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Original Article

Physiotherapy Section

The Impact of a Novel Postural Supporting Device on Neuromotor and Behavioural Development of Premature Neonates: A Pilot Study

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ABSTRACT

Introduction: Preterm neonates face significant challenges in neurobehavioural development compared to full-term neonates, as they often experience delayed motor coordination and cognitive development. Therapeutic positioning is an essential neurodevelopmental intervention in the Neonatal Intensive Care Units (NICU), as it supports the infant's posture and movement.

Aim: To develop a new postural supporting device and evaluate its impact on the neuromotor development of premature neonates.

Materials and Methods: This pilot study was conducted at level III NICU at Dhiraj Hospital, Vadodara, Gujarat, India, from April 2024 to July 2024. Nine medically stable preterm neonates, within the first 72 hours of life and with a gestational age between 30 weeks 0/7 days and 36 weeks 6/7 days, who were referred for physiotherapy, were included in the study. Conventional physiotherapy intervention, along with positioning in a novel postural supporting device, was administered. After one week, their neuromotor behaviour was assessed using the neuromotor behavioural assessment scale.

Results: All nine preterm neonates demonstrated significant improvement when comparing pre- and post-outcomes, with p-values of 0.007 for neurological components, 0.007 for behavioural components, 0.011 for autonomic components and 0.016 for motor components.

Conclusion: The present study shows that the "New Postural Supporting Device" has a positive impact on neuromotor and behavioural organisation in premature neonates.

Keywords: Child development, Gestational age, Infant, Infant behaviour, Motor activity, Patient positioning

INTRODUCTION

Preterm neonates encounter notable challenges in neurobehavioural development when compared to full-term newborns, as they frequently experience delays in the development of motor coordination and cognitive skills [1]. Research indicates that preterm and Very Low Birth Weight (VLBW) infants are at a higher risk of neurobehavioural issues, such as inattention, poor posture, irritability and difficulty self-soothing compared to full-term babies [1-3]. These negative outcomes are often linked to low birth weight and prematurity. Additionally, premature neonates are vulnerable to neurodevelopmental abnormalities caused by factors like infection, hyperbilirubinemia and severe hypoxia during the early postnatal period [4,5].

When preterm neonates are admitted to NICU, they often adopt a hypotonic extension posture due to low postural tone, gravity and a lack of flexor muscle tone, making it difficult for them to assume a flexed position. This difficulty arises because they are exposed to gravity before their bodies can adjust and their environment in the NICU is vastly different from the protected, confined space of the uterus [4-6]. Poor positioning of premature neonates can increase the risk of apnoea, neurobehavioural stress and even intracranial haemorrhage due to improper handling during the early postnatal period [6,7].

Therapeutic positioning is an essential neurodevelopmental intervention in the NICU. It supports the infant's posture and movement, promotes proper skeletal and biomechanical alignment, offers controlled exposure to various sensory stimuli and helps regulate the infant's behavioural state [8]. Positioning the newborn in physiological flexion supports joint alignment, neuromuscular development, oral feeding skills and behavioural organisation, including self-soothing [7,8].

To encourage flexion in premature neonates, NICU professionals often use positioning aids such as swaddling, circular nests, positioning rolls, or more advanced devices like the Snuggle Up, Bendy Bumper, or Dandle Roo. However, traditional devices are often too soft to adequately support the infant's movements, failing to prevent unwanted hip abduction and negatively impacting motor and neurodevelopment. On the other hand, sophisticated devices are often costly; for instance, the Snuggle Up costs £97.50 [9], the Bendy Bumper costs $190.95 [10], the Dandle Roo costs $645.99 [11] and the Cocoonababy costs between $270.00 and $349.99 [12]. These devices are also less accessible in developing countries. Additionally, some of these devices may offer limited space and support for the infant's needs.

Although positioning devices are commonly used, there is a lack of comprehensive research on the commercially available options and their effects. Therefore, there is a need to create a new postural supporting device that addresses these limitations and evaluates its impact on the neuromotor development of premature neonates. The goal of the present study was to determine how a novel postural supporting device affects a premature neonate's neuromotor activity and behavioural development through the standardised Neuromotor Behavioural Assessment Scale.

The null hypothesis posits that the novel "Postural Supporting Device" does not improve the neuromotor and behavioural development of premature neonates. The alternative hypothesis suggests that the novel "Postural Supporting Device" improves the neuromotor and behavioural development of premature neonates.

MATERIALS AND METHODS

The present pilot study was conducted from April 2024 to July 2024 in a Level III NICU at Dhiraj Hospital, Vadodara, Gujarat, India. The Institutional Ethics Committee approved the study (SVIEC/ON/PHYS/PhD/22012). All guardians of the study participants provided

their permission for study enrollment and signed informed consent before the study commenced.

Inclusion and Exclusion criteria: All preterm neonates who were medically stable within the first 72 hours of life, with a gestational age between 30 weeks 0/7 days and 36 weeks 6/7 days and who were referred for physiotherapy, were included in the study. Preterm neonates who required oxygen therapy or any respiratory support (ventilation, continuous positive airway pressure and high-flow nasal cannula) beyond 72 hours, as well as neonates with a diagnosis of any neurological, musculoskeletal, or genetic/chromosomal/metabolic disorders, were excluded.

Study Procedure

A total of nine preterm neonates were included in this pilot study. Before commencing the study, a detailed physiotherapy assessment of all included preterm neonates was conducted. As a pre-outcome measure, the Neuromotor Behavioural Assessment Scale was administered. The assessment (Burns and O'Callaghan, 1988) is subdivided into four sections: neurological items, behavioural items, autonomic items and motor functions, with scoring on a point system from 0 to 4. A score of zero or one indicates the worst possible responses, while scores of two, three and four indicate better to best responses, respectively. For ease of interpretation, total scores for each parameter were categorised into one of three groups: abnormal, suspect, or normal. These anticipated developmental categories were derived from the assessment by considering the scores allocated to each functional area. Generally, scores of 0 or 1 were considered abnormal; scores of 2 were classified as suspect; and scores of 3 or 4 were considered normal [13]. For all the included neonates, according to the recommendations provided by Sweeney JK et al., (2010) and McManus BM et al., (2013) [14,15], conventional tailor-made neonatal physiotherapy interventions were administered once a day for approximately 20 minutes, six days a week. All the neonates were positioned in the newly developed postural supporting device continuously, 24 hours a day, until the time of discharge.

The design of the device was self-developed and based on a review of the available literature [8] and the experience of the principal investigator in the NICU. The device was developed with the aim of simulating the position of the foetus in the uterus. It could be used by physiotherapists, nurses and medical staff in the NICU to position the preterm neonate. The device was made from memory foam and cotton, which was precut and quilted. The boundaries and support for the head and limbs were designed in such a way that they could be adjusted to accommodate the size of preterm infants. Prior to using the device, all possible aseptic precautions were taken into account. The "Postural Supporting Device" has been submitted for patent design publication, which was published under Design No.: 403807-001 [Table/Fig-1]. Parents were involved in treatment sessions and were advised to perform these activities whenever they visited their baby in the NICU. The intervention was provided during the infant's awake state, preferably before the next feeding schedule. The intervention was discontinued if the child showed any signs of stress, like fussing, crying, or sleeping. At the end of one week, reassessment of the same outcome measures was conducted.

[Table/Fig-1]: Postural supporting device.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel. After data cleaning, the data were imported into the Statistical Package for Social Sciences (SPSS) version 25.0 and analysed using the same. Data were analysed for descriptive and inferential statistics. The Wilcoxon test was used for within-group comparison. A p-value of less than 0.05 was considered statistically significant.

RESULTS

In the present study, nine preterm neonates with a mean gestational age of 235.55±5.04 days were included. Among the included neonates, the majority 5 (55.55%) were male. The mean weight was 1.57±0.28 kg [Table/Fig-2]. The data presented in [Table/Fig-3] show significant changes in all components of the Neuromotor Behavioural Assessment (Neurological, Behavioural, Autonomic, Motor) score pre- and post-intervention after one week (p-value <0.05). Therefore, the null hypothesis was rejected.

Variables	n (%)
Gender	
Males	5 (55.55)
Females	4 (44.44)
Oxygen support	
Yes	1 (11.11)
No	8 (88.88)
	Mean±SD
Gestational age (in days)	235.33±5.04
Birth weight (kg)	1.57±0.28

[Table/Fig-2]: Demographic characteristic data (gender, requirement of oxygen support, gestational age and birth weight) of included preterm newborns.

DISCUSSION

According to the World Health Organisation (WHO), neurodevelopmental outcomes are a primary concern for preterm neonates [16]. Prematurity disrupts normal intrauterine growth and hampers the ability of these infants to adapt to life outside the womb. Once hospitalised in NICUs, preterm infants are exposed to an environment that differs significantly from the protective, controlled conditions of the uterus [14,17]. When the external demands placed on these neonates surpass their ability to regulate and cope, it can lead to neurobiological dysfunction. Thus, there is a clear need to modify neonatal care practices within NICUs to better support the neurodevelopmental processes of preterm infants in the extrauterine environment.

One approach that has been employed to facilitate optimal behavioural development and support the organisation of the preterm neonate is the maintenance of proper posture [17]. Postural support is crucial in improving physiological function, reducing stress and preventing sudden increases in blood pressure, which can lead to complications such as intraventricular haemorrhage. In this regard, positioning is one of the most commonly used developmental techniques in NICUs. Proper positioning not only helps preterm infants regulate their behaviour but also enhances their stability, promotes organisation, conserves energy and supports growth [15,18,19].

The present study introduces a "New Postural Supporting Device" that offers better support for premature neonates in maintaining a physiological flexion posture, resulting in fewer instances of extended

Variables	Prescore			Postscore			p-value
	Mean±SD	Standard error of mean	Median	Mean±SD	Standard error of mean	Median	
Neurological	21.33±3.64	1.21	21	29.55±2.06	0.68	29	0.007*
Behavioural	6.77±1.09	0.36	6	10.88±0.33	0.11	11	0.007*
Autonomic	8.55±0.88	0.29	8	10±0	0	10	0.011*
Motor	4.44±1.23	0.41	5	6±0	0	6	0.016*

[Table/Fig-3]: Shows pre- and post-score comparisons of the Neuromotor Behavioural Assessment Scale.
Wilcoxon test

arms, legs, or abrupt rolling movements compared to traditional nesting practices. The key difference appears to stem from the distinct structural design and materials used in the postural supports. Traditional nesting practices, which typically involve blankets and washcloth rolls, have been found to be too soft to prevent intense abduction or abrupt rolling movements, leading to suboptimal positioning for preterm infants [8,20,21].

The "New Postural Supporting Device" features a boundary with a pouch at the bottom, allowing infants to extend their legs and touch the sides for weight-bearing movements or to transition freely between an extended and flexed posture. Additionally, the surrounding boundary, along with a headpiece component, provides unique support for the neck and head, reducing sudden head movements and preventing neck extension. The device also includes adjustable straps on both sides that help support elbow flexion and encourage hand-to-mouth movements, promoting midline orientation of the extremities to the trunk.

Infants using the "New Postural Supporting Device" demonstrated better midline body posture and motor development for less than 2000 Indian rupees. The study's findings align with existing literature, which highlights the challenges premature neonates face in achieving mature neurobehavioural development without proper postural support. Without adequate positioning, these neonates often exhibit signs of neurobehavioural stress such as shaking, tremors, finger spreading, body arching and extremity extension/abduction [18,19,22-24].

Furthermore, the results of the present study indicated that the "New Postural Supporting Device" did not increase any stress-related gestures, like open-hand and arm-freeze-fist behaviours, which are often linked to stress in infants. This suggests that the device improved comfort levels, reduced stress-related behaviours, minimised discomfort and allowed infants to rest more easily. As a result, the infants using the device showed better sleep patterns, which are essential for promoting neurobehavioural maturation [25-28].

The available literature that used positioning devices showed better outcomes in body posture and movements, improved sleep-wake cycling, weight gain and enhanced behavioural organisation, as evidenced by higher scores on the Preterm Neonate's Behaviour Assessment Scale. Additionally, the duration of hospital stay was reduced in comparison to the "Traditional Nesting Device" [8,18,28-30].

The study suggests that future research should explore ways to further encourage smooth, free movement of the upper extremities. This is important for developing eye-hand coordination and supporting midline orientation of the extremities to prevent abducted postures. Furthermore, ensuring that premature infants can enter deeper sleep cycles may play a vital role in fostering neurobehavioural development and maturation.

Limitation(s)

The study had several limitations that need to be considered in future research. Firstly, the small sample size may have affected the statistical power and the ability to generalise the results. Moreover, the lack of a control group receiving standard care made it challenging to determine whether the outcomes were directly linked to the intervention or influenced by other variables. Lastly, the short duration of the intervention limited the ability to evaluate long-term effects or lasting changes. A longer intervention period would provide a clearer understanding of the lasting impact of the intervention.

CONCLUSION(S)

Poor posture is thought to have detrimental effects on neurobehavioural development. The present study presents evidence that the "New Postural Supporting Device" has a more positive impact on neuromotor and behavioural organisation in premature neonates. Future studies should involve a larger sample size through controlled, randomised trials to improve the reliability and broader applicability of the results. Expanding the sample will help minimise biases and provide stronger evidence. Furthermore, extending the duration of the intervention is crucial to assess its long-term effects on neurodevelopment. Longer-term research would offer important insights into whether the benefits of early interventions are sustained as individuals continue to develop, helping to understand if these effects endure or fade over time.

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