.

Table 4. Motor Development between the 1st, 2nd, and 3rd Assessment

		Average at the 1st assessment Mean (SD)	Average at the 2nd assessment Mean (SD)	Average at the 3rd assessment Mean (SD)	P-value
VPI (GA <34 wk)	HNNE				
	Posture and tone	1.45 (±0.33)	2.60 (±0.40)	3.34 (±0.49)	0.003
	Tone pattern	3.57 (±0.38)	4.15 (±0.57)	4.50 (±0.18)	0.176
	Reflexes	1.68 (±0.44)	2.80 (±0.36)	3.24 (±0.21)	0.009
	Movements	1.45 (±0.63)	2.68 (±0.51)	3.22 (±0.59)	0.001
	Abnormal signs/patterns	2.83 (±0.69)	4.12 (±0.48)	4.53 (±0.48)	0.353
	Orientation and behavior	1.85 (±0.52)	3.12 (±0.57)	3.68 (±0.38)	0.002
	NBAS				
	Motor system	2.33 (±0.75)	4.01 (±0.89)	4.88 (±0.87)	0.000
	Autonomic system	4.12 (±0.55)	5.36 (±0.55)	6.08 (±0.74)	0.000
LPI (GA ≥34 wk)	Supplementary item	2.86 (±0.59)	4.49 (±0.57)	5.47 (±0.68)	0.002
	Average of HNNE and NBAS	2.20 (±0.36)	3.41 (±0.42)	4.00 (±0.41)	0.000
	HNNE				
	Posture and tone	1.76 (±0.22)	2.89 (±0.31)	3.75 (±0.29)	0.287
	Tone pattern	3.63 (±0.51)	4.42 (±0.27)	4.53 (±0.16)	0.078
	Reflexes	1.99 (±0.28)	3.10 (±0.20)	3.30 (±0.06)	0.085
	Movements	1.94 (±0.54)	3.05 (±0.33)	3.69 (±0.45)	0.001
	Abnormal signs/patterns	3.31 (±0.68)	4.19 (±0.53)	4.60 (±0.28)	0.005
	Orientation and behavior	2.24 (±0.37)	3.46 (±0.28)	3.89 (±0.17)	0.011
	NBAS				
	Motor system	2.94 (±0.52)	4.46 (±0.63)	5.39 (±0.61)	0.057
	Autonomic system	4.64 (±0.65)	6.01 (±0.63)	6.58 (±0.48)	0.000
	Supplementary item	3.23 (±0.59)	4.82 (±0.65)	5.99 (±0.61)	0.030
	Average of HNNE and NBAS	2.59 (±0.24)	3.78 (±0.24)	4.37 (±0.23)	0.004

Abbreviations: GA, gestational age; HNNE, Hammersmith Neonatal Neurological Examination; NBAS, Neonatal Behavioral Assessment Scale.

Table 5. The Total and the Average Scores of the Sum of the HNNE and NBAS at 40 Weeks PMA in the PI and the FC Groups

	PI			FC	
	VPI (GA <34 wk) Mean (SD)	LPI (GA ≥34 wk) Mean (SD)	P-value	Mean (SD)	P-value
Number	14	28		20	
Total score	221.92 (±21.97)	240.17 (±12.75)	0.003	196.85 (±11.44)	0.000
Average score	4.00 (±0.41)	4.37 (±0.23)	0.002	3.66 (±0.25)	0.000

Abbreviations: HNNE, Hammersmith Neonatal Neurological Examination; NBAS, Neonatal Behavioral Assessment Scale; PMA, postmenstrual age; PI, preterm intervention; FC, full term control; GA, gestational age.

4. Secondary outcome

The LPI subgroup showed a significantly shorter transitional period from gavage feeding to oral feeding and in the length of the stay in the NICU as compared to the VPI subgroup. There was no apnea and bradycardia during intervention, and late sepsis after intervention in the PI group (Table 9).

Discussion

In this study, we investigated the effects and efficiency of NDT on growth and motor development and the usefulness of HNNE and NBAS in assessing neurodevelopment in the premature infants. For this, we performed the NDT on motor development and growth in the premature infants.

With regards to the NDT in premature infants, many previous studies have reported about the various inter-

Fig. 2. Average of each clusters in the VPI subgroup, LPI subgroup, and the FC group at the 1st assessment (before NDT), at the 2nd assessment (2 weeks after the NDT), and at the 3rd assessment (40 weeks PMA). Average scores of 6 clusters of HNNE (Posture and tone, Tone pattern, Reflex, Movement, Abnormal sings/patterns, Orientation and behavior), 3 clusters of NBAS (Motor system, Autonomic system, Supplementary items), and average of total score were calculated. The average scores of each clusters of HNNE and NBAS were improved and the average scores at the time of the 3rd assessment were higher in the PI group than the FC group, especially LPI subgroup.

ventions including the positioning^{9, 10)}, stimulation¹¹⁾, handling¹²⁾, and nonnutritive sucking¹³⁾. These interventions were usually provided by parents¹⁴⁾, occupational therapists, developmental specialists, nurses, social workers¹⁵⁾. At our NICU, oral stimulation and positional intervention by the physical therapist in the incubator of the NICU were performed usually, and no complications from these

Table 6. Pearson Correlation Tests at 0.05 Significant Levels

Variable	Pearson coefficient of correlation
Total score	1
Use of the early respiratory support	-0.625
Use of the surfactant	-0.631
BPD	-0.639
IVH	-0.724
ROP	-0.567
PDA	-0.693
Gestational age	-0.381

BPD, bronchopulmonary dysplasia; IVH, intraventricular hemorrhage; ROP, retinopathy of prematurity; PDA, patent ductus arteriosus.

Table 7. Growth Outcome between the VPI Subgroup and the LPI Subgroup

	PI		P-value
	VPI (GA <34 wk) Mean (SD)	LPI (GA ≥34 wk) Mean (SD)	
Change in the body weight between the 1st and 2nd assessment (g/d)	25.30 (±19.70)	24.02 (±13.38)	0.804
Change in the body weight between the 2nd and 3rd assessment (g/d)	32.66 (±14.43)	45.96 (±22.12)	0.068
Change in the height between the 1st and 2nd assessment (cm/d)	0.099 (±0.061)	0.156 (±0.191)	0.286
Change in the height between the 2nd and 3rd assessment (cm/d)	0.143 (±0.082)	0.181 (±0.106)	0.281
Change in the HC between the 1st and 2nd assessment (cm/d)	0.097 (±0.072)	0.088 (±0.071)	0.695
Change in the HC between the 2nd and 3rd assessment (cm/d)	0.098 (±0.054)	0.128 (±0.074)	0.230

Abbreviations: PI, preterm intervention; GA, gestational age; HC, head circumference.

interventions were observed, which is consistent with the results from the previous study^{9-11, 13)}. There are many methods for assessment of the effect of NDT, including Bayley Scales of Infant Development (BSID)¹⁶⁾, Assessment of Preterm Infant's Behavior (APIB)¹⁷⁾, Brazelton Cambridge Newborn Scale (BCNS)¹⁸⁾, Cattell Infant Intelligence Scale (CIIS)¹⁸⁾, Infant Behavioral Assessment and Intervention Program (IBAIP)¹⁹⁾, Test of Infant Motor Performance (TIMP)²⁰⁾, NBAS^{6, 7, 21)}. At our NICU, HNNE and NBAS are

Table 8. Change in the growth between the 1st and 2nd assessment and between the 2nd and 3rd assessment in the VPI and the LPI subgroups

	Mean	SD	Standard error of mean	Lower limit	Upper limit	<i>t</i>	Degree of freedom	Significance probability
GA <34 wk (VPI)								
Body weight change1-Body weight change2	-7.19	27.77	8.02	-24.84	10.45	-0.90	11	0.389
HT change1-HT change2	-0.04	0.12	0.35	-0.12	0.04	-1.17	11	0.269
HC change1-HC change2	-0.00	0.12	0.03	-0.08	0.07	-0.09	11	0.928
GA ≥34 wk (LPI)								
Body weight change1-Body weight change2	-22.25	23.86	4.87	-32.33	-12.18	-4.57	23	0.000
HT change1-HT change2	-0.04	0.21	0.04	-0.13	0.05	-0.84	23	0.408
HC change1-HC change2	-0.05	0.10	0.21	-0.09	-0.01	-2.37	23	0.027

Abbreviations: HT, Height; HC, Head circumference

change 1: change between 1st assessment and 2nd assessment, change 2: change between 2nd assessment and 3rd assessment

Table 9. Secondary Outcome

	PI		<i>P</i> -value
	VPI (GA <34 wk) Mean (SD)	LPI (GA ≥34 wk) Mean (SD)	
Transitional period from gavage feeding to oral feeding (day)	25.71 (±28.29)	9.93 (±6.73)	0.007
Length of stay in the NICU (day)	76.07 (±41.79)	26.57 (±11.54)	0.000
Apnea and bradycardia during intervention	0	0	
Late sepsis after intervention	0	0	

usually performed for these purposes. These assessments were conducted by physical therapist before the intervention (1st assessment), at 2 weeks after the intervention (2nd assessment) and at 40 weeks' PMA (3rd assessment). Also, we usually checked the short-term prognosis by conducting intervention and assessment during the care in the NICU and at 40 weeks PMA, and compared with the other institutions doing assessments outside the NICU.

With regards to motor development, we have seen a significant improvement between the 1st, 2nd, and 3rd assessment when the NDT was conducted in the premature infants in the NICU, which was in agreement with the previous reports^{14, 19, 22}. Premature infant group was subdivided into the VPI subgroup (<34 weeks of GA) and the LPI subgroup (≥34 weeks of GA) modified from the previous report²³. Both the VPI and LPI subgroups showed improvement in all the clusters of the NBAS and the HNNE. Also, these improvements were more noticeable when we compared between the FC group and the PI group at the time of the 3rd assessment (40 weeks' PMA). Controlling for the time of the 3rd assessment and other multiple factors,

there was still a significant difference in the total scores between the PI group and the FC group using a multiple regression model, the PI group had more improving total scores than the FC group because the PI group was more susceptible to the intervention. High-risk patients who needed early respiratory support, had severe BPD, severe IVH, severe ROP, PDA showed less scores at 40 weeks' PMA than in the others based on the Pearson correlation tests, even though they had improving total scores between the 1st, 2nd, and 3rd assessment which is in conjunction with the previous reports^{8, 24}. Among the items of motor development assessments, 5 items (flexor tone, leg extensor tone, increase extensor tone, tendon reflex, eye appearance) did not show any noticeable difference after the intervention because of such factors as unskilled physical therapist, wrong scoring and so on. Further studies are needed to confirm the exact effects of NDT on these items of motor development in premature infants. With regards to the growth outcome, the PI group showed more weight gain without secondary sepsis between the 1st, 2nd, and 3rd assessment, especially in the LPI subgroup, which was in

agreement with the previous reports²⁵⁾. Also, the LPI subgroup had a shorter transitional period from gavage feeding to oral feeding¹¹⁾ and a shorter length of stay in the NICU as compared with the VPI subgroup, even though we did not compare with the premature control group which was in agreement with the other reports⁹⁾.

The LPI subgroup showed higher total scores and average score of the sum of HNNE and NBAS at 40 weeks' PMA, and more weight gain and change in the HC between the 1st and 3rd assessment than in the VPI subgroup. It seems that the NDT might have a more positive effect in the LPI subgroup than in the VPI subgroup^{10, 26)}. More studies will be needed to determine the effect of NDT in the premature groups.

Based on the results from our study and from the previous reports, we suggest that the NDT in premature infants is one of the good modalities for growth and motor development, and the HNNE and NBAS are useful methods for assessing neurodevelopment in premature infants, even though there were some limitations to our study, including a lack of premature control group, no long-term outcome.

한글요약

목적: 본 연구의 목적은 미숙아에게 조기 중재 프로그램을 시행할 때 운동 발달과 성장에 미치는 효과와 발달 평가 도구(NBAS, HNNE)의 유용성을 조사하고자 하였다.

방법: 부산성모병원에서 태어난 42명의 미숙아와 부산성모병원과 좋은문화병원에서 태어난 20명의 만삭아를 대상으로 하였다. 조기 중재 프로그램과 발달 평가는 신생아 중환자실 물리치료사에 의해 시행되었다. 자료는 전향적으로 수집되었다.

결과: 재태주령 34주 미만의 미숙아 중재 그룹에서 인공호흡기와 폐표면활성제 사용, 심한 기관지 폐 이행성증, 뇌실 내 출혈, 수술을 시행한 동맥관 개존증이 재태주령 34주 이상 37주 미만 미숙아 중재 그룹보다 많았다. 미숙아 중재 그룹은 1번째, 2번째, 3번째 평가에서 NBAS와 HNNE 평균 점수의 향상을 보였다($P=0.000$). 미숙아 중재 그룹은 재태주령 40주 평가에서 만삭아 대조 그룹에 비해 더 높은 NBAS와 HNNE 평균 점수를 보였다($P=0.000$). 재태주령 34주 이상 37주 미만 미숙아 중재 그룹은 1번째와 3번째 평가 사이에 체중과 두위의 더 많은 성장을 보였

다($P<0.05$). 미숙아 중재 그룹은 중재와 평가 중 무호흡, 서맥, 후기 패혈증이 없었다.

결론: 조기 중재 프로그램은 미숙아의 운동 발달과 성장에 양호한 영향을 미쳤다. 발달 평가 도구(NBAS, HNNE)는 미숙아의 운동 발달을 평가하는 안전하고 유용한 도구로 사용될 수 있다고 생각한다.

References

- 1) Kim MS. The effects of sensory simulation on body weight and behavioral states of premature infant [dissertation]. [Seoul]: Yonsei University; 2000.
- 2) Holditch-Davis D, Bartlett TR, Belyea M. Developmental problems and interactions between mothers and prematurely born children. *J Pediatr Nurs* 2000;15:157-67.
- 3) Long JG, Philip AG, Lucey JF. Excessive handling as a cause of hypoxemia. *Pediatrics* 1980;65:203-7.
- 4) Gottfried AW, Gaiter JL. Infant stress under intensive care [dissertation]. [Baltimore]: Park Press University; 1985.
- 5) Lester BM, Tronick EZ. Guidelines for stimulation with preterm infants. *Clin Perinatol* 1990;17:xv-xvii.
- 6) Ohgi S, Fukuda M, Akiyama T, Gima H. Effect of an early intervention programme on low birthweight infants with cerebral injuries. *J Paediatr Child Health* 2004;40:689-95.
- 7) Kusaka R, Ohgi S, Gima H, Fujimoto T. Short-term effects of the neonatal behavioral assessment scale-based intervention for infants with developmental disabilities. *J Phys Ther Sci* 2007;19:1-8.
- 8) White-Traut RC, Nelson MN. Maternally administered tactile, auditory, visual, and vestibular stimulation: Relationship to later interactions between mothers and premature infants. *Res Nurs Health* 1988;11:31-9.
- 9) Gaetan EM, Moura-Ribeiro MV. Developmental study of early posture control in preterm and fullterm infants. *Arq Neuropsiquiatr* 2002;60:954-8.
- 10) Monterosso L, Kristjanson LJ, Cole J, Evans SF. Effect of postural supports on neuromotor function in very preterm infants to term equivalent age. *J Paediatr Child Health* 2003;39:197-205.
- 11) Fucile S, Gisel E, Lau C. Oral stimulation accelerates the transition from tube to oral feeding in preterm infants. *J Pediatr* 2002;141:230-6.
- 12) Achenbach TM, Howell CT, Aoki MF, Rauh VA. Nine-year outcome of the Vermont intervention program for low birth weight infants. *Pediatrics* 1993;91:45-55.
- 13) Boiron M, Da Nobrega L, Roux S, Henrot A, Saliba E. Effects of oral stimulation and oral support on non-nutritive sucking and feeding performance in preterm infants. *Dev Med Child Neurol* 2007;49:439-44.
- 14) Vanderveen JA, Bassler D, Robertson CM, Kirpalani H. Early

- interventions involving parents to improve neurodevelopmental outcomes of premature infants: a meta-analysis. *J Perinatol* 2009; 29:343-51.
- 15) Mahoney MC, Cohen MI. Effectiveness of developmental intervention in the neonatal intensive care unit: implications for neonatal physical therapy. *Pediatr Phys Ther* 2005;17:194-208.
 - 16) Resnick MB, Eyler FD, Nelson RM, Eitzman DV, Bucciarelli RL. Developmental intervention for low birth weight infants: improved early development outcome. *Pediatrics* 1987;80:68-74.
 - 17) Mouradian LE, Als H. The influence of neonatal intensive care unit caregiving practices on motor functioning of preterm infants. *Am J Occup Ther* 1994;48:527-33.
 - 18) Scarr-Salapatek S, Williams ML. The effects of early stimulation on low-birth-weight infants. *Child Dev* 1973;44:94-101.
 - 19) Koldewijn K, Wolf MJ, van Wassenae A, Beelen A, de Groot IJ, Hedlund R. The Infant Behavioral Assessment and Intervention Program to support preterm infants after hospital discharge: a pilot study. *Dev Med Child Neurol* 2005;47:105-12.
 - 20) Lekskulchai R, Cole J. Effect of a developmental program on motor performance in infants born preterm. *Aust J Physiother* 2001;47:169-76.
 - 21) Tronick EZ. The neonatal behavioral assessment scale as a biomarker of the effects of environmental agents on the newborn. *Environ Health Perspect* 1987;74:185-9.
 - 22) Laudert S, Liu WF, Blackington S, Perkins B, Martin S, Macmillan-York E, et al. Implementing potentially better practices to support the neurodevelopment of infants in the NICU. *J Perinatol* 2007;27 Suppl 2:S75-93.
 - 23) Kalia JL, Visintainer P, Brumberg HL, Pici M, Kase J. Comparison of enrollment in interventional therapies between late-preterm and very preterm infants at 12 months' corrected age. *Pediatrics* 2009; 123:804-9.
 - 24) Resnick MB, Armstrong S, Carter RL. Developmental intervention program for high-risk premature infants: effects on development and parent-infant interactions. *J Dev Behav Pediatr* 1988;9:73-8.
 - 25) Mendes EW, Procionoy RS. Massage therapy reduces hospital stay and occurrence of late-onset sepsis in very preterm neonates. *J Perinatol* 2008;28:815-20.
 - 26) Cameron EC, Maehle V, Reid J. The effects of an early physical therapy intervention for very preterm, very low birth weight infants: a randomized controlled clinical trial. *Pediatr Phys Ther* 2005;17:107-19.