RESEARCH ARTICLE

Physiotherapy for preterm infants in the neonatal intensive care unit using the international classification of function framework

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Abstract

Objective: To assess the influence of physiotherapy programmes on early preterm infants' activity level.

Method: The prospective, randomised case-control study was conducted at the neonatal intensive care unit of Ondokuz Mayıs University Hospital, Samsun, Turkey, from January 2022 to May 2023, and comprised early preterm infants born at 30 weeks of gestational age or earlier. After the infants' vital signs stabilised, they were randomised into intervention group A and control group B. Those in group A received a one-month physiotherapy programme, while those in group B received daily standard care and positioning. Other than sociodemographic data and vital signs, variations in the infants' height and weight were monitored. Motor skills were evaluated using the Test of Infant Motor Performance, Dubowitz Neurological Examination with cut-off score of ≥30.5), and the Preterm Oral Feeding Readiness Scale were noted and compared between the groups. Data was analysed using SPSS 25.

Results: Of the 38 infants with mean gestational age 29.03±1.26 weeks and mean and birthweight 1299.15±318.98gr, 19(50%) were in group A: 12(63.2%) girls and 7(36.8%) boys. There were 19(50%) infants in group B; 10(52.6%) girls and 9(47.4%) boys. There was no significant intergroup difference at the baseline (p>0.05). There was a significant improvement in motor skills, neurological development and feeding readiness in group A compared to group B (*p*=0.00). No significant intergroup differences were observed with respect to the length of stay under intensive care, respiration rate, heart rate, body temperature, oxygen saturation, body weight on the evaluation day, body weight at discharge, and head circumference at discharge (*p*>0.05).

Conclusion: Physiotherapy in the neonatal intensive care improved motor, neurological and feeding outcomes in preterm infants.

Keywords: Early intervention, Preterm infants, Motor skills, Neonatal intensive care units.

(JPMA 75: 1360; 2025) **DOI: https://doi.org/10.47391/JPMA.20469**

Introduction

Every year, approximately 15 million infants are born prematurely worldwide.[1] Although advanced perinatal care has reduced mortality rates in preterm infants, developmental morbidity remains significantly high.[2] Long-term studies on preterm infants show substantial developmental conditions, such as growth delays, cerebral palsy, vision impairments, and hearing loss.[3,4] Neurological care involves strategies aimed at preventing neuronal connectivity loss and enhancing brain function by establishing new pathways.[5] Given that the vulnerability of the infant's brain increases with immaturity, neurological care becomes increasingly critical.[6] Various approaches, including developmental care methods, have been proposed over the past few decades to address these complications in the neonatal intensive care unit (NICUs) settings. These interventions aim at adapting the NICU environment to reduce stress, enhance behavioural organisation, promote neural growth, and support infant maturation.[7,8] Beyond medical care, diverse physiotherapy techniques aim at promoting normal maturation of sensorimotor organisation while reducing the risks that adversely affect neurodevelopment. Such techniques include joint protection, appropriate positioning, massages and oral motor training.[9]

The International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) serves as a framework for identifying impairments in body functions and structures, limitations in activities and participation, and environmental barriers faced by children with developmental delays. It provides a holistic view of the child's health and the factors influencing their wellbeing.[10]

The current study was planned to evaluate the impact of NICU physiotherapy intervention, using the ICF-CY biopsychosocial model for assessment.

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Submission complete: 01-08-2024 **1st Revision received:** 11-10-2024

Acceptance: 21-06-2025 **Last Revision received:** 20-06-2025

Subjects and Methods

The prospective, randomised case-control study was conducted at the Ondokuz Mayıs University Hospital, Samsun, Turkey, from January 2022 to May 2023, and comprised preterm infants born at 30 weeks of gestational age or earlier who were admitted to Level 4 NICU with stable vital signs. Infants with significant congenital abnormalities, those undergoing invasive mechanical ventilation, and those diagnosed with sepsis and necrotising enterocolitis were excluded. Also excluded were infants who were intubated or had sepsis after enrolment.

After taking informed consent from the parents, the infants were randomised using the R software 3.5.1 into physiotherapy group A and control group B. The intervention started when the infants' vital signs stabilised, which was around the 31st week of post-conceptional age. The sampling technique was simple randomisation according to the time of admission to the hospital. During randomisation, it was prioritised to add infants with the same gestational weeks to each group. The infants' families were blinded to the randomisation.

Group A underwent sessions lasting 25-30 minutes three days a week for one month. The sessions included massage of the mouth and swallowing muscles, with a focus on areas such as around the mouth for sucking and stimulation, and within the mouth for inner area stimulation, while targetting the hyoid muscles for swallowing. Exercises were part of the intervention to mobilise the whole body in all positions through range of motion (ROM) exercises and position changes. Weight-bearing exercises included weight-bearing to the sides and the body parts, and massage therapy targetted the extremities. The intervention, inspired by the neurodevelopmental approach of the infants who were under the risk of neuromotor disorders, was carried out by a professional physiotherapist with five years of professional experience. Group B received daily standard care. and underwent positioning in supine, prone and side-lying positions. The families of both the groups received information about handling and positioning of their infants, and they were also informed about feeding their babies routinely.

Following the collection of demographic information during the initial assessment, the vital signs of the infants were documented. Sociodemographic data comprised details, such as gender, gestational age, postnatal age, Appearance-Pulse-Grimace-Activity-Respiration (APGAR) score,[11] birthweight, mode of delivery, maternal birth information, and parental details, like age, occupation and educational status. Vital signs, including oxygen saturation (SpO_2), blood pressure (BP) and heart rate (HR), were meticulously documented. Variations in the infant's height and weight were systematically observed, and their overall growth and development were closely monitored and recorded. In the second evaluation phase, conducted after the one-month intervention, the assessment encompassed the infant's vital signs, motor skills and feeding abilities. A blinded evaluator did the post-intervention assessment using standardised tools, including the Test of Infant Motor Performance (TIMP), which is capable of detecting changes in motor development at two-week intervals, spanning from post-menstrual 34 weeks of age to five months of corrected age (CA).[12,13] The TIMP was used to assess different facets of movement and postural control, conducting evaluations in prone, supine, supported sitting, and standing positions.[13] The observed items (1-13) were scored 1 point for 'yes' responses and 0 for 'no'. Elicited items (14-41) had scores ranging 0-3, 0-4, 0-5 and 0-6, with the score determined by the infant's performance. The raw scores were obtained by summing the scored items. The raw scores were converted into Z scores to facilitate intergroup comparisons. Infants were subsequently assigned an age standard based on their performance. The age standard classification comprised categories of average, low average, below average, and far below average. The maximum achievable raw score was 142.[13]

The Dubowitz Scale for Neurological Assessment of Preterm and Full-term Infants[14] has been standardised for both preterm and full-term infants, and its item validity and reliability have been demonstrated.[15,16] The Dubowitz examines the neuromotor functions of the baby for neurological examination using 34 items and 6 subgroups, including tonus pattern, reflexes, movement, abnormal findings, orientation and behaviour.[15] The scale provides ease of application in the NICU taking 10-15 minutes, and has simple instructions schematised with drawings related to the movements of the baby. The Dubowitz Infant Neurological Assessment Scale can be used to calculate the raw score, where each item is calculated between 1 and 5 points. On the other hand, a combined optimal score calculation method was developed,[15] stating that the raw score calculation method may not be able to determine the neuromotor status of premature infants by the gestational week accurately enough, and that it is expected that the infant may not reveal some responses in line with the gestational week.[14] In this method, an optimality score is given separately for each item, with 1 point given if the baby elicits the movement appropriate for the gestational week, and 0 point if the baby does not. The total combined optimal score ranges 0-34. The cut-off point for babies born at term is taken as a combined optimal score ≥30.5.[16]

The Preterm Oral Feeding Readiness Assessment Scale (POFRAS)[16] is a tool specifically crafted to evaluate the preparedness for oral feeding in preterm infants. It consists of 18 items categorised into five groups: corrected gestational age, behavioural organisation, mouth posture, oral reflexes, and non-nutritive sucking. The scoring system for the items range 0-2, and the total score ranges 0-36. The established transition cut-off point for preterm infants to begin oral feeding was set at 30.[17]

Within the components of the ICF-CY, activity and participation are regarded as the most crucial outcomes.[18] A comprehensive developmental test was employed to assess the overall development, specifically designed to encompass the ICF-CY component of activity and participation.[19] All the tools used to identify the children's developmental outcomes were influenced by multiple predictors, including body function and structures, environmental factors, personal factors, activity, participation and health condition of the infants.[18] In measuring health condition in the NICU, premature birth was recognised as one of the indicators. Regarding body functions and structures, numerous studies have highlighted the influence of movement-related factors on developmental outcomes, including sitting balance, muscle power function, muscle tone function, visual function, auditory functions, and attention.[20] The current study used birthweight, and gender for personal factors,

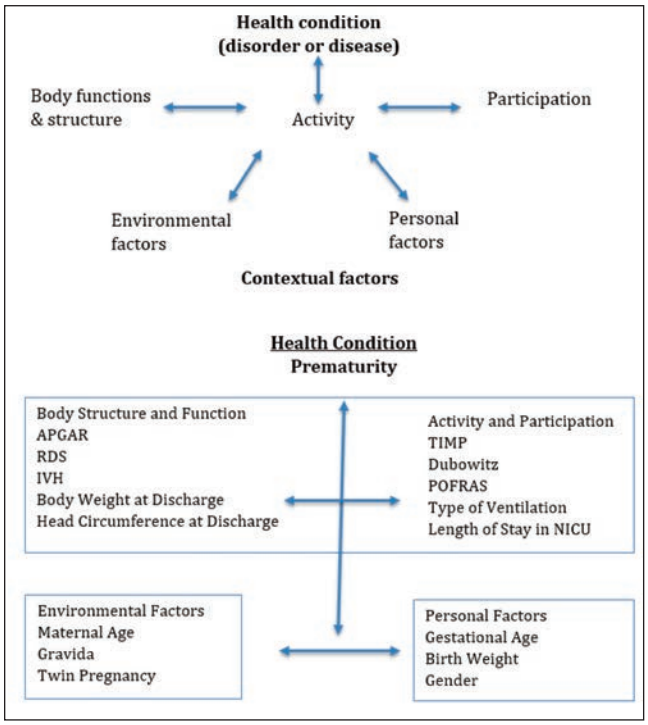

Figure-1: The developmental outcomes model for the infants structured according to the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) framework.

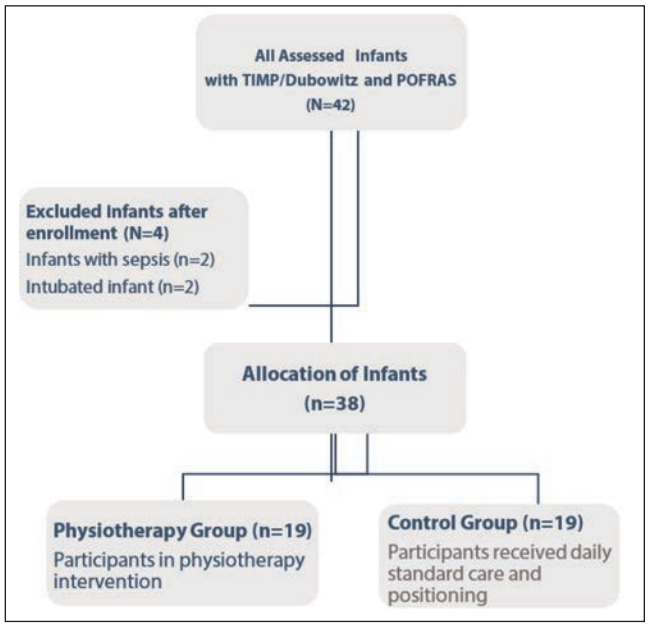

Figure-2: The study's flowchart.

respiratory distress syndrome (RDS), intraventricular haemorrhage (IVH) for body functions and structures, maternal age and twin pregnancy for environmental factors (Figure 1).

The sample size was determined using PASS 2005 with 90% power and 5% type 1 error. The sample was inflated to cover for a possible 20% dropout rate.[21]

Data was analysed using SPSS 25. Data was reported either as mean±standard deviation, or as frequencies and percentages. Data homogeneity was tested with Levene's test, while data normality was assessed using Shapiro-Wilk tests. Data with normal distribution and homogeneous variance was compared between the groups using student's t-test. Comparisons between two independent groups were conducted using the Mann-Whitney U test. For the analysis of categorical data, Fischer's exact test and chi-square test were utilised. In instances where the expected number of cases was anticipated to be <20%, the Monte Carlo Simulation Method was applied to determine the values. P<0.05 was deemed statistically significant.

Results

Of the 42 infants assessed, 2(4.76%) required intubation and 2(4.76%) developed sepsis. As such, the study was completed by 38(90.47%) infants with mean gestational age 29.03±1.26 weeks and mean and birthweight 1299.15±318.98gm. There were 19(50%) subjects in group A: 12(63.2%) girls and 7(36.8%) boys. There were 19(50%) infants in group B; 10(52.6%) girls and 9(47.4%) boys. There was no significant intergroup difference at the baseline (p>0.05) (Table 1).

Table-1: Clinical characteristics at te baseline (n=38).

	Physiotherapy Group (n=19)	Control Group (n=19)	*p-value
Gestational age (weeks)	29.03±1.26	29.08±1.13	0.902
Birth weight (grams)	1299.15±318.98	1233.94±314.86	0. 325
Gender			
Girls n (%)	7 (36.8)	9 (47.4)	0.523
Boys n (%)	12 (63.2)	10 (52.6)	
Maternal Age (years)	30.84±5.93	30.31± 6.65	0.968
Gravida (median)	3.0	3.0	0.883
Twin Pregnancy n (%)	4 (21.1)	8 (42.1)	0.166
APGAR score			
1st min	3.78±3.37	4.52±3.18	0.493
5th min	5.05±1.47	5.21±1.22	0.657
Dubowitz Optimal Scores before intervention	10.63±2.89	10.00±2.00	0.731
CRIB-2 Scores	5.18±3.93	7.16±1.94	0.237
Heart Rate	153.78±11.63	149.76±10.67	0.196
Respiration Rate	51.37±4.66	51.03±4.79	0.845
Oxygen Saturation	94.73±10.30	93.35±11.72	0.851
Type of Ventilation			
Non-invasive ventilation	9 (47.4)	11 (57.9)	0.516
Oxygen supplementation	10 (52.6)	8 (42.1)	
RDS n (%)	7 (36.8)	10 (52.6)	0.217
IVH n (%)			
Grade 1	9 (47.4)	6 (31.6)	0.605
Grade 2	2 (10.5)	1 (5.3)	

IVH: Intraventricular haemorrhage, RDS: Respiratory distress syndrome, CRIB: Clinical risk index for babies, APGAR: Appearance-Pulse-Grimace-Activity-Respiration; *Mann-Whitney U test.

Table-2: Intergroup comparison of clinical data.

	Domain of ICF	Physiotherapy Group (n=19)	Control Group (n=19)	*p-value
Initiation time for the intervention in the infant groups (weeks)	Personal Factor	31.48 ± 0.86	31.54 ± 0.64	0.340
Post-intervention assessment age of the infants (weeks) (Mean±SD and Median)	Personal Factor	35.48 ± 0.86 (35.6)	35.45 ± 0.72 (35.2)	0.502
Length of stay in ICU (days)	Activity and Participation	52.89± 24.91	55.57 ± 14.74	0.861
Body weight on the evaluation day (grams)	Body Functions and Structure	2182.50 ± 261.87	2011.84 ± 281.40	0.095

ICF: International classification of functioning, disability and health, NICU: Neonatal intensive care unit, SD: Standard deviation; *Mann-Whitney U test.

Table-3: Intergroup comparison of motor evaluation outcomes post-intervention.

	Domain of ICF	Physiotherapy Group (n=19)	Control Group (n=19)	*p-value
POFRAS score	Activity and Participation	32.60 ± 3.00	21.60 ± 6.30	**0.001****
TIMP				
Raw score	Activity and	33.50 ± 4.90	17.42 ± 5.71	**0.001****
z-score	Participation	0.799 ± 0.514	-0.843 ± 0.608	**0.001****
Dubowitz Optimal Score	Activity and Participation	32.42 ± 2.96	21.05 ± 6.09	**0.001****
		n (%)	**n (%)**	
TIMP Range				
Average	Activity and	8 (42.1)	0 (0)	**0.001****
Below average	Participation	11 (57.9)	5 (26.3)	
Far below average		0 (0)	13 (68.4)	

*Mann-Whitney U test; ** $p<0.05$; TIMP: Test of infant motor performance, POFRAS: Preterm oral feeding readiness scale.

Table-4: Intergroup comparison of clinical evaluation post-intervention.

	Domain of ICF	Physiotherapy Group (n=19)	Control Group (n=19)	*p-value
Body Weight at Discharge (grams)	Body Functions and Structure	2337.25±385.47	2334.47±237.02	0.923
Head circumference at Discharge (cm)	Body Functions and Structure	31.65±1.07	31.60±1.64	0.923
		n (%)	**n (%)**	
Type of Ventilation				
Non-invasive ventilation		0 (0)	1 (5.3)	
Oxygen supplementation	Activity and	4 (21)	5 (26.3)	0.636
No Oxygen	Participation	15 (79)	13 (68.4)	

*Mann-Whitney U Test used for evaluation.

The intervention initiation time and the length of NICU stay was not significantly different between the groups ($p>0.05$) (Table 2).

TIMP, Dubowitz and POFRAS scores were significance better in group A compared to group B ($p<0.05$) (Table 3).

Clinical evaluation showed no significant difference post-intervention between the groups ($p>0.05$) (Table 4).

Discussion

The current study aimed at examining the effectiveness of a one-month physiotherapy intervention for early preterm infants in the NICU who were at risk of neuromotor delay. The study approached the subject within the context of the ICF framework.[10]

The objective was to implement the intervention within the NICU to capitalise on the considerable neuroplasticity that exists during early infancy,[22,23] although this may be influenced by infant's medical stability and length of stay. A recent systematic review evaluating motor development interventions for preterm infants, whether initiated during their hospital stay or afterwards, concluded that interventions emphasising the infants' active movements in various positions were found to be the most effective in enhancing motor skills from birth up to CA 24 months.[24] While the influence diminished over time, motor-specific interventions demonstrated a substantial and noteworthy effect size on motor skills at CA 3 months. The majority of these interventions encompassed developmental assistance for the infant as well as guidance and education for the parents.

The current findings showed beneficial outcomes in the motor and feeding skills of the preterm infants. This indicates that there exists a potential timeframe in which

providing optimal support for adaptive development is most effective. Infants who received the intervention demonstrated positive improvements in developmental assessment and imaging metrics, thereby endorsing the findings of previous literature which propose that early physical therapy interventions may be advantageous for overall development.[125-27] These findings justify the need for additional research involving larger study cohorts to systematically evaluate the differential effects of an intervention compared to standard care.

In contrast to other intervention studies focussing on specific populations of high-risk infants,[25,28,29-31] the current study recruited infants with high-risk levels because of their very early prematurity as all infants were born at 30th or <30 weeks of gestational age. All the infants had nearly the same medical condition and, as such, were at the same risk of neuromotor delay.[32] This transdiagnostic approach enabled the study to pinpoint all the infants who could derive benefits from early therapeutic intervention.

A research[33] indicated that the intervention had no detrimental effects on weight gain, and it did not lead to an increase in apnoea or heart rate changes during the intervention. The current study presented similar results between the groups in terms of length of hospital stay, body weight and head circumference at discharge.

The majority of physiotherapy studies conducted in the NICU involved training parents to administer the intervention, which resulted in improved scores for infants. Moreover, studies suggest that maternal interventions, such as baby massage and skin-to-skin care in the NICU, yielded positive effects on developmental outcomes.[34-36] It has been proposed that optimising interactions between parents and children, as well as enhancing the infant's environment, can act protectively and supportively towards the infant's development and competence.[35,37,38] In contrast to these studies, the current study exclusively involved physiotherapists administering the intervention, with a focus on demonstrating the outcomes within the ICF-CY framework. The families of both groups only received information about handling and positioning their infants, and they were also informed about feeding their babies routinely. Future research could involve the inclusion of the infants' families to explore the effects within the ICF-CY framework.

Pan et al.[10] developed an ICF-CY code set for the initial assessment of early retardation and disability in infants under three years of age. They established a set of 82 ICF-CY categories to delineate the functional status of infants experiencing developmental delays. Of these, 28 included activities and participation. The distribution of categories in activities and participation reflected the observation that significant functional changes and developmental milestones during infancy were associated with learning, communication, and mobility. These categories are also the areas in which general difficulties are addressed for infants with developmental delays.[39,40] Hwang et al.[20] assessed 122 infants at birth, 4 months, 6 months, and 2.5 years of age. They noted that, among the components of ICF-CY, activities and participation were regarded as the most critical outcomes for children. Fonseca et al.[41] evaluated 35 premature infants at CA 38 weeks and 12 months. Similar to the current study, they evaluated gestational week, CA, and gender as personal factors, activities, and participation with Ages and Stages Questionnaire-3 which evaluates motor functions, family-related conditions, and physiotherapy as environmental factors.

The current study has limitations as it did not have a follow-up. Since the institutional NICU was part of a large healthcare centre accepting many out-of-town families, most of the babies were not brought back for follow-up.

Future studies should follow up the cases, and explore the family's contribution to supporting the development of the child.

Conclusions

Physiotherapy in the neonatal intensive care improved motor, neurological and feeding outcomes in preterm infants.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Agyeman-Duah J, Kennedy S, O'Brien F, Natalucci G. Interventions to improve neurodevelopmental outcomes of children born moderate to late preterm: a systematic review protocol. Gates Open Res 2021;5:78. doi: 10.12688/gatesopenres.13246.2
2. Fernández de Gamarra-Oca L, Ojeda N, Gómez-Gastiasoro A, Peña J, Ibarretxe-Bilbao N, García-Guerrero MA, et al. Long-term neurodevelopmental outcomes after moderate and late preterm birth: a systematic review. J Pediatr 2021;237:168-76.e11. doi: 10.1016/j.jpeds.2021.06.004
3. Sevoyan M, Geraci M, Frongillo EA, Liu J, Boghossian NS. Interpregnancy interval and adverse perinatal outcomes: a within-individual comparative method. Health Sci Rep 2024;7:e2313. doi: 10.1002/hsr2.2313
4. Heroual N, Boukfoussa N, Houti L. Épidémiologie et facteurs de risque de la prématurité dans le nord-ouest algérien [Epidemiology and risk factors for preterm births in north-western Algeria]. Pan Afr Med J 2024;47:183. French. doi: 10.11604/pamj.2024.47.183.40657
5. Meredith Weiss S, Aydin E, Lloyd-Fox S, Johnson MH. Trajectories of brain and behaviour development in the womb, at birth and through infancy. Nat Hum Behav 2024;8:1251-62. doi:

10.1038/s41562-024-01896-7

6. DiBari JN, Rouse L. Parent perspectives: part 1-considerations for changing the NICU culture. Children (Basel) 2023;10:1735. doi: 10.3390/children10111735
7. Alsadaan N, Ramadan OME, Alqahtani M, Shaban M, Elsharkawy NB, Abdelaziz EM, et al. Impacts of integrating family-centered care and developmental care principles on neonatal neurodevelopmental outcomes among high-risk neonates. Children (Basel) 2023;10:1751. doi: 10.3390/children10111751
8. Soleimani F, Azari N, Ghiasvand H, Shahrokhi A, Rahmani N, Fatollahierad S. Do NICU developmental care improve cognitive and motor outcomes for preterm infants? A systematic review and meta-analysis. BMC Pediatr 2020;20:67. doi: 10.1186/s12887-020-1953-1
9. Balci N, Kaya Kara Ö. Bebeklik döneminde fizyoterapi gerektiren durumlar. In: Riskli bebeklerde fizyoterapi ve rehabilitasyon. Ankara, TR: Hipokrat Publising, 2019.
10. Pan YL, Hwang AW, Simeonsson RJ, Lu L, Liao HF. ICF-CY code set for infants with early delay and disabilities (EDD Code Set) for interdisciplinary assessment: a global experts survey. Disabil Rehabil 2015;37:1044-54. doi: 10.3109/09638288.2014.952454
11. Calmes SH. Dr. Virginia Apgar and the Apgar Score: how the Apgar Score came to be. Anesth Analg 2015;120:1060-4. doi: 10.1213/ANE.0000000000000659
12. Campbell SK, Hedeker D. Validity of the Test of Infant Motor Performance for discriminating among infants with varying risk for poor motor outcome. J Pediatr 2001;139:546-51. doi: 10.1067/mpd.2001.117581
13. Campbell SK, Levy P, Zawacki L, Liao PJ. Population-based age standards for interpreting results on the test of motor infant performance. Pediatr Phys Ther 2006;18:119-25. doi: 10.1097/01.pep.0000223108.03305.5d
14. Mercuri E, Guzzetta A, Laroche S, Ricci D, vanhaastert I, Simpson A, et al. Neurologic examination of preterm infants at term age: comparison with term infants. J Pediatr 2003;142:647-55. doi: 10.1067/mpd.2003.215
15. Mercuri E, Ricci D, Pane M, Baranello G. The neurological examination of the newborn baby. Early Hum Dev 2005;81:947-56. doi: 10.1016/j.earlhumdev.2005.10.007
16. Dubowitz L, Mercuri E, Dubowitz V. An optimality score for the neurologic examination of the term newborn. J Pediatr 1998;133:406-16. doi: 10.1016/s0022-3476(98)70279-3
17. Fujinaga CI, de Moraes SA, Zamberlan-Amorim NE, Castral TC, de Almeida e Silva A, et al. Clinical validation of the Preterm Oral Feeding Readiness Assessment Scale. Rev Lat Am Enfermagem 2013;21:140-5. doi: 10.1590/s0104-11692013000700018
18. Azar R, Doucet S, Horsman AR, Charlton P, Luke A, Nagel DA, et al. A concept analysis of children with complex health conditions: implications for research and practice. BMC Pediatr 2020;20:251. doi: 10.1186/s12887-020-02161-2
19. Simeonsson RJ, Leonardi M, Lollar D, Bjorck-Akesson E, Hollenweger J, Martinuzzi A. Applying the International Classification of Functioning, Disability and Health (ICF) to measure childhood disability. Disabil Rehabil 2003;25:602-10. doi: 10.1080/0963828031000137117
20. Hwang AW, Liao HF, Chen PC, Hsieh WS, Simeonsson RJ, Weng LJ, et al. Applying the ICF-CY framework to examine biological and environmental factors in early childhood development. J Formos Med Assoc 2014;113:303-12. doi: 10.1016/j.jfma.2011.10.004
21. Althubaiti A. Sample size determination: A practical guide for health researchers. J Gen Fam Med 2022;24:72-8. doi: 10.1002/jgf2.600
22. Kuhn HG, Skau S, Nyberg J. A lifetime perspective on risk factors for cognitive decline with a special focus on early events. Cereb Circ Cogn Behav 2024;6:100217. doi: 10.1016/j.cccb.2024.100217
23. Deng W, Anastasopoulos S, deRegnier RA, Pouppirt N, Barlow AK, Patrick C, et al. Protocol for a randomized controlled trial to evaluate a year-long (NICU-to-home) evidence-based, high dose physical therapy intervention in infants at risk of neuromotor delay. PLoS One 2023;18:e0291408. doi: 10.1371/journal.pone.0291408
24. Dusing SC, Burnsed JC, Brown SE, Harper AD, Hendricks-Munoz KD, Stevenson RD, et al. Efficacy of supporting play exploration and early development intervention in the first months of life for infants born very preterm: 3-arm randomized clinical trial protocol. Phys Ther 2020;100:1343-52. doi: 10.1093/ptj/pzaa077
25. Finlayson F, Olsen J, Dusing SC, Guzzetta A, Eeles A, Spittle A. Supporting play, exploration, and early development intervention (SPEEDI) for preterm infants: a feasibility randomised controlled trial in an Australian context. Early Hum Dev 2020;151:105172. doi: 10.1016/j.earlhumdev.2020.105172
26. Dusing SC, Tripathi T, Marcinowski EC, Thacker LR, Brown LF, Hendricks-Muñoz KD. Supporting play exploration and early developmental intervention versus usual care to enhance development outcomes during the transition from the neonatal intensive care unit to home: a pilot randomized controlled trial. BMC Pediatr 2018;18:46. doi: 10.1186/s12887-018-1011-4
27. Khurana S, Kane AE, Brown SE, Tarver T, Dusing SC. Effect of neonatal therapy on the motor, cognitive, and behavioral development of infants born preterm: a systematic review. Dev Med Child Neurol 2020;62:684-92. doi: 10.1111/dmcn.14485
28. Øberg GK, Handegård BH, Campbell SK, Ustad T, Fjørtoft T, Kaaresen PI, et al. Two-year motor outcomes associated with the dose of NICU based physical therapy: the Noppi RCT. Early Hum Dev 2022;174:105680. doi: 10.1016/j.earlhumdev.2022.105680
29. Morgan C, Novak I, Dale RC, Guzzetta A, Badawi N. GAME (Goals—Activity—Motor Enrichment): protocol of a single blind randomised controlled trial of motor training, parent education and environmental enrichment for infants at high risk of cerebral palsy. BMC Neurol 2014;14:203. doi: 10.1186/s12883-014-0203-2
30. Lima CRG, de Abreu RWF, Verderio BN, Brugnaro BH, dos Santos MM, dos Santos AN, et al. Early intervention involving specific task-environment-participation (STEP) protocol for infants at risk: a feasibility study. Phys Occup Ther Pediatr 2023;43:303-20. doi: 10.1080/01942638.2022.2142084 15
31. Dusing SC, Harbourne RT, Hsu LY, Koziol NA, Kretch K, Sargent B, et al. The SIT-PT trial protocol: a dose-matched randomized clinical trial comparing 2 physical therapist interventions for infants and toddlers with cerebral palsy. Phys Ther 2022;102:pzac039. doi: 10.1093/ptj/pzac039
32. Caesar R, Boyd RN, Colditz P, Cioni G, Ware RS, Salthouse K, et al. Early prediction of typical outcome and mild developmental delay for prioritisation of service delivery for very preterm and very low birthweight infants: a study protocol. BMJ Open 2016;6:e010726. doi: 10.1136/bmjopen-2015-010726
33. Girolami GL, Campbell SK. Efficacy of a neuro-developmental treatment program to improve motor control in infants born prematurely. Pediatr Phys Ther 1994;6:175-84.
34. Lai M, D'Acunto G, Guzzetta A, Finnigan S, Ngenda N, Ware RS, et al. Infant massage and brain maturation measured using EEG: a randomised controlled trial. Early Hum Dev 2022;172:105632. doi: 10.1016/j.earlhumdev.2022.105632
35. Welch MG, Grieve PG, Stark RI, Isler JR, Ludwig RJ, Hane AA, et al. Family nurture intervention increases term age forebrain EEG activity: a multicenter Randomized Controlled Trial. Clin Neurophysiol 2022 Jun:138:52-60. doi: 10.1016/j.clinph.2022.02.018
36. Welch MG, Barone JL, Porges SW, Hane AA, Kwon KY, Ludwig RJ, et al. Family nurture intervention increases term age forebrain EEG activity: a multicenter replication trial. Clin Neurophysiol 2022;138:52-60. doi: 10.1016/j.clinph.2022.02.018

37. Welch MG, Stark RI, Grieve PG, Ludwig RJ, Isler JR, Barone JL, et al. Family nurture intervention in preterm infants increases early development of cortical activity and independence of regional power trajectories. Acta Paediatr 2017;106:1952-60. doi: 10.1111/apa.14050
38. Baraldi E, Allodi MW, Löwing K, Smedler AC, Westrup B, Ådén U. Stockholm preterm interaction-based intervention (SPIBI) - study protocol for an RCT of a 12-month parallel-group post-discharge program for extremely preterm infants and their parents. BMC Pediatr 2020;20:49. doi: 10.1186/s12887-020-1934-4
39. Treyvaud K, Anderson VA, Howard K, Bear M, Hunt RW, Doyle LW, et al. Parenting behavior is associated with the early neurobehavioral development of very preterm children. Pediatrics 2009;123:555-61. doi: 10.1542/peds.2008-0477
40. Severino M, Geraldo AF, Utz N, Tortora D, Pogledic I, Klonowski W, et al. Definitions and classification of malformations of cortical development: practical guidelines. Brain 2020;143:2874-94. doi: 10.1093/brain/awaa174
41. Aldosari AN, Aldosari TS. Comprehensive evaluation of the child with global developmental delays or intellectual disability. Clin Exp Pediatr 2024;67:435-46. doi: 10.3345/cep.2023.01697
42. DA Fonseca Filho GG, Lopes AC, Bezerra RB, de M Candido A, Arrais N, Pereira SA, et al. Assessment of child development in premature babies based on the ICF biopsychosocial model. Eur J Phys Rehabil Med 2021;57:585-92. doi: 10.23736/S1973-9087.20.06543-0

Author Contribution:
NCB: Concept, design, data acquisition, analysis, interpretation, final approval and agreement to be accountable for all aspects of the work.
ST & MAA: Concept, design, data acquisition, analysis, interpretation, drafting, revision, final approval and agreement to be accountable for all aspects of the work.