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The Impact of Physiotherapy on the Developmental Progress of Preterm Infants Hospitalized in the Intensive Care Unit

Argyro Hatzopoulou 1, Stilianos Xinias 2, Ourania Papadopoulou 3, Antigoni Mavroudi4, Emmanouil Trevlakis 5, Anna Chalkia 6, Ioannis Xinias7, Alexandra Hristara8

1 MSc Pediatric Physiotherapist, Hippocration Hospital, Thessaloniki, Greece
2 Dr Med, Trainee Pediatrician, Aristotle University Thessaloniki
3 MSc Physiotherapist, Academic Fellow of International University of Greece
4 Professor of Pediatric Allergy, Aristotle University
5 Fellow assistant of International University of Greece
6 Assistant Professor of International University of Greece
7 Professor of Pediatric Gastroenterology,
8 Professor of Physiotherapy, International University of Greece

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Abstract

Introduction: Every year, worldwide, 14.9 million babies are born prematurely. Therefore, these children are at greater risk of respiratory, cardiac, and neurodevelopmental disorders.

Purpose: The purpose of the study was to investigate the effectiveness of physiotherapy intervention in premature newborns and whether the utilized techniques promote their normal development

Patients: the study population consisted of 20 randomly selected neonates. The 20 neonates were randomly divided into two groups, the intervention group (Group A, 10 neonates) and the control group (Group B, 10 neonates).

Methods: In the newborns of the intervention group (A), an intervention was carried out that focused on the correct positioning in a "nest" (imitation of intrauterine experience), on the changes of supine, prone, right, and left side positions, on the reduction or elimination of stress signs and passive mobilization in the supine position. Oxygen saturation (SpO2) and heart rate were continuously recorded, as well as neurodevelopmental assessment and recording of any feeding problems. weight gain, but also the length of stay of newborns in the hospital.

Results: Oxygen saturation was clearly improved in premature neonates who followed respiratory physical therapy as well as improved (decreased) heart rate. Neurological examination in the neonates of the intervention group was normal and none showed feeding problems. It was also found that the newborns in the intervention group had a more stable rate of weight gain compared to the newborns in the control group.

Conclusions: It is considered necessary to implement early intervention programs to prevent or minimize the negative effects of prematurity on the respiratory and neurodevelopmental development of newborns

Introduction

Prematurity is defined as the birth of a child before the 37th week of gestation. Internationally, the average rate of preterm births is around 11.1%. When an infant is born prematurely, while its maturation is still in progress, frequent neurodevelopmental and respiratory medical monitoring is essential. Additionally, close monitoring of premature neonates is required, regarding their nutritional and metabolic profiles, with necessary support provided as needed (1). Most infants born extremely premature (<28 weeks of gestation) are not adapted and practically are unprepared to survive outside the uterus. Survival achievement does not ensure the good development and health of preterm infants, who may potentially develop chronic neurodevelopmental problems (1). Preterm infants face a multitude of problems that manifest after birth. Moreover, prematurity can be a cause of long-term disorders that require monitoring and interventions (2,3). It has been found that depending on birth weight and gestational age, a preterm birth can cause neurodevelopmental disorders of varying severity.

Research on children born prematurely has shown disorders in behavior, cognitive and perceptual abilities, academic performance, difficulties in adaptation, concentration, hyperactivity, and motor disorders (4,5). It was found that 25% of infants born between 28 and 32 weeks of gestation presented neurodevelopmental disorders (6).

Infants requiring intensive medical care are hospitalized in Neonatal Intensive Care Units (NICUs). NICUs combine advanced technology and trained healthcare professionals to provide specialized care. NICUs have intermediate or continuous care areas for infants who are not as sick but still require specialized nursing and physiotherapy care.

The neurodevelopmental progression of preterm infants is influenced during their hospitalization in the NICU. The infant's brain during NICU stay undergoes a critical period of development between the 24th and 40th weeks of gestation. Factors influencing the neurological development of preterm infants during hospitalization include the formation of synaptic and neural connections, multiplication of significant structures, environmental stimulation, and interactions between parents and infants.

The effectiveness of interventions during hospitalization has been evaluated in previous systematic studies. These interventions include developmental care, noise reduction in the NICU, skin-to-skin contact, and early parental interventions. While research data highlight the long-term development of preterm infants, studies investigating the effectiveness of interventions in the neurodevelopment of preterm infants during their NICU stay are limited (10,11).

The provision of developmental care for neonates in the NICU includes the use of individualized positioning strategies for infants. Positioning and handling are two fundamental components of neonatal care in the neonatal unit (12). To achieve the best possible outcomes, healthcare professionals should collaborate with the neonatology team to facilitate individualized recommendations for infant positioning. This collaboration aims to promote desired motor outcomes, self-regulation abilities, and prevention of respiratory risks (13).

Chest physiotherapy is applied to preterm infants to remove secretions, assist in cases of atel-ectasia, and generally promote lung ventilation (14). However, concerns about the safety of certain forms of chest physiotherapy have been raised, especially for very low birth weight neonates and infants, due to the risk of brain injury associated with some chest physiotherapy techniques. Nevertheless, active respiratory physiotherapy may prove to be an effective intervention for preterm infants. Chest physiotherapy techniques such as percussion, vibration, and compression are performed in the NICU to prevent complications in the chest cavity (15).

Over the past 20 years, several studies have been conducted to investigate the impact of tactile and kinesthetic stimulation (TKS) on preterm infants. These studies have shown that TKS therapy can have positive effects on preterm infants, such as rapid weight gain, shorter hospital stays, and improvement in behavioral and motor responses of the infant (16). The evidence indicates that improvements in weight gain are related to improved metabolism leading to smoother weight gain (17).

Additionally, the environment of a newborn has a significant impact on sensory, neural, and behavioral development. Complementary and alternative medical therapies aim to create an environment that reflects the intrauterine environment. Many neonatal units seek to modify existing conditions by emphasizing environmental modifications that include particular attention to noise levels, exposure to light, organization of care, and family-centered care (18).

The recognition that improving the conditions of care can play a significant role in the future development of preterm infants has led to continuous research, with the collaboration and participation of various neonatal units, to achieve improvements in the way care is provided for a variety of neurological conditions (19). Furthermore, many complementary and alternative medical practices currently applied in neonatal units are referred to as developmental care.

Purpose

The purpose of this study is to investigate the extent to which the neurodevelopment of premature infants may be affected by the implementation of specific physiotherapy techniques during their hospitalization in the Neonatal Intensive Care Unit (NICU). Specifically, the aim is to examine the impact of early intervention in the NICU on improving the overall developmental level of the newborn, using passive mobilization and proper positioning techniques, as well as on preventing potential compensations or correcting pathological patterns through personalized intervention. Additionally, the goal is to assess the effect of these specific physiotherapy methods on the vital signs of the neonates, on improving feeding, on weight gain, and on the length of hospital stay.

Patients

The study included 20 neonates selected randomly. The selection criteria for the neonates were gestational age ranging from 24 to 37 weeks and birth weight ranging from 600 to 3190 grams. Neonates with congenital abnormalities or syndromes, those requiring surgical intervention, and neonates of substance-dependent mothers were excluded from the study. The 20 neonates were randomly divided into two groups, with the first group (Group A) being the control group (10 neonates) and the second group (Group B) being the intervention group (10 neonates).

Methods

The assessment tools used for the implementation of the study were:

a) oxygen saturation and heart rate monitoring device (Masimo T 330)

b) specialized infant scale

c) form for recording monitor indications

d) form for recording other significant stress points of the intervention

e) form for recording anthropometric data of the neonate

f) positioning aids for neonates simulating the womb, "nests" constructed according to the size and weight of the neonate.

Initially, both groups of patients had their clinical condition and medical history recorded. Neonates receiving early intervention followed a specific program after their transfer from level 3 to level 2 intensive care once their health condition had stabilized.

The interventions were conducted by the same neonatal pediatric physical therapist. Each intervention lasted for 20 minutes and took place on a daily basis over a period of 20 days or until discharge, excluding weekends. In group A neonates, the intervention focused on proper positioning in nests (mimicking intrauterine experience), changing positions to prone, supine, right lateral, and left lateral, reducing, or eliminating stress points, and passive mobilization in the supine position. Position changes were made not only during the intervention but throughout the neonates' hospital stay.

The physical therapy intervention was conducted following the assessment of the neonates and the identification of any dysfunctions or deficits they may have presented. In cases where neonates had not developed deficits or dysfunctions, the goal was to normalize muscle tone, guide normal movement patterns, and ensure good feeding ability. In the control group neonates, daily recordings were made of oxygen saturation, heart rate, weight, and assessment of their neurological status upon discharge from the hospital, without receiving any other form of intervention.

The early intervention program aimed to:

a) enhance symmetry and movement in the midline of the body

b) improve symmetry of the head

c) strengthen flexor ability

d) prevent neck hyperextension when it occurred

e) enhance hand-to-mouth approach

f) reduce stress points

g) enhance experience in all positions (supine, prone, right and left side)

h) strengthen the lumbar region and trunk to facilitate feeding.

The goal of this specific early intervention method was the normal motor development of the neonates. The neonates who received intervention were compared with those who did not.

Results

Initially, regarding the birth weight of the neonates, both the control and intervention groups did not show significant differences. The birth weight of preterm neonates in the control group ranged from 850 grams to 3,140 grams, with a mean weight of 1,621 grams. The mean weight of the intervention group is 1,501.2 grams, ranging from 950 grams to 1,870 grams.

1.Statistical measures of central tendency and dispersion for birth weight.

	n	Mean	SD	Median	Min	Max
Control Group	10	1.621,0	668,34	1570	850	3.140
Intervention Group	10	1.501,2	293,31	1545	950	1.870

Regarding the gestational age of the neonates, the analysis revealed that the minimum value in both groups was 29 weeks. The maximum value differed by 2 weeks, but the mean gestational age was similar, namely 32.2 weeks for the control group and 32 weeks for the intervention group.

2.Statistical measures of central tendency and dispersion for gestational weeks.

	n	Mean	SD	Median	Min	Max
Control Group	10	32,20	3,1	31,5	29	36
Intervention Group	10	32,00	1,8	32,5	29	34

Next, there was conducted a comparison between the head circumference and body length. From the data in the table below, no differences were observed between the two groups.

3.Statistical measures of central tendency and dispersion for head circumference and body length at birth.

	n	Mean	SD	Median	Min	Max
Head Circumference (cm)						
Control Group	10	28,49	2,1	28,6	26	31
Intervention Group	10	28,31	1,2	28,5	27	30
Body Length (cm)						
Control Group	10	40,10	5,2	40,25	32	48
Intervention Group	10	41,00	2,8	41,00	37	45

Regarding oxygen saturation (SpO2) and heart rate (pulses), it was observed that stabilized premature infants in the control group had a mean oxygen saturation of 92.2% with a standard deviation of 1.55, while premature infants in the intervention group had a mean oxygen saturation of 93.7% with a standard deviation of 1.70. Although there were differences between the two groups, mainly in the mean values, these were not statistically significant ($p > 0.05$).

4.Means, standard deviation, and non-parametric tests for oxygen saturation (SpO2) and heart rate between the groups before intervention.

	n	Mean	SD	Mean Rank	*Mann-Whitney*	*z value*	*p-value*
SpO2 (Before intervention)							
Control Group	10	92,2	1,55	7,9	24	-2,014	0,054
Intervention Group	10	93,7	1,70	13,1			
Heart rate (Before intervention)							
Control Group	10	171,5	14,54	11,3	42	-0,611	0,541
Intervention Group	10	169,9	15,88	9,7			

The same was observed in heart rate, where there was a minimal difference in the mean (1.6) and in the median (1.34).

Regarding the changes in oxygen saturation and heart rate, statistically significant differences were found between the two groups ($p<0.05$).

5.Means, standard deviation, and non-parametric tests for oxygen saturation (SpO2) and heart rate between the groups after intervention.

	n	Mean	SD	Mean Rank	*Mann-Whitney*	*z value*	*p-value*
SpO2 (after intervention)							
Control Group	10	92,2	1,55	5,6	1	-3,76	0,000
Intervention Group	10	96,9	1,20	15,4			
Heart rate (after intervention)							
Control Group	10	171,5	14,54	14,4	11	-2,984	0,003
Intervention Group	10	145,7	5,25	6,6			

The mean values in oxygen saturation differed by 4%, with that of the intervention group being significantly improved, and simultaneously, heart rates were at better levels compared to the control group. During the intervention, oxygen saturation values increased more, and heart rates improved at various stages of the premature infants' stay. The differences in study variables between stages were statistically significant ($p<0.05$).

6.Mean values, standard deviation, and non-parametric tests for oxygen saturation (SpO2) and heart rates during the stages of stay in the NICU during the intervention.

	N	Mean	SD	Mean Rank	*Kruskal-Wallis*	*p-value*
SpO2						
Begining	9	98,1	1,2	6,72		
Mid	10	99,5	0,7	16,65	16,252	0,000
Ending	10	99,9	0,3	20,8		

		N	Mean	SD	Mean Rank	Kruskal-Wallis	p-value
Heart rate							
	Begining	9	153,6	10,2	18,83	12,524	0,002
	Mid	10	151,4	5,5	19,15		
	Ending	10	142,5	4,2	7,4		

At the end of the intervention, statistically significant differences were also observed among the three levels of stay in the NICU. The premature infants who underwent physical therapy intervention showed continuous improvement in oxygen saturation and heart rates.

7.Mean values, standard deviation, and non-parametric tests for oxygen saturation (SpO2) and heart rate during the stages of stay in the NICU at the end of the intervention.

		N	Mean	SD	Mean Rank	*Kruskal-Wallis*	*p-value*
SpO2							
	Begining	10	96,9	1,2	7	17,619	0,000
	Mid	10	98,6	1,1	16,5		
	Ending	10	99,5	0,5	23		
Heart rate							
	Begining	10	145,7	5,3	22,85	15,589	0,000
	Mid	10	140,2	4,8	16		
	Ending	10	133,9	4,4	7,65		

Another aspect studied was whether gender affects oxygen saturation and heart rate. From the results of the following table, it becomes apparent that there are no statistically significant differences (p > 0.05).

8.Impact assessment of gender on the variability of oxygen saturation (SpO2) and heart rate at various intervention stages.

	N	Mean	SD	Mean Rank	Mann-Whitney	z-value	p-value
Begining of intervention							
SpO_2							
Male	6	96,9	2,3	17,0	95	-0,796	0,426
Female	4	96,0	3,0	14,4			
Heart rate							
Male	6	156,7	16,3	13,8	72,5	-1,693	0,090
Female	4	164,1	16,2	19,5			
During the intervention							

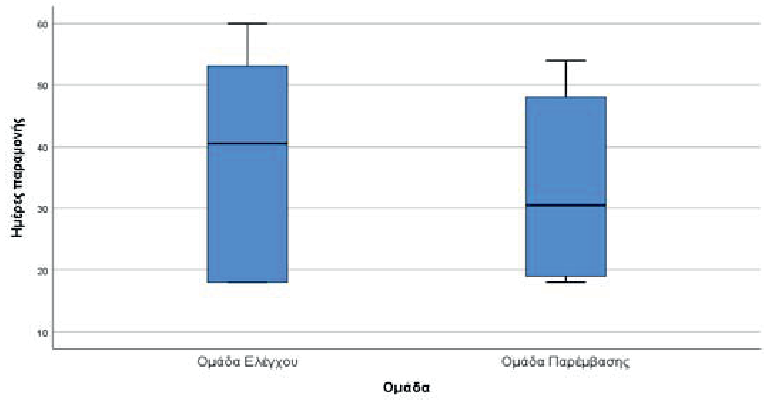
SpO_2							
Male	6	99,3	1,0	15,5	93,5	-0,413	0,680
Female	4	99,1	1,2	14,3			
Heart rate							
Male	6	148,6	10,1	14,0	84,5	-0,786	0,432
Female	4	149,6	5,2	16,5			
Ending of intervention							
SpO_2							
Male	6	98,4	1,4	15,8	102,5	-0,239	0,811
Female	4	98,3	1,5	15,0			
Heart rate							
Male	6	139,3	7,3	14,8	94,5	-0,584	0,560
Female	4	140,8	6,0	16,6			

Additionally, a check was conducted for any difference in the length of stay of neonates in the NICU. From the results, it was observed that there were no statistically significant differences ($p > 0.05$). However, upon closer examination of the data in Table 9, we find that there is an almost 4-day difference between the two groups, with a smaller standard deviation in the intervention group.

9.Means, standard deviation, and non-parametric tests for the days of stay in the NICU between the two groups.

Groups	n	Mean	SD	Median	Min	Max	*Mann-Whitney*	*p-value*
Control	10	38,0	16,9	40,5	18	60	43	0,593
Intervention	10	34,4	14,8	30,5	18	54		

The box plot below illustrates that the intervention group has fewer days of stay in the NICU. Fifty percent of premature infants in the intervention group had a stay of less than 30 days, while premature infants in the control group had a stay of less than 40 days, indicating a difference of approximately 10 days.



Finally, from the comparison of the somatometric measurements of the neonates (head circumference and body length) upon admission and discharge from the NICU, no statistically significant differences were found between the two groups. The differences were negligible, and there was no observed effect of physiotherapy intervention on the anthropometric characteristics.

10.Means, standard deviations, and non-parametric tests for somatometric characteristics

	N	Mean	SD	Mean Rank	*Mann-Whitney*	*p-value*
Head circumference (admission)						
Control Group	10	28,5	2,1	10,0	35,5	0,687
Intervention group	10	28,3	1,2	8,9		
Body length (admission)						
Control Group	10	40,1	5,2	9,0	34,5	0,624
Intervention group	10	41,0	2,8	10,2		
Head circumference (discharge)						
Control Group	10	32,1	1,1	9,9	43,5	0,615
Intervention group	10	32,3	1,0	11,2		
Body length (discharge)						
Control Group	10	44,4	2,2	9,3	37,5	0,336
Intervention group	10	45,2	1,6	11,8		

Discussion

The aim of this study was to investigate the effectiveness of early intervention using methods that promote the smooth motor development of premature infants hospitalized in a NICU. Recordings were made, among other variables, on parameters such as oxygen saturation (SpO2) and heart rate. Additionally, daily measurements of the infants' body weight were recorded. Furthermore, the duration of the infants' hospital stay was documented to explore how physiotherapy intervention affected their length of stay in the NICU.

Oxygen saturation and heart rate were significantly improved in premature infants who underwent respiratory physiotherapy. All results showed statistically significant differences. Regarding the length of hospitalization of premature infants in the NICU and the effect of physiotherapy intervention, although the results did not show statistically significant differences, it was observed that premature infants in the control group remained hospitalized for more days, indicating that the intervention was beneficial in reducing the hospitalization time.

The effect of physiotherapy intervention on the neurodevelopmental progress of the neonates was also studied. The neurological examination results for the neonates in the intervention group were normal, indicating satisfactory muscle tone for their gestational age and no more than one pathological neurological sign. Regarding the neonates in the control group, three of them had borderline neurological examination results, exhibiting greater hypotonia for their gestational age accompanied by asymmetry and unsatisfactory head control. Three neonates in the control group experienced feeding difficulties, while none of the neonates in the intervention group encountered feeding problems. Conversely, the transition to bottle feeding was quick and easy for the intervention group. A comparison of the two groups revealed advantages for the intervention group regarding weight gain.

In other words, it was observed that during early intervention, the neonates in the intervention group showed improvement in oxygen saturation, a factor that remained stable, highlighting the long-term positive outcomes. Particularly noteworthy is the issue of weight gain, which exhibited steady gradual improvement in the intervention group compared to the neonates who did not receive intervention.

It should not be overlooked that a significant advantage of early intervention programs implemented in the NICU is the alleviation of difficulties before they become entrenched, as well as the opportunity for timely management of neurodevelopmental dysfunctions before they become established and ultimately lead to deformities. (20)

Therefore, the implementation of early intervention programs is deemed necessary to prevent or minimize the negative impacts of prematurity on the neurodevelopmental progress of neonates. (21)

Considering both the continuous increase in premature birth rates and the results yielded by this particular study, the need for designing and implementing intervention programs for preterm infants is recognized. This is to make the support of neonates as effective as possible and to ensure the quality of life for these children.

Conclusions

In this context, there is an urgent need for further research targeting, at a primary level, an expanded study sample. It is essential for research to be conducted with a diverse sample to ensure safe results. At a secondary level, future research should leverage more assessment tools.

Lastly, at a tertiary level, a comparative approach between similar intervention and control groups should be pursued.

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Panhellenic Physiotherapists Association
34 Alexandras St. Athens, 11 473
Tel: 210 8213905, 210 8213334
Fax: 210 8213760
E-mail: ppta@otenet.gr • www.psf.org.gr