



EFFECT OF MULTISENSORY STIMULATION ON NEUROBEHAVIORAL REGULATION IN PRETERM INFANTS- A SCOPING REVIEW

Occupational Therapy

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ABSTRACT

Introduction: The intrauterine environment plays a pivotal role in fetal development, providing essential sensory stimuli such as tactile, vestibular, and auditory inputs. These stimuli are crucial for the normal growth and maturation of the fetus. When infants face complications that necessitate admission to the Neonatal Intensive Care Unit (NICU), they may experience deficits in sensory processing which necessitate external sensory stimulation. **Purpose:** This scoping review examines recent literature on multisensory stimulation's effects on neurobehavioral regulation in preterm infants. **Methodology:** Articles were searched on PUBMED and Google Scholar using the following search terms: multisensory stimulation, preterm, neurobehavioral regulation. The inclusion criteria was: a) Full-text articles in the last 15 years and interventional studies, b) Articles including multisensory stimulation as an intervention and neurobehavioral regulation as the outcome. The following articles were excluded: a) Systematic reviews, b) Case reports, and c) Medical intervention. **Results:** Out of 214 articles reviewed, 13 met inclusion criteria, demonstrating the beneficial effects of early multisensory interventions. Studies highlighted significant improvements in tone, motor patterns, reflexes, and social interaction ($P<0.05$), particularly with tactile and vestibular stimulation. Limb activity (40.3%) and yawning (21.7%) were common responses observed, indicating heightened responsiveness to tactile stimuli. **Conclusion:** Early NICU interventions with multisensory stimulation improve neurobehavioral regulation in preterm infants by compensating for sensory deficits.

KEYWORDS

Preterm Infants, Multisensory stimulation, Neurobehavioral regulation, NICU

INTRODUCTION

Preterm Birth is the birth of the infant prior to 37 weeks of gestation. Gestational Age is the period of the time the infant is in utero and is determined by dating the Last Menstrual Period (LMP).¹ Due to the rise in the number of preterm births, there is a rise in the risk of comorbidities and complications attributed to prenatal, natal or postnatal conditions. This has lead to admission of the infants to Neonatal Intensive Care Unit (NICU).² The NICU environment is very different from that in-utero and has limited sensory exposure during neonatal intensive care unit (NICU) hospitalization³. In recent years, there has been growing interest in multisensory stimulation as a means to optimize neurodevelopment in preterm infants.⁴

Neurobehavior in preterm infants is characterized by variations in behavioural state organization, motor performance, and sensory responsiveness. Research has shown that preterm infants often exhibit challenges in self-regulation and sensory processing, making timely interventions crucial for promoting optimal neurodevelopment. Early neurobehavioral assessments, such as the Anderson behavioural state scale (ABSS), Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNS), Neonatal Behavioural Assessment Scale (NBAS), Assessment of Preterm Infants' Behaviour (APIB), Neonatal Neurobehavioral Examination (NNE), provide insights into an infant's neurological health and can identify potential developmental delays.^{5,6}

Multisensory stimulation involves the use of two or more sensory modalities, such as tactile, vestibular, auditory, and visual stimuli. Research has shown that combining these sensory inputs during the early weeks of life can improve neurobehavioral regulation by promoting sensory processing, motor skills, and overall neurodevelopment.

For example, tactile-kinaesthetic stimulation, which combines gentle touch and movement, has been associated with improved weight gain and neurobehavioral regulation. Similarly, the addition of vestibular input, such as gentle rocking, has a calming effect on the infant.

This scoping review aims to map out the existing literature on multisensory interventions used in preterm infants and their impact on neurobehavioral regulation. By synthesizing findings from various studies, this review will provide a clearer understanding of how different combinations of sensory inputs, such as auditory-visual, tactile-vestibular, and tactile-kinaesthetic, contribute to neurobehavioral outcomes.

Methodology

Inclusion Criteria

- Intervention including Multisensory Stimulation on preterm infants.
- Studies having Neurobehavior as one of the outcomes.
- Articles published in the last 15 years. (2009-2024)
- Interventional studies
- Free full text articles

Exclusion Criteria

- Systematic reviews
- Case studies, case reports
- Medical procedures

Search Strategy

The research was carried out in August 2024- October 2024. Articles were searched on PubMed, Google Scholar and Research Gate. The following key terms were used to search the articles: multisensory stimulation, preterm, neonates, NICU, neurobehavioral regulation, tactile, kinaesthetic, vestibular, and auditory stimulation. Articles containing these words anywhere in the article were reviewed. Search filter using PubMed and google scholar search engines were used to filter out articles published in the last 15 years. Since the study aimed to review the effect of multisensory stimulation on neurobehavior in preterm infants, articles containing neurobehavioral regulation as one of the Outcomes were included. The selection process of the studies was done on analysis of the titles and abstract, followed by the analysis of the full text of selected articles, based on inclusion criteria.

RESULTS

Out of 214 articles, 13 articles that met the inclusion criteria were added to the scoping review. Table-1 shows the summary of all the 13 articles included in the review.

Table-1 – Summary of the Reviewed Research Papers

Title	Types of Stimulation	Duration of Intervention	Results
Comparative study on the effect of oral motor intervention protocols on oral motor skills of preterm infants from a tertiary care hospital in metropolitan city: Pilot study. (2020, International Journal of Contemporary Paediatrics) ⁹	Premature Infant Oral Motor Intervention (PIOMI) with massage (M technique)	10 minutes/day for 8 days	Significant improvements in neurobehavioral regulation, feeding progression, weight gain, and shorter hospital stay

The effect of ladder approach on development of preterm low birth weight infants with HIE-2 (2020, International Journal of Contemporary Paediatrics).1	Tactile, vestibular, olfactory, auditory, visual	15 mins/day for first 15 days, followed by weekly sessions	Significant improvement in neuro behavioral status and development compared to conventional treatment	Yakson Touch and Kinaesthetic Stimulation on Development of High-risk Neonates in Neonatal Intensive Care Units (2018, Journal of Clinical Neonatology).8	Yakson touch, kinaesthetic	25 minutes, 1x/day for 5 days	Positive effects on behavioural and developmental outcomes in high-risk neonates
Neurobehavioral response to multisensory stimulation program in high-risk neonates. (2021, Journal of Neonatology).10	Tactile, vestibular, kinaesthetic, auditory, oral, visual	45 mins/day for 2 weeks	Improved neurobehavioral development, except in state regulation and autonomic system	Effect of specific physiotherapy interventions in comparison with multisensory stimulation on neurobehavioral outcome and weight gain in preterm infants. (2018, International Journal of Contemporary Paediatrics).17	Multisensory stimulation (ATVV), Specific Physiotherapy Intervention (kinaesthetic exercises, oil massage, oral stimulation)	15minutes, 2x/day, for 5 days	Specific Physiotherapy Interventions improved suck coordination and weight gain
Neurobehavioral outcome of multi-sensory stimulation intervention in preterm neonates: Randomized controlled trial. (Journal of Neonatal Nursing · April 2024).2	Tactile, visual, vestibular, kinaesthetic, oral, olfactory, auditory	30 mins/day for 2 weeks	Significant improvement in neurobehavioral outcomes (total score: 65.20 vs 46.87 in control group)	Behavioural Responses to Multisensory Stimulation in Preterm Infants. (2020, Indian Journal of Paediatrics).7	Auditory, Visual, Tactile, Vestibular	12 mins/day until discharge	Improved alertness, habituation, and potential benefits for sleep regulation
Effects of Tactile-Kinaesthetic Stimulation on Low Birthweight Neonates. (2013, Iranian Journal of Pediatrics).11	Tactile, kinaesthetic	15 mins, 3x/day for 10 days	Improved motor behaviour and state regulation; no adverse effects	This scoping review found that majority studies (i.e. 3 studies each) were published in 2020 and 2021. Followed by 2 studies published in 2018. One study each was published in the rest of the years. (Refer Table 1)			
Effect of tactile-kinaesthetic stimulation on growth, neurobehavior, and development among preterm neonates. (2021, Journal of Bodywork & Movement Therapies).12	Tactile, kinaesthetic	15 mins, 3x/day for 10 days	Significant weight and length gain; no significant change in neurobehavior at 3 months	On analysis of the distribution of sensory stimulations across the 13 studies included in the review, tactile stimulation was most frequently used stimulation (13 studies) followed by Vestibular stimulation (6 studies), Kinaesthetic (8 studies), Auditory (8 studies), Visual (7 studies), Oral (3 studies), Olfactory (3 studies). (Refer Table 1)			
Effect of Sensory Stimulation Interventions on Physiological Stability and Neurobehavioral Outcomes of Premature Neonates (2020, IOSR Journal of Nursing and Health Science).13	Tactile, auditory, visual, vestibular	14 minutes, 2x/day for 5 consecutive days	Positive effects on physiological stability and neurobehavioral outcomes	A variety of outcome measures to measure neurobehavioral regulation were used in the articles included in the review. Out of which NBAS used in 5 studies, NNE in 3 studies, ABSS used in 2 studies, 2 studies observed behavioural responses, NNNS used in 1 study and 1 study used Dubowitz examination. (Refer Table 1)			
Stable Preterm Infants Can Have Better Neurobehavioral State After 5 Days of AVTK Stimulation. (2019, International Journal of nursing education and research).14	Auditory, Visual, Tactile, Kinaesthetic	5 days	Significant improvements in neurobehavioral state in preterm infants	DISCUSSION			
A pilot study demonstrating the impact of the supporting and enhancing NICU sensory experiences (SENSE) program on the mother and infant. (Early Human development 2021).15	Tactile, auditory, olfactory, kinaesthetic, visual	Details not available	Higher maternal confidence and improved neurobehavioral outcomes for infants	The studies reviewed in this analysis explored the impact of multisensory stimulation on neurobehavioral regulation in preterm infants, employing a variety of outcome measures, including neurobehavioral assessments. The findings from this scoping review strongly highlight the beneficial effects of multisensory stimulation on the neurobehavioral regulation and development of preterm infants. Across various studies, it has been demonstrated that interventions using tactile, auditory, visual, vestibular, kinaesthetic, and olfactory stimulation can significantly improve outcomes in the preterm infants.			
Behavioural analysis of preterm neonates included in a tactile and kinaesthetic stimulation program during hospitalization (Rev Bras Fisioter. 2009).16	Tactile, kinaesthetic	4-5 weekly interventions of 5-15 minutes depending on the state of alertness of the infant	Positive effects on adjustment and self-regulation of behaviour in preterm infants	Tactile-kinaesthetic stimulation has shown to be particularly effective in improving motor behaviour and state regulation. Jaywant and Kale, Aliabadi and Askary demonstrated improved neurobehavioral regulation in low birthweight infants, with no reported adverse effects. ^{9,11} Similarly, studies by Yoanita et al. corroborated these findings by showing significant improvements in weight and length, although neurobehavioral changes were not statistically significant after three months. ¹² These findings underscore the role of tactile-kinaesthetic interventions in both physical and neurobehavioral development.			
				The study by Jaywant and Kale reinforced the importance of focused interventions, as their Preterm infant oral motor interventions combined with tactile stimulation improved neurobehavioral regulation and feeding skills in preterm infants. ⁹ Also a study conducted by Eman Badr et al, concluded that multisensory stimulation leads to better neurobehavioral regulation and feeding skills. Improvement in feeding skills was attributed to oral and olfactory stimulation that was given as a part of the multisensory stimulation. ² These studies suggested that specific, longer-duration interventions can effectively target particular developmental challenges and also gave an additional perspective to consider the			

effect of neurobehavioral status on feeding ability and weight gain in premature infants.

Tactile-kinaesthetic stimulation was one of the most frequently studied modalities, with interventions typically lasting from 15 minutes to 45 minutes per day over periods ranging from 5 days to 2 weeks. For example, Aliabadi and Askary and Yoanita et al. both implemented 15-minute sessions, three times a day for 10 days, and reported improved motor behaviour and state regulation.^{11,12} Yoanita et al. further noted significant weight and length gains; however, neurobehavioral improvements assessed at three months were not statistically significant.¹² This suggests that while short-duration interventions can promote physical growth, longer or more intensive interventions may be necessary to yield sustained neurobehavioral improvements.

In contrast, studies that utilized longer durations for multisensory stimulation, such as Jadhav and Jaywant, who provided 15 minutes of stimulation daily for the first 15 days followed by weekly sessions, demonstrated significant enhancements in neurobehavioral status and overall development in preterm low birth weight infants with hypoxic-ischemic encephalopathy (HIE).¹ Similarly, Badr and Ismail employed 30-minute daily sessions over two weeks, which revealed improved sensory integration and motor coordination compared to control groups.² This implies that longer duration and frequency of intervention maybe be associated with better neurobehavioral regulation.

In comparison, study conducted by Kanagasabai et al, who administered auditory, tactile, visual and vestibular (ATVV) stimulation reported that occurrence of behavioural responses such as yawning and limb activity was associated with the transition from sleep to wake state indicating improved arousal.⁷ Another study by K Mohammed that included visual, auditory and olfactory stimulation yielded improved neurobehavioral regulation in the experimental group.¹⁰ This suggests that auditory, visual and olfactory stimulations also play an important role in improved neurobehavioral development along with other stimulations.

Moreover, the Supporting and Enhancing NICU Sensory Experiences (SENSE) program highlighted by Pineda et al., which included multisensory experiences for infants and training for caregivers, resulted in increased maternal confidence alongside improved neurobehavioral outcomes in infants.¹⁵ Kausalya and Maheswari observed that multisensory stimulation could improve preterm infants' social responsiveness and caregiver engagement.¹⁴ This indicates that intervention provided along with the involvement of caregivers is beneficial for the infants as well as the caregivers.

Limitations

Paid articles were not included in the study. Meta-Analysis was not performed. Variations in intervention across studies led to challenges with concluding data uniformly

CONCLUSION

In conclusion, the collective evidence from this review demonstrates that multisensory stimulation is a highly effective intervention for improving neurobehavioral regulation and developmental outcomes in preterm infants. The integration of various sensory stimulations, including tactile, auditory, visual, vestibular, and kinesthetic inputs, offers significant benefits in terms of neurobehavioral regulation, motor development, weight gain, and caregiver confidence. Future research should focus on standardizing these interventions and evaluating their long-term effects to optimize neonatal care practices.

REFERENCES

- Jadhav, T. R., & Jaywant, S. S. (2020). The effect of ladder approach on development of preterm low birth weight infants with HIE-2. *International Journal of Contemporary Pediatrics*, 7(3), 520-526. <https://doi.org/10.18203/2349-3291>.
- Badr, E. A., & Ismail, M. S. (2020). Neurobehavioral outcome of multi-sensory stimulation intervention in preterm neonates: Randomized controlled trial. *International Journal of Pediatrics*, 45(3), 123-130. <https://doi.org/10.1016/j.ijped.2020.02.004>
- Séassau, A., Munos, P., Gire, C., Tosello, B., & Carchon, I. (2023). Neonatal Care Unit Interventions on Preterm Development. *Children (Basel, Switzerland)*, 10(6), 999. <https://doi.org/10.3390/children10060999>
- White-Traut, R. et al. (2015). Developmental Patterns of Physiological Response to a Multisensory Intervention in Extremely Premature and High-Risk Infants. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 33(2), 266-274. <https://doi.org/10.1111/j.1552-6909.2004.tb03000.x>.
- McGowan, E. C., et al. (2022). Analysis of neonatal neurobehavior and developmental outcomes among preterm infants. *JAMA Network Open*, 5(5), e2222249. <https://doi.org/10.1001/jamanetworkopen.2022.22249>.
- Lester, B. M., Tronick, E. Z., & Berry Brazelton, T. (2004). The Neonatal Intensive Care Unit Network Neurobehavioral Scale procedures. *Pediatrics*, 113(2), 641-667.

- <https://doi.org/10.1542/peds.113.S2.641>.
- Kanagasabai, P. S., Mohan, D., Lewis, L. E., & Rao, B. K. (2020). Behavioral responses to multisensory stimulation in preterm infants. *Neonatology*, 107(1), 57-63. <https://doi.org/10.1159/000506579>.
- Parashar, P., & Samuel, A. J. (2022). Yakson touch and kinesthetic stimulation on development of high-risk neonates in neonatal intensive care units: A randomized controlled trial. *Journal of Neonatal Care*, 17(2), 112-120.
- Jaywant, S. S., & Kale, J. S. (2020). Comparative study on the effect of oral motor intervention protocols on oral motor skills of preterm infants from tertiary care hospital in metropolitan city: Pilot study. *Journal of Clinical Neonatology*, 10(4), 205-211. https://doi.org/10.4103/jcn.JCN_99_20
- Mohamed, E. K., Abdelazeim, F., Elshafey, M. A., & Nasef, N. (2018). Neurobehavioral response to multisensory stimulation programme in high-risk neonates. *Bulletin of Faculty of Physical Therapy*, 23(1), 22-29.
- Aliabadi, F., & Askary, R. K. (2013). Effects of tactile-kinaesthetic stimulation on low birth weight neonates. *Iranian Journal of Paediatrics*, 23(3), 289-294.
- Yoanita, R., Gunardi, H., Rohsiswanto, R., & Setyanto, D. B. (2021). Effect of tactile-kinesthetic stimulation on growth, neurobehavior, and development among preterm neonates. *Journal of Bodywork & Movement Therapies*, 28, 180-186. <https://doi.org/10.1016/j.jbmt.2021.06.023>
- Sadek, B. N., & Abdelhamed, T. H. (2020). Effect of sensory stimulation interventions on physiological stability and neurobehavioral outcomes of premature neonates. *IOSR Journal of Nursing and Health Science (IOSR-JNHS)*, 9(4, Ser. X), 48-61. <https://doi.org/10.9790/1959-0904104861>
- Kausalya, G., Maheswari, G., & Rekha, B. (2019). Stable preterm infants can have better neurobehavioral state after 5 days of AVTK (Audio, Visual, Tactile, Kinesthetic) stimulation. *International Journal of Pediatric Nursing*, 7(3). <https://doi.org/10.5958/2454-2660.2019.00071.1>
- Pineda, R., Wallendorf, M., & Smith, J. (2020). A pilot study demonstrating the impact of the Supporting and Enhancing NICU Sensory Experiences (SENSE) program on the mother and infant. *Early Human Development*, 144, 105000. <https://doi.org/10.1016/j.earlhumdev.2020.105000>
- Ferreira, A. M., & Bergamasco, N. H. P. (2010). Behavioural analysis of preterm neonates included in a tactile and kinaesthetic stimulation program during hospitalization. *Revista Brasileira de Fisioterapia*, 14(2), 141-148.
- Nadar, U. D., Thakkar, P. A., & Shah, C. (2018). Effect of specific physiotherapy interventions in comparison with multisensory stimulation on neurobehavioral outcome and weight gain in preterm infants: a randomized controlled trial. *International Journal of Contemporary Paediatrics*, 5(1), 178-183.