Review article
Effects of vestibular stimulation on neurophysiologic impact among preterm infants - A systematic review

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ABSTRACT

The preterm birth can have impact on child development. Hence the purpose of this systematic review is to find the effect of vestibular stimulation and its impact when given to preterm infant. The database search for this systematic review includes Google Scholar, PubMed, Pedro, Research Gate, and Cochrane. A Total of 96 articles were obtained using the key words search. The articles were filtered and sorted according to the inclusion and exclusion criteria. 6 articles were selected for the review. The review search included all clinical trials in preterm babies (28-37 weeks) with the birth weight ranging from 1,000-2,000g, medically stable, stable vital signs and had a control group that did not receive any intervention in addition to the standard treatment provided by the NICU. The articles which did not contain, full text, appropriate data and published in any other language other than English were excluded. The review search analysis reflected that, vestibular stimulation for preterm infants is beneficial and necessary. Vestibular stimulation proves to have a significant amount of positive beneficial outcomes when compared to other stimulations. Assessment of the methodology of the studies reviewed herein showed that vestibular stimulation is efficient in determining the developmental behaviour, to enhance the respiratory functioning, to ensure physical growth, in promoting mature sleep and to maintain arousal state.

Keywords: Vestibular stimulation; tactile kinaesthetic stimulation; preterm infants.

INTRODUCTION

Every year, an estimated 15 million babies are born preterm (before 37 completed weeks of gestation), and this number is rising. That is more than 1 in 10 babies. Approximately 1 million children die each year due to complications of preterm birth. A few preterm babies, however, do develop important and lasting neurodevelopment problems (1,2). The period between 20 and 32 weeks after conception is one of rapid brain growth and development. Illness, under nutrition, and infection during this time may compromise neurodevelopment. The clinical consequences can include serious neuromotor problems, visual and hearing impairments, learning difficulties, and psychological, behavioural, and social problems (3).

The neonatal intensive care unit (NICU) environment can disrupt the sequential order of events needed for brain development and is considered a rate-limiting environment that deprives infants of sensory stimulation they would otherwise receive in utero. Neonatal complications, invasive oxygen therapies, numerous daily medical procedures and stationery-confining isolates all reduce the amount of vestibular, kinesthetic, tactile, auditory and visual information available to the infant. The duration of these maladaptive exposures can last from a few days to a few months depending on the stability and comorbidities of the preterm infant (4).

To decrease the immediate misfortune and developmental deficits associated with prematurity. Various forms of stimulation include vestibular, tactile, kinesthetic, auditory, oral, and other multimodal combinations. All these interventions have been developed to compensate for the environmental deprivation, and to accelerate the development of preterm infants. Vestibular stimulation is one among the intervention that is being considered important for a preterm infant over other stimulations. Morphogenesis of the vestibular apparatus in humans is complete by the 49th day in utero, and the vestibular nerve is myelinated and functional between the 8th and 9th month of intrauterine life (5-7). Response to vestibular stimulation has been observed as early as 25 weeks gestational age (8). Foetal buoyancy in amniotic fluid creates a whirlpool-like milieu rich in sensory cues, including potent and nearly continuous vestibular and cutaneous stimulation (9,10). Owing to the early maturation of the vestibular system, it is one the best mechanisms for providing developmentally appropriate stimulation to the infants born premature (11). Since tactile stimulation if given without any addition or in combination with other stimulations, causes increased arousal in preterm infants, and so vestibular stimulation is considered to be superior over that (12). This review was made to identify the effects of vestibular stimulation in preterm infants and to know the respective results that were significantly observed among the preterm infants. This review serves as a gleam in exposing the importance and necessity of vestibular stimulation.

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METHODOLOGY

Study design

This systematic review was conducted based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines.

Selection of studies

A total of 96 articles were obtained as a result of search using the key words and the articles were filtered and sorted according to the inclusion and exclusion criteria. The article which met the inclusion criteria and 6 articles were included in the study.

Inclusion criteria and Exclusion criteria

This present review included all clinical trials that included preterm babies (28-37 weeks), birth weight ranging from 1,000-2,000 g, medically stable, stable vital signs and had a control group that did not receive any intervention in addition to the standard treatment provided by the NICU. The articles which met the inclusion criteria were included in the study. The articles which did not contain the full texts, articles which included preterm participants with any congenital anomalies, infants with birth infection and the articles which did not contain appropriate data and in any other language other than English were excluded.

Fig. 1: Study selection strategy

Table 1: Summary of studies included

<table>
<thead>
<tr>
<th>Author</th>
<th>Study-design</th>
<th>Participants (Gestational week)</th>
<th>Objective of the study</th>
<th>Results obtained</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-Traut et al., (12)</td>
<td>Experimental study</td>
<td>33-34 weeks of gestation</td>
<td>To examine the immediate responses of preterm infants to two forms of unimodal [auditory only (A) and tactile only (T)] and two forms of multimodal sensory stimulation [auditory, tactile and visual (ATV); auditory, tactile,</td>
<td>Infants receiving any intervention with a tactile component showed increasing arousal (change in BS), and increased PR and RR during stimulation.</td>
<td>Tactile stimulation alone may be too arousing for these infants while the addition of vestibular stimulation may modulate arousal and facilitate optimal arousal prior to feeding.</td>
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<tr>
<td>Study</td>
<td>Design</td>
<td>Duration of Gestation</td>
<td>Details</td>
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<td>Zimmerman and Barlow (13)</td>
<td>Quasi experimental study</td>
<td>28-34 Weeks of gestation</td>
<td>To examine the role of vestibular inputs on respiratory and oro-motor systems in healthy preterm infants. Infants increased their respiratory rate in response to vestibular stimuli and that the highest vestibular acceleration delivered to the infants (0.51 s) resulted in significant increase in breaths per minute. Vestibular stimulation delivered to preterm infants before scheduled feeds effectively modulates respiratory rate and resets the respiratory central pattern generator.</td>
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<td>Cordero et al., (14)</td>
<td>Experimental study</td>
<td>28-33 weeks of gestation</td>
<td>To study the effects of vestibular stimulation on sleep states in premature infants. Those exposed to the vestibular stimulation showed a significant decrease in proportion of active and a concomitant increase in proportion of quite sleep. Vestibular stimulation, even in the early postconceptional age, results in a more mature sleep pattern.</td>
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<tr>
<td>Mary V. Neal (15)</td>
<td>Experimental study</td>
<td>28-37 weeks of gestation</td>
<td>To explore the effects of vestibular stimulation on the developmental behaviour, respiratory functioning, weight and length gains, and morbidity and mortality rates of premature infants. Infants who received vestibular stimulation (motorized hammock) had higher pH levels and greater linear growth. Those infants placed in hammock but were free to remain still and initiate motion by themselves showed a significant weight gain. These data are interpreted as suggesting that the development of integrating biological behaviours of the small premature infant may be influenced by a specific motion pattern.</td>
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<tr>
<td>Dekker et al., (16)</td>
<td>Randomised control trial</td>
<td>27-32 weeks of gestation</td>
<td>To evaluate the direct effect of repetitive tactile stimulation on breathing effort of preterm infants at birth. There was no significant difference in respiratory minute volume in the repetitive stimulation group when compared to the standard group. The increase in respiratory effort during repetitive stimulation did not reach significance oxygenation significantly. Repetitive tactile stimulation could be of added value to improve breathing effort at birth.</td>
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<tr>
<td>Pepino and Mezzacappa (17)</td>
<td>A systematic review</td>
<td>Pre-term infants</td>
<td>To verify the methods used by the clinical trials that assessed the effect of tactile/kinaesthetic stimulation on weight gain in preterm infants and highlight the similarities and differences among such studies. There were many differences in the application of tactile/kinaesthetic stimulation techniques among studies, which hindered the accurate reproduction of the procedure. Also, many studies did not describe the adverse events that occurred during stimulation, the course of action taken when such events occurred, and their effect on the outcome. These studies made a relevant contribution towards indicating tactile/kinaesthetic stimulation as a promising tool but there was no standard for application among them.</td>
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**RESULTS**

A total of 96 articles were found in the above-mentioned databases. Out of these 96 articles, 73 were excluded based on duplication, not having proper data, unable to access and not relevant to the study. 23 articles were fully read out of which 6 articles met the...
inclusion criteria. By reviewing the articles included in the study, the following results were obtained.

The importance of the above essential stimulation has been emphasized in many studies; the evidence thus strongly suggests that stimulation in infancy is beneficial, specifically for the premature infant. From the above findings, according to Zimmerman (13), the effects of vestibular stimulation in preterm infants seems to have a greater significance in respiratory rate when compared to Dekker et al., repetitive tactile stimulation (16), as no significant difference in the intervention group was observed. In addition, weight gain is observed in preterm infants receiving vestibular stimulation and also more mature sleep pattern is seen. Cordero et al., in their study concluded that vestibular stimulation in addition to tactile stimulation results in modulate arousal and facilitate optimal arousal prior to feeding. As there are variations among the application of tactile/kinaesthetic stimulation, no standard application exists. Vestibular stimulation proves to have a significant amount of positive beneficial outcomes over the other stimulations and seems to effective results among preterm population.

DISCUSSION

The preterm infants experience a range of morbidity related to the immaturity of their organ systems and to concurrent disease states. There is concern that an unfavourable environment in the neonatal intensive care unit (NICU) may compound this morbidity. Modification of the environment could minimize the iatrogenic effects. Developmental care is a broad category of interventions designed to minimize the stress of the NICU environment. These interventions may include elements such as control of external stimuli (vestibular, auditory, visual, tactile), clustering of nursery care activities, and positioning or swaddling of the preterm infant. Individual strategies have also been combined to form programs, such as the New born Individualized Developmental Care and Assessment Program.

The stimulus deprivation on preterm is deleterious for later intellectual, emotional and developmental functioning and stimulation accelerates the development of the central nervous system, produces earlier onset and better utilization of ACTH functions. Vestibular system is one of the first sensory systems to develop; the premature infant may be more receptive to stimulation in this modality than in any other.

Vestibular stimulation has been studied by Pomerleau-Malcuit and Clifton (18) relation to heart rate and they determined that the infants had a declarative cardiac response following the stimulation. Arousal levels may be reduced behaviourally and physiologically when stimulation is offered continuously while intermittent. Our study was designed to explore the importance of vestibular stimulation and its respective results on preterm infants.

Zimmerman (13) the literature examined the role of vestibular inputs on respiratory and oromotor systems in healthy preterm infants. A multi-level regression model revealed that treatment infants increased their respiratory rate in response to vestibular stimulus, and that the highest level of vestibular acceleration delivered to the infants (0.51 m s) resulted in a significant increase in breaths per minute.

Neal (15) the study which was designed to explore the effects of vestibular stimulation on the developmental behaviour, respiratory functioning, weight and length gains, and morbidity and mortality rates of premature infants, and its findings indicated that the infants in group A had higher pH levels and greater linear growth than the infants in any of the other groups and that the group B infants showed the greatest weight gain. These data are interpreted as suggesting that the development of integrating biological behaviours of the small premature infant may be influenced by a specific motion pattern.

Cordero et al., (14), in his study found the effects of vestibular stimulation on sleep status in premature infants was included in this study and this article proves that vestibular stimulation eventually has effect on improving the sleeping pattern in preterm, the author measured neurologic maturation, behavioural and physiologic parameters characterizing sleep states and recorded at the onset and termination of the 2-week period. The ratio of active-to-quiet sleep did not change significantly in control patients. Those exposed to vestibular stimulation showed a significant decrease in proportion of active and a concomitant increase in the proportion of quiet sleep. These results may indicate that vestibular stimulation, even at this early postconceptional age, results in a more mature sleep pattern.

White Traut et al., (12) examined the immediate responses of preterm infants to two forms of unimodal [auditory only (A) and tactile only (T)] and two forms of multimodal sensory stimulation-auditory, tactile and visual (ATV); auditory, tactile, visual and vestibular and concluded tactile stimulation alone may be too arousing for these infants while the addition of vestibular stimulation may modulate arousal and facilitate optimal arousal prior to feeding benefit of adding vestibular stimulation when compared to the T and ATV protocols was that the infant's increased arousal was obtained more often after the intervention, rather than during the intervention. The soothing effects of vestibular stimulation on both full-term and premature infants are well documented and, as these results suggest, might be used to modulate responding. In other words, vestibular stimulation may be used in conjunction with auditory, tactile and visual...
stimulation to help the premature infant organize behaviour.

CONCLUSION

Assessment of the methodology of the studies reviewed herein showed that vestibular stimulation is efficient in determining the developmental behaviour, to enhance the respiratory functioning, to ensure physical growth, in promoting mature sleep and to maintain arousal state. However, tactile stimulation seems to be beneficial but there is no standard application of this technique and the number of positive output results seems to be less when compared to vestibular stimulation. Although all forms of application of vestibular stimulation gives a positive effect and good outcome in the preterm population, upcoming studies must focus on one particular best form of application of vestibular stimulation that would yield a cent percent effect on the preterm infants.

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CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

REFERENCES