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Physiotherapy Section

# Different Positioning Practices in Neonatal Intensive Care Unit and their Effects on Neuromotor Development of Preterm Neonates: A Systematic Review

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## ABSTRACT

**Introduction:** Advances in neonatal intensive care have markedly improved the survival of preterm infants. However, without appropriate interventions, many preterm infants face long-term disabilities. Preterm infants often adopt postures that differ from those they would typically develop in utero. Therapeutic positioning is among the earliest neurodevelopmental interventions implemented in the Neonatal Intensive Care Unit (NICU). The primary goals of positioning are to provide support, facilitate movement and optimise neurodevelopment.

**Aim:** To examine various positioning practices and their effects on neuromotor development in preterm infants admitted to the NICU.

**Materials and Methods:** A literature search of PubMed, MEDLINE, CINAHL, DARE, ScienceDirect and Embase was conducted covering from January 2000 to June 2024, focusing on studies that examined different positioning techniques and their effects on posture and neuromotor development. Articles were screened against predefined inclusion and exclusion criteria. Eligible studies were identified and the methodological quality of the included studies was assessed. A qualitative synthesis of the findings was performed.

**Results:** Eleven studies were included in this review. The included studies employed various postural strategies, such as different types of nests, mattresses and postural support devices (rolls or diapers) and assessed their effects on posture and neuromotor development.

**Conclusion:** Positioning strategies for preterm infants are diverse. By adopting specific positions or using particular equipment, NICU care can address some of the unique needs of preterm infants during their stay. Positioning in certain positions may be associated with pain relief, improved flexion posture, enhanced neuromotor development and shorter lengths of hospital stay.

**Keywords:** Infant, Motor skills, Physical therapy, Posture, Premature

## INTRODUCTION

According to the World Health Organisation (WHO), an estimated 13.4 million babies were born preterm in 2020 (i.e., before 37 completed weeks of gestation) [1]. This corresponds to one in 10 babies. In India, between 2019 and 2021, approximately 12% of infants were born preterm, and 18% had low birth weight [2]. In recent decades, the availability of advanced technological resources, such as mechanical ventilators and cardiorespiratory monitors, in NICUs has significantly improved the survival rates of premature newborns [3,4]. However, preterm infants who do not receive timely and appropriate interventions often develop long-term disabilities. These infants often exhibit neurological, motor and behavioural developmental issues. Impairments may be observed in muscle tone, reflex development and voluntary movements. Additionally, many preterm neonates experience difficulties with feeding and self-regulation [5,6].

The intrauterine environment provides an integrated, multimodal array of sensory stimuli including vestibular, auditory, chemical, hormonal, tactile and visual input, which protects the developing foetus from external stressors [7]. Typically, the foetus maintains a physiologically flexed posture within the womb, with the arms and legs bent and the trunk tucked forward. The uterine walls offer physical boundaries that serve as both support and reference points for movement [3].

In contrast, when infants are born preterm, they lack the opportunity to develop and maintain this flexed posture. Instead, preterm infants admitted to NICUs characteristically adopt a hypotonic, extended posture. It is difficult for preterm infants to assume a flexed posture because of low postural tone, the influence of gravity and insufficient flexor tone. Because they are born before their bodies are developmentally ready, they must adapt to an external environment that differs significantly from the protective confines of the uterus. As a result, preterm infants are often unable to control the movements necessary to sustain a symmetrical flexed posture or transition smoothly out of it. This is primarily due to their immature central nervous system and lack of proximal stability. To compensate, they seek postural stability by bracing against a firm surface—typically the mattress in the NICU, which may contribute to the development of excessive extension postures [7,8]. Poor positioning of premature infants can increase the risks of apnoea and neurobehavioural stresses. It can also cause intracranial haemorrhage due to inappropriate handling of these vulnerable preterm infants in early postnatal life [9].

Preterm infants often differ in posture when compared with those born at term due to reduced muscle tone and the influence of gravity, which leads to a more extended body position. This is largely because they arrive early into an environment where gravity affects them more profoundly, and their bodies are not yet fully prepared to handle external forces. To feel secure and stable, these infants tend to press against firm surfaces like the NICU mattress. Providing appropriate postural support is therefore vital to safeguard their health and encourage better neuromotor development [6-8].

Therapeutic positioning in supine, prone, side-lying and fixed contained positions are commonly used. It is a core intervention in NICU rehabilitation for preterm neonates; the main objectives during positioning are to provide support, facilitate movement and optimise

neurodevelopment, skeletal alignment and biomechanical function. Preterm newborns' neurodevelopmental journey is especially delicate during their stay in the NICU, since this is a crucial time for brain development to proceed outside the womb. The NICU environment, including how infants are positioned, significantly impacts how they develop neurologically [10-12].

In caring for preterm infants, several positioning strategies are used to support their posture and encourage healthy development. One common method is nesting positioning, where a rolled sheet is shaped like a tube to gently hold the baby in a curled, midline position. This helps reduce sudden, jerky movements and prevents the arms and legs from becoming stiff or immobile, creating a sense of security similar to the womb [10,13-16]. Another approach is cocoon positioning, which focuses on maintaining proper alignment of the head and body while allowing the baby's limbs to move freely and comfortably. Such positioning supports healthy musculoskeletal growth and reduces the risk of postural issues [17].

Postural support rolls and nappies are practical tools that aid in proper shoulder and hip positioning. The support roll prevents the shoulders from pulling back and encourages natural hand-to-mouth movements, which are important for early self-soothing. The specially designed nappy helps keep the hips flexed and close together, promoting healthy joint development and movement [18].

Special garments like the Dandle Roo, made with gentle stretch fabric, provide soft support to improve muscle tone, promote longer sleep and aid neurological development in preterm babies [5]. Supportive surfaces such as moldable mattresses or positioning mats help maintain normal muscle and joint function. These surfaces encourage spontaneous, natural movements, which are crucial for the baby's motor development [8,19].

Similarly, specially designed nesting devices recreate the snug, flexed environment of the womb, helping babies maintain midline posture and supporting early brain and motor development [7]. Finally, swaddling remains a valuable technique for calming infants by improving their ability to regulate sleep states, reducing pain and stress and promoting overall physiological stability. Together, these methods provide a nurturing and developmentally supportive environment that helps preterm infants thrive outside the womb.

Despite the large number of studies investigating how posture affects the neurodevelopment of preterm newborns, the research is still dispersed and lacks a thorough synthesis. A comprehensive evaluation is necessary to compile the available data, clarify trends, and offer guidance on the best positioning techniques for fostering the neurodevelopment of preterm newborns in NICU settings. Therefore, this systematic review aims to explore different positioning practices and their effects on the neuromotor development of preterm neonates admitted to the NICU.

## MATERIALS AND METHODS

This systematic review was structured according to the PICOS framework, focusing on preterm neonates in the NICU (Population), therapeutic positioning interventions (Intervention), compared with standard or no specific positioning (Comparison), with outcomes related to neurodevelopment (Outcomes) and including randomised controlled trials and observational studies (Study design). The design, search strategy and reporting of this systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The systematic review was registered in PROSPERO (International Prospective Register of Systematic Reviews) on 16 June 2024 under the identification number CRD42024554906. The comprehensive literature search was conducted from January 2000 to June 2024. PubMed, MEDLINE, CINAHL, DARE, ScienceDirect and Embase databases were used to explore the literature. The combination of Medical Subject Headings (MeSH) terms with "AND" and "OR" operators was used [Table/Fig-1]. No date restrictions were applied initially. Filters for human subjects and the English language were applied where available. In addition, the reference lists of the final selected articles were screened against the inclusion criteria.

| Searching keywords | Pubmed | Medline | CinahL | Dare | Science direct | Embase |
|---|---|---|---|---|---|---|
| ("Infant, Premature" (MeSH) OR "Preterm neonates" OR "Premature infants") | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ |
| AND | | | | | | |
| ("Therapeutic Positioning" OR "Posture"(MeSH) OR "Positioning techniques" OR "Nest positioning") | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ |
| AND | | | | | | |
| ("Neonatal Intensive Care Units"(MeSH) OR "NICU") | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ |
| AND | | | | | | |
| ("Motor Skills"(MeSH) OR "Neuromotor development" OR "Neuro-development") | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ | ✔☐ |

**[Table/Fig-1]:** Search strategy using keywords and Medical Subject Headings (MeSH).

**Inclusion criteria were:**

- Preterm neonates admitted to the NICU (born before 37 weeks of gestation);
- Infants without severe medical complications or congenital neurological/musculoskeletal malformations;
- Studies that implemented various positioning-based interventions compared with either standard care or alternative positioning methods;
- Studies that assessed neurodevelopmental outcomes, including cognitive, motor and sensory functions.

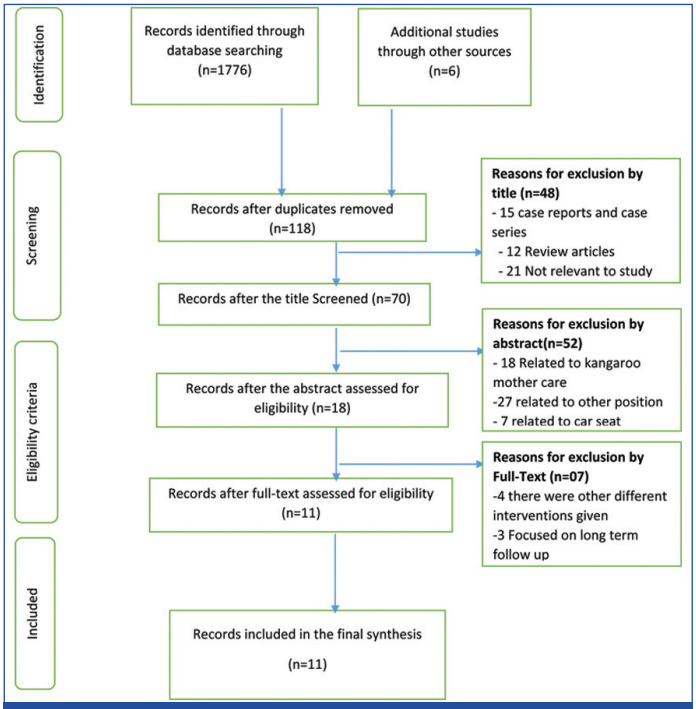
**Exclusion criteria included:**

- Review articles;
- Low-level evidence;
- Unpublished studies;
- Studies focusing on interventions unrelated to positioning.

All retrieved records were imported into EndNote (version X20.6). A total of 1,782 records were identified through independent database searches conducted separately by two reviewers (DC and NM), with contributions from PubMed (n=400), MEDLINE (n=320), CINAHL (n=256), DARE (n=200), ScienceDirect (n=300), and Embase (n=306). Given the overlap between databases and duplicate searches by both reviewers to enhance sensitivity, a substantial number of duplicate entries was anticipated. Prior to screening, all records were deduplicated using EndNote.

Following the merging of search results and removal of duplicates (n=1,664), 118 unique records remained for title and abstract screening. Of these, 48 articles were excluded: 15 were case reports or case series, 12 were review articles, and 21 were deemed irrelevant. An additional 52 articles were excluded after evaluating the methodology described in the abstracts. Specifically, 18 employed Kangaroo Mother Care positioning, 27 used alternative positions other than supine lying, and seven utilised car seats for positioning.

After these exclusions, 18 articles were shortlisted for full-text review. Of these, 11 randomised controlled trials were assessed in detail to determine eligibility for final inclusion (see [Table/Fig-2]). Throughout the review process, a third reviewer (NG) was consulted to resolve any disagreements.




**[Table/Fig-2]:** The PRISMA flow diagram.

For data extraction, tables were created to record the results of the extraction DC and NM independently read the full text and extracted the characteristics of the included studies, including author, publication year, study type, sample size, inclusion criteria, intervention, main outcomes, findings, positioning practices and device design. The data were integrated and checked by a third assessor (NG) and the disagreement was discussed and resolved together.

## RESULTS

Eleven articles were included in this review, as summarised in [Table/Fig-3] [5-14,20]. Structured positioning methods such as nesting, posture rolls and specialised postural support devices consistently led to more symmetrical body alignment, improved regulation of muscle tone and enhanced neuromotor performance when compared to conventional care. These positive effects were reflected in higher scores on standardised postural assessment tools, including the Infant Positioning Assessment Tool (IPAT), as well as improved behavioural regulation scores [6-9].

Similarly, quasi-experimental investigations [10-13] reported that providing supportive alignment, often replicating the curled foetal posture, helped infants maintain a flexed and midline-oriented position. This positioning was associated with smoother, more coordinated limb movements, greater motor control and more stable behavioural states.

Further insights came from exploratory and prospective studies [5,14,20] employing techniques such as video analysis, EEG monitoring and neuroimaging. These studies confirmed that developmentally supportive positioning reduced abrupt, uncoordinated motor activity, encouraged organised and purposeful movement patterns and fostered postures aligned with typical developmental trajectories for preterm infants.

Overall, evidence across different study designs demonstrates that therapeutic positioning not only improves physical alignment but also supports neuromotor stability and early neurobehavioural organisation, reinforcing its value as a key component of developmental care in NICU. The methodological appraisal of the included studies, using the Mixed Methods Appraisal Tool (MMAT), revealed that most studies were of moderate to high quality [Table/Fig-4] [6-9,12,13].

| Article title | Author | Study type | Outcome | Summary |
|---|---|---|---|---|
| Comparative effects of two positional supports on neurobehavioural and postural development in preterm neonates [5] | Vaivre-Douret L and Golse B | A prospective study | Assessments of body posture and of neurobehaviour | The group used Coconou," had showed promoting optimal prophylactic neurobehavioural and postural developmental care for preterm neonates. |
| Effect of postural supports on neuromotor function in very preterm infants to term equivalent age [6] | Monterosso L et al., | A randomised controlled trial | Measurements of shoulder and hip posture were performed | Combined use of a postural support roll and a postural support nappy improves hip posture and postural support roll improves shoulder posture up to term equivalent age. |
| The effects of alternative positioning on preterm infants in the Neonatal Intensive Care Unit (NICU): A randomised clinical trial [7] | Madlinger-Lewis A et al., | A randomised clinical trial | Neurobehavioural testing using the NICU Network Neurobehavioural Scale | At the time of discharge, the effects of positioning can be seen in preterm neonates by assuming less asymmetrical positioning. |
| Effect of nesting on extensor motor behaviours in preterm infants: A randomised clinical trial [8] | Eskandari Z et al., | A randomised clinical trial | Newborn Individualised Developmental Care and Assessment Program (NIDCAP) | Supporting the preterm infant body even by accessible materials could enhance their neurodevelopmental strengths and motor behaviour stabilities. |
| Effect of positioning on the incidence of abnormalities of muscle tone in low-risk, preterm infants [9] | Vaivre-Douret L et al., | A randomised clinical trial | Self-made neurological and psychological assessment tool | Regular changes in posture, along with positioning in functional positions, enhance the normal neuromuscular and osteo-articular function. This enhances the spontaneous movements and motor activity. |
| The influence of positioning on spontaneous movements of preterm infants [10] | Nakano H et al., | A quasi-experimental study | Spontaneous movements through video recording | Properly aligned positioning facilitates flexed posture and midline movement patterns resemble like foetus in the womb. |
| The effects of a postural supporting "New Nesting Device" on early neurobehavioural development of premature infants [11] | Tang X et al., | A quasi-experimental study | Digital video camera to obtain posture and behavioural data, EEG and cranial ultrasonography to evaluate early neurobehavioural outcomes | New Nesting Device" helps in assuming a comfortable flexed posture, like in the uterus, and smooth body movements. It helps in the promotion of early neurobehavioural development. |
| Effectiveness of nesting on posture and motor performance among high-risk newborn [12] | Jeyabarathi K and Shalini N | A quasi-experimental study | Posture by Infant Position Assessment Tool (IPAT) and motor performance was assessed by using Modified Ferrari tool | The nesting group showed effectiveness in maintaining posture and motor performance among high-risk newborns. |
| Effect of nesting position on behavioural organisation among preterm neonates [13] | Radwan RI and Mohammed AA | A quasi-experimental study | Behaviour Assessment Scale | This study shows the fact the nesting is one of the positioning methods which enhance the preterm neonate's neurobehavioural organisation. |
| Posture and movement in healthy preterm infants in supine position in and outside the nest [14] | Ferrari F et al., | An explorative study | General movements by scoring the predominant postural pattern based on serial video recording in the supine position | A nest promotes a flexed posture of the limbs with adduction of shoulders, facilitates elegant wrist movements and movements towards and across the midline and reduces abrupt movements and frozen postures of the arms and legs. |

| | | | | |
|---|---|---|---|---|
| A new type of swaddling clothing improved development of preterm infants in neonatal intensive care units [20] | Kitase Y et al., | A prospective clinical trial | Electroencephalogram, Head Magnetic Resonance Imaging (MRI), Neonatal Behavioural Assessment Scale (NBAS), evaluation of muscle tone, reflection, movement, abnormal signs by Dubowitz | The new stretchable cloth promotes muscle tone and sleep. It helps in reducing abnormal state levels in the preterm newborns. |

**[Table/Fig-3]:** Characteristics of the included studies about the improved positions [5-14,20].

| Study (author, year) | Study Design | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 |
|---|---|---|---|---|---|---|
| Vaivre-Douret L and Golse B [5], 2007 | Prospective | Yes | Yes | Unclear | Unclear | Yes |
| Monterosso L et al., [6], 2003 | RCT | Yes | Yes | Yes | Yes | Yes |
| Madlinger-Lewis et al., [7], 2014 | RCT | Yes | Yes | Yes | Yes | Yes |
| Eskandari Z et al., [8], 2020 | RCT | Yes | Yes | Yes | Yes | Yes |
| Vaivre-Douret L et al., [9], 2004 | RCT | Yes | Yes | Yes | Yes | Yes |
| Nakano H et al., [10], 2010 | Quasi-experimental | Yes | Yes | Yes | Unclear | Yes |
| Tang X et al., [11], 2021 | Quasi-experimental | Yes | Yes | Unclear | Unclear | Yes |
| Jeyabarathi K and Shalini N [12], 2018 | Quasi-experimental | Yes | Yes | Yes | Yes | Yes |
| Radwan RI and Mohammed AA [13], 2019 | Quasi-experimental | Yes | Yes | Yes | Yes | Yes |
| Ferrari F et al., [14], 2007 | Explorative | Yes | Yes | Unclear | No | Yes |
| Kitase Y et al., [20], 2017 | Prospective | Yes | Yes | Unclear | Yes | Yes |

**[Table/Fig-4]:** Evaluation of the methodological quality of the studies included in this review using the MMAT Scale [5-14,20].

## DISCUSSION

One of the biggest concerns with preterm babies is their neurodevelopment—the way their brains and nervous systems grow and function over time. Stays in the NICU expose them to environments that differ markedly from those experienced in utero [21]. Premature birth disrupts growth and development within the womb and makes it difficult for them to adjust to life outside it. Neural dysfunction can arise in preterm infants when external demands surpass their ability to cope and regulate their responses [22]. Numerous studies have noted that preterm newborns' nervous-system development is not aligned with the sensory overload experienced in the NICU [23]. Neonates, therefore, exhibit a wide range of neurophysiological reactions as well as behavioural stress indicators in response to environmental stressors. They may show certain symptoms of stress, including jerking, grimacing, gazing and irritability, which can be elicited by stimulating the newborn's reflexes [24-27]. That is why adopting proper supported postures is important for optimal brain growth outside the womb.

This systematic review synthesised findings from a range of studies assessing the effects of various postural support interventions on the developmental outcomes of preterm infants. Despite differences in methodology, setting and intervention design, a consistent theme emerged: developmentally supportive positioning contributes positively to postural alignment, neuromotor performance and early neurobehavioural outcomes in preterm neonates.

Numerous studies, including Monterosso L et al., and Vaivre-Douret L, demonstrated that using supportive devices such as molded mattresses or postural rolls improved specific aspects of infant posture, particularly at the shoulders and hips [6,9]. This aligns with the broader understanding that flexed positioning, mimicking intrauterine posture, supports maturation of the musculoskeletal and motor systems. Similarly, Ferrari F et al., and Nakano H et al., found that oval nests and specially designed mats facilitated midline orientation and smoother, more coordinated movements—hallmarks of healthy motor development [10,14].

Furthermore, studies by Jeyabarathi K and Shalini N (2018) and Radwan RI and Mohammed AA (2019) emphasised the neurobehavioural advantages of nesting over routine care [12,13]. These benefits were observable even with minimal intervention periods, suggesting that simple postural support mechanisms can offer meaningful developmental support when integrated into standard NICU care. Devices like the Dandle Roo and U-shaped cloth nests were also found to reduce asymmetry and promote organised motor patterns, indicating that both specialised equipment and improvised methods have value when used correctly.

While the overall findings are promising, several limitations within the included studies must be acknowledged. Firstly, sample sizes were often small, especially in the quasi-experimental and exploratory designs (e.g., Nakano H et al., 2010; Ferrari F et al., 2007), which may limit the statistical power and generalisability of the results [10,14]. Additionally, several studies lacked randomisation or blinding, which can introduce selection and observer biases.

There was also variability in the types of outcomes measured and tools used. Some studies relied on standardised tools like the IPAT, while others used custom-made or observational scales without reported validity or reliability. This lack of uniformity limits the ability to make direct comparisons between studies and weakens the strength of pooled conclusions.

Moreover, the duration of interventions varied widely—from as short as one day (as in Jeyabarathi K and Shalini N, 2018) to several weeks—which makes it challenging to determine the optimal frequency and duration needed to yield significant benefits [12]. Many studies also did not report long-term follow-up outcomes, so it remains unclear whether the observed short-term improvements translate into lasting developmental gains.

Finally, some studies [5,11,14] lacked detailed descriptions of their intervention protocols or control conditions, making it difficult to assess the fidelity and reproducibility of the interventions. For instance, vague references to "routine care" without a standardised baseline make it difficult to evaluate the true added value of the positioning devices. Although this review aimed to provide a comprehensive and objective synthesis of available evidence, certain methodological limitations must be considered. The inclusion criteria restricted the review to English-language publications, which may have led to the exclusion of relevant studies published in other languages, introducing language bias.

Additionally, while the MMAT was used to assess methodological quality, several studies did not provide adequate information to score all criteria confidently, limiting transparency and affecting the accuracy and completeness of the quality assessment. Another limitation was the heterogeneity in study designs, outcomes and populations, which prevented pooling data into a meta-analysis and necessitated a descriptive synthesis. Moreover, unpublished studies, grey literature and conference proceedings were not included, which could contribute to publication bias, particularly if studies with non significant results were underrepresented.

Policymakers and hospital administrators may consider developing and implementing standardised postural care protocols that are evidence-informed and adaptable across settings. Such policies could improve the uniformity and quality of neonatal care, potentially reducing developmental delays and the burden of long-term neurodisability. Future research should aim to overcome the limitations of existing studies by employing larger sample sizes, randomised designs, and longer follow-up durations to assess sustained developmental impact. There is also a need for research that directly compares different types of positioning interventions and explores their integration with other neuroprotective NICU strategies, such as Kangaroo Mother Care and individualised developmental care programs.

Additionally, qualitative research exploring parental and staff perceptions of these interventions could offer insights into feasibility, acceptability and implementation barriers—critical factors for translating research into practice.

## CONCLUSION(S)

The review shows that different positioning methods such as nesting, Coconou supports, postural rolls and nappies, stretchable clothing, moldable mats and swaddling are effective in supporting the growth and development of preterm infants. These techniques help babies maintain a comfortable, curled posture similar to their time in the womb, which encourages healthy muscle tone, reduces stress, and promotes natural movements. Although the studies varied in design and size, they all point to the positive impact of well-planned positioning on the physical and neurological development of these vulnerable newborns. Creating a cozy, womb-like environment through proper positioning is a key to helping preterm babies thrive. Simple, thoughtful positioning interventions can make a big difference in supporting their early motor skills, brain development, and overall health, giving them a better start in life.

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