

Estratégias de intervenção sensório-motora para crianças prematuras no cuidado intensivo neonatal: uma revisão sistemática**Sensory-motor intervention strategies for premature infants in neonatal intensive care: a systematic review**

DOI:10.34117/bjdv6n7-586

Recebimento dos originais: 21/06/2020

Aceitação para publicação: 21/07/2020

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ABSTRACT

Background: Interventions that imitate the intrauterine environment can have beneficial effects on the development of premature infants. **Purpose:** The aim of the present literature review was to determine what sensory-motor stimulation techniques are administered to premature newborns in neonatal intensive care units and analyze the impact of these interventions on neuropsychomotor development. **Methods:** The SciELO, LILACS, PubMed, PEDro and Cochrane databases were searched for pertinent articles published between 2007 and 2018. **Results:** Seventy-five articles were identified and 10 were included in the review. Different sensory-motor interventions are employed, the most widely used of which are tactile and acoustic stimuli. Such interventions generate both immediate and long-term benefits to neuropsychomotor development in this population. **Implications:** Premature newborns have the ability to interact with different environment and sensory-motor stimulation methods. These interventions generate both immediate and long-term benefits to neuropsychomotor development in this population, leading to weight gain and other improvements, such as a reduction in pain in this population.

PROSPERO register number: CRD42018098693.

Key words: Infant, Premature, Neonatal Intensive Care Units, Acoustic Stimulation, Photic Stimulation, Physical Stimulation, Therapeutic Touch, Physical therapy modalities.

RESUMO

Antecedentes: As intervenções que imitam o ambiente intra-uterino podem ter efeitos benéficos no desenvolvimento de bebês prematuros. Objetivo: O objetivo da presente revisão da literatura era determinar que técnicas de estimulação sensorial-motora são administradas a recém-nascidos prematuros em unidades de cuidados intensivos neonatais e analisar o impacto destas intervenções no desenvolvimento neuropsicomotor. Métodos: As bases de dados SciELO, LILACS, PubMed, PEDro e Cochrane foram pesquisadas para artigos pertinentes publicados entre 2007 e 2018. Resultados: Setenta e cinco artigos foram identificados e 10 foram incluídos na revisão. São utilizadas diferentes intervenções sensoriais-motoras, as mais utilizadas são estímulos tácteis e acústicos. Tais intervenções geram benefícios tanto imediatos como a longo prazo para o desenvolvimento neuropsicomotor nesta população. Implicações: Os recém-nascidos prematuros têm a capacidade de interagir com diferentes ambientes e métodos de estimulação sensório-motora.

Estas intervenções geram benefícios tanto imediatos como a longo prazo para o desenvolvimento neuropsicomotor nesta população, levando ao aumento de peso e outras melhorias, tais como a redução da dor nesta população.

PROSPERO register number: CRD42018098693.

Palavras-chave: Lactente, Prematuro, Unidades de Cuidados Intensivos Neonatais, Estimulação Acústica, Estimulação Física, Estimulação Física, Toque Terapêutico, Modalidades de Fisioterapia.

1 INTRODUCTION

The World Health Organization classifies premature newborns according to gestational age and birth weight. Prematurity is defined as a birth that occurs prior to the 37th week of pregnancy and low birth weight is defined as less than 2500 g¹⁻³. These factors are determinants of neonatal morbidity and mortality, higher hospitalization rates and deficits in gross motor development^{4,5}.

The functional and structural immaturity of organs and tissues can cause deviations in the motor development pattern of premature children, leading to a significantly increased risk of motor impairment with the reduction in birth weight and gestational age⁶. One of the possible consequences of premature birth that impact neurodevelopment is the occurrence of cerebral palsy, visual impairment and hearing impairment, which are highly prevalent in this population^{7,8}. Moreover, pre-term children are more prone to exhibit sensory-motor difficulties, learning difficulties and behavioral problems in subsequent phases of life^{9,10}.

Premature birth not only disrupts normal development, but also places the infant in a highly technological environment¹¹. Such infants are exposed to stressors¹¹ in the neonatal intensive care unit (NICU), such as high levels of physical (light and sound) and painful (invasive procedures) stimulation that affects development¹². Although this environment is necessary for survival, it often exposes infants to inadequate stimuli, causing a mismatch between the actual sensory input and that which the fetus would receive in the uterus. In the intrauterine environment, the fetus receives frequent stimulation through contact with the amniotic fluid and the uterine wall. These intrauterine sensations are necessary to normal growth and neurobehavioral development¹³. After being delivered, premature infants are deprived of these stimuli.

This incompatibility in the sensory input at a time when the central nervous system is undergoing growth and maturation is speculated to alter neuronal organization and connections, which, in turn, can exert a negative impact on subsequent neurodevelopment. Thus, efforts have been made to employ early sensory-motor interventions with this population. This approach is based on the concept that brain development, although primarily regulated by genetics, is also influenced by environmental inputs through the different senses. According to this concept, the intrauterine

environment provides all the sensory stimulation necessary to optimize the development of the senses¹¹. Interventions that mimic the intrauterine environment can have beneficial effects on the development of premature children and help them cope better with the unfavorable environment of the NICU. Thus, early sensory stimulation can promote the maturation of premature infants by simulating what the fetus experiences in the womb¹⁴.

Humanization in this context involves the appropriate interventions, which constitute an important aspect of improving the quality of care offered premature newborns¹⁵. Behavioral strategies of restraint, positioning and non-painful sensory stimulation are used, along with the encouragement of the family's presence in the NICU, such as the "kangaroo mother" project¹⁶. One of the main advantages of this project is to avoid long periods without sensory stimulation and diminish the length of the hospital stay¹⁷.

The use of a hammock in the incubator is another method that has successfully been employed to reduce the irritability of premature newborns, promoting less heat loss and energy expenditure, with a consequent increase in weight. This method enables the infant to relax, improves behavioral responses and provides adequate sensory (visual, tactile and vestibular) stimulation, contributing to neuropsychomotor development¹⁸. "Nesting"¹⁹ and the ofuro bath²⁰ are other examples of interventions for premature infants.

The aim of the present study was to determine the sensory-motor techniques used with premature infants in the NICU and analyze the impact of these interventions on neuropsychomotor development.

2 METHODS

2.1 PROTOCOL AND REGISTRY

The present systematic review is registered with the International Prospective Register of Systematic Reviews (PROSPERO n° CRD42018098693) and was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

2.2 ELIGIBILITY CRITERIA

Table 1 displays the four components of the PICO strategy used for this present review.

P	Premature newborns with no diseases diagnosed prior to birth and no malformations
I	Sensory-motor (tactile, vestibular, proprioceptive, olfactory, visual, auditory and taste) stimulation techniques
C	No intervention or sensory stimulation, receiving only the routine care offered in the NICU
O	Contribution to neuropsychomotor development and weight gain (growth), reduction in stress (behavioral states – sleeping and awake), reduction in time in the NICU, pain control and prevention of complications

2.3 DATA SOURCES AND SEARCH STRATEGY

After the determination of the research question using the PICO strategy, we searched for evidence-based results²¹ in pertinent articles published between 2007 and 2019 in the following databases: Scientific Electronic Library Online (SciELO), Latin American and Caribbean Health Sciences Literature (LILACS), PubMed, Physiotherapy Evidence Database (PEDro) and Cochrane Library. No restrictions were imposed with regards to language.

Key words were selected using the Medical Subject Headings (MeSH) of the U.S. National Library of Medicine. The strategy employing descriptors was based on each type of sensory stimulation separately and the use of the Boolean operator “AND”: “*Neonatal Intensive Care Units AND Infant, Premature AND Acoustic Stimulation*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Physical stimulation*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Touch Perception*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Therapeutic Touch*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Smell*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Taste*”, “*Neonatal Intensive Care Units AND Infant, Premature AND Photic Stimulation*”.

Reporting the search strategy is part of the assessment step of a systematic review. Therefore, the search protocol should be published with details of the database interface, the terms and filters used and any other decisions taken. The entire process should be documented and clearly reported to ensure the reproducibility and reliability of the results of the review²². Therefore, it is important to point out that the search terms were used separately for each type of stimulation in all databases. No filters were used; the searches were only limited by the predetermined timeframe (2007 to 2018).

A specific search strategy was used only in the PubMed database. During the study, we found that it was possible to arrange the search by either “most recent” or “best correspondence”.

Performing the search using the two specific orders, it was determined that “best correspondence” would lead to the identification of a greater number of records and would also improve the quality of the study, since pertinent studies were found with this method that were not located using the “most recent” order. Thus, only for the PubMed database, the search strategy was to alter the order from “most recent” to “best correspondence” to find a greater number of records and enhance the quality of the search through the identification of additional studies.

2.4 STUDY SELECTION PROCESS

The initial analysis involved the reading of the title, abstract and, if necessary, parts of the texts to determine the methods and essence of the study. This technique is denominating “skimming”. If questions remained regarding the inclusion of an article based on the selection criteria, the “scanning” technique was employed, which consists of a brief reading of the complete study to determine its eligibility.

2.5 INCLUSION CRITERIA

The inclusion criteria were experimental studies (randomized controlled clinical trials or controlled clinical trials) published between 2007 and 2018 involving premature newborns in the NICU who received some type of sensory-motor stimulation either alone or combined with other sensory stimulations.

2.6 EXCLUSION CRITERIA

Non-experimental studies, studies that did not meet the inclusion criteria, studies involving premature infants with pathologies prior to birth or malformations, studies involving the use of drugs concomitantly to the interventions and studies not addressing the contribution of the intervention to neuropsychomotor development, weight gain (growth), reductions in stress and time spent in the NICU, pain control and the prevention of complications were excluded from the review.

2.7 QUALITY APPRAISAL OF STUDIES

The preselected articles were appraised for methodological quality using the Brazilian-Portuguese version of the PEDro scale, which is composed of 11 items totaling 10 points. Only studies that met the eligibility criteria and achieved a quality score of at least four points on the PEDro scale were included in the review (Table 2). All ten studies that met these criteria were randomized controlled clinical trials.

Sensitivity analysis was performed with the Cochrane tool for assessing the risk of bias in randomized clinical trials to investigate the robustness of the results (Table 3). This information was used to guide our judgments regarding the quality of the evidence along with the appraisal of the methodological quality using the PEDro scale.

Table 2 – Methodological quality scores of articles selected for present review - PEDro scale and Cochrane Collaboration of risk of bias (N = 10)

Study	Items on PEDro scale ^a										Points
	1	2	3	4	5	6	7	8	9	10	
Vaivre-Douret et al.	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
Fucile et al.	Y	N	Y	N	N	Y	N	N	Y	Y	5/10
Massaro et al.	Y	Y	Y	N	N	Y	Y	N	Y	Y	7/10
Hyesang et al.	Y	N	Y	N	N	N	N	N	Y	Y	4/10
Kanagasabai et al.	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
Johnston et al.	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
Ozdemir et al.	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
Rosales et al.	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
Qiul et al.	Y	N	Y	N	N	Y	Y	N	Y	Y	6/10
Tandoi et al.	Y	N	Y	N	N	N	Y	N	Y	Y	5/10

a-1:
random

allocation; **2:** concealed allocation; **3:** baseline comparability; **4:** blinded participants; **5:** blinded therapists; **6:** blinded evaluators; **7:** adequate follow up; **8:** intention-to-treat analysis; **9:** between-group comparisons; **10:** point measures and measures of variability. **Y:** yes; **N:** no

Study	Random allocation	Concealed allocation	Blinding of patients, therapists	Blinding of evaluators	Data on incomplete results	Reporting of selective results	Other
Vaivre <i>et al.</i>	Low	High	High	High	Low	Low	Low
Fucile <i>et al.</i>	Low	High	High	Low	High	Low	Low
Massaro <i>et al.</i>	Low	Low	High	Low	High	Low	Low
Hyesang <i>et al.</i>	Low	High	High	High	High	Low	Low
Kanagasabai <i>et al.</i>	Low	High	High	High	High	Low	Low
Johnston <i>et al.</i>	Low	High	High	High	High	Low	Low
Ozdemir <i>et al.</i>	Low	High	High	High	Low	Low	Low
Rosales <i>et al.</i>	Low	High	High	High	High	High	Low
Qiul <i>et al.</i>	Low	High	High	Low	High	Low	Low
Tandoi <i>et al.</i>	Low	High	High	High	High	Low	Low

3 RESULTS

Seventy-five articles were retrieved from the databases. After the removal of duplicates, the analysis of the titles, abstracts and complete texts and the appraisal of methodological quality using the PEDro scale, only 10 articles met the inclusion criteria and

had a quality score of four or more points. Figure 1 displays the flowchart of the article selection process. Tables 4, 5 and 6 display the characteristics of the studies included in the present review.

Figure 1 – Flowchart of article selection process.

Figure 1 – Flowchart of article selection process.

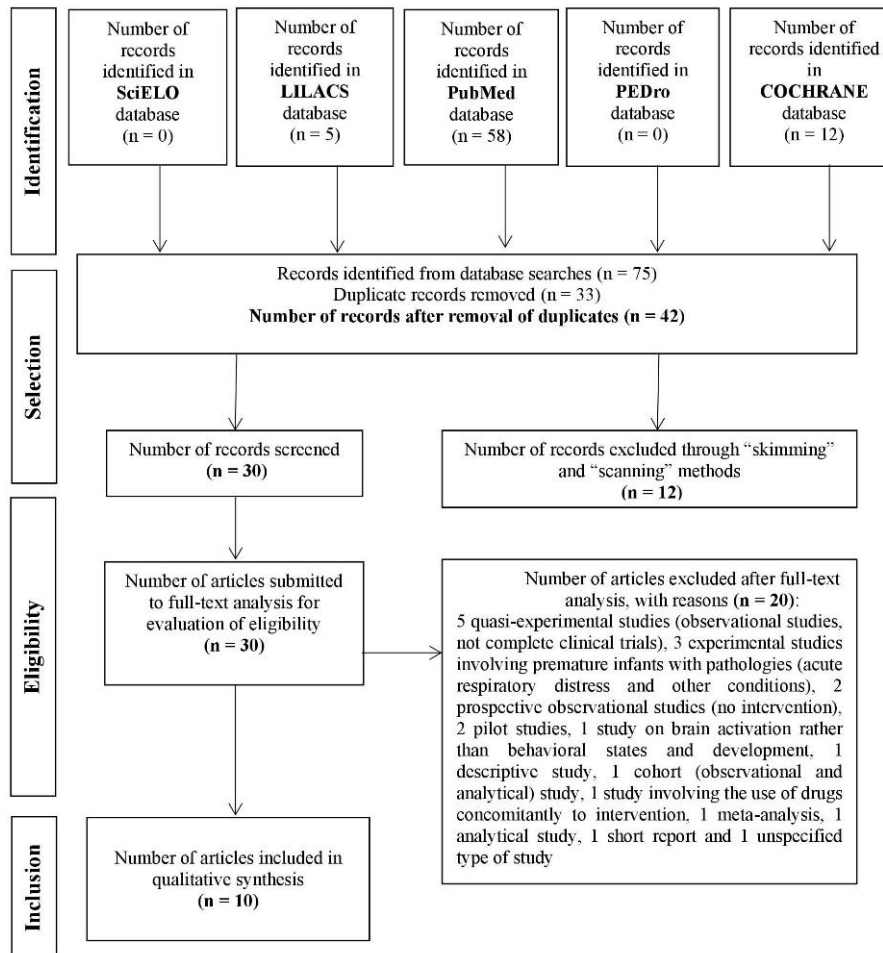


Table 3 – Characteristics of studies included in review (N = 10)

AUTHOR/YEAR	PARTICIPANTS	TYPE OF STIMULUS	INTERVENTION	MAIN RESULTS
Suganthini et al 2013	Pre-term newborns N = 50	Acoustic, tactile, visual and vestibular	Multi-sensory stimulation administered for 12 minutes per day, five days a week until discharge from hospital.	Infants submitted to multisensory stimulation had higher neuromotor scores compared to control group (p = 0.001). The outcome was positive: Multisensory stimulation had a beneficial effect on the tonal maturation of premature infants.
Jie Qiu ¹ et al 2017	Pre-term newborns N = 62	Acoustic and tactile	Intervention (continual playing of music) administered five minutes prior to experimental procedure (touch) to 30 minutes after procedure.	PIPP scores were significantly lower in the experimental group than the control group. Beta endorphin concentration was higher in the experimental group than the control group. The outcome was positive: Combined touch and music stimulation lowered the response to pain in newborns, with an increase in β -endorphins, but no change in cortisol.
Hyesang Im et al 2009	Pre-term newborns N = 40	Tactile	Gentle human touch administered for 15 minutes (morning and afternoon) for 15 days.	A significantly better sleep state was found in both groups after touch therapy. The effect was significantly stronger with control group than gentle human touch, demonstrated a significant excitation effect, whereas the children in the human touch group showed little change. The outcome was positive: The infants were calmer after both interventions.
Domínguez et al 2008 Rosales	Pre-term newborns N = 78	Tactile	Therapeutic touch administered for 10 minutes three times a day until discharge from hospital.	Mean weight was 1867.80 g in the experimental group and 1.860 g in the control group. The infants in the experimental and control groups respectively spent 16.82 and 20.30 days in the NICU. The frequency of postnatal complications was 5.3% in the experimental group and 20% in the control group. The outcome was positive: Touch therapy was effective at reducing hospital stay and complications as well as favoring weight gain (growth) in premature newborns.
Fucile et al 2010	Pre-term newborns N = 84	Oral, tactile and kinesthetic	Oral intervention, tactile/kinesthetic intervention, or both (combined intervention) administered for 15 minutes twice a day.	All experimental groups exhibited greater weight gain during the intervention period than the control group. All experimental groups exhibited better motor function than the control group. The outcome was positive: The individual and combined interventions led to improvements in growth and motor function in premature infants.

Table 3 – Characteristics of studies included in review (continuation)

AUTHOR/YEAR	PARTICIPANTS	TYPE OF STIMULUS	INTERVENTION	MAIN RESULTS
Massaro et al 2009	Pre-term newborns N = 60	Tactile kinesthetic	Therapeutic massage, or massage with kinesthetic stimulation administered twice a day for 15 minutes each.	Mean daily weight gain and hospital stay were similar in both groups. For pre-term infants, the mean weight gain was higher in the intervention group than the control group. Positive outcome: Massage with kinesthetic stimulation improved weight gain in premature newborns. Negative outcome: The duration of hospital stay was unaffected by massage with or without kinesthetic stimulation.
Vaivre-Douret et al 2008	Pre-term newborns N = 49	Tactile, proprioceptive, vestibular, kinesthetic, acoustic, visual and olfactory	Multimodal stimulation and touch with saline solution or sweet almond or vegetable oil administered for 15 minutes twice a day for 10 consecutive days.	The group that used the vegetable oil blend exhibited greater weight gain and increases in psychomotor scores and time spent calm while awake in comparison to the other groups. All multimodal stimulation groups had shorter hospital stays (mean reduction of 15 days) and an increase in body length. Both groups massaged with oil (almond and vegetable blend) had higher neurological scores compared to the other groups. The outcome was positive: The combination of multimodal stimulation and the application of oils to the skin of healthy premature infants resulted in greater weight gain and neurological development as well as a shorter hospital stay.
Kardas et al 2013	Pre-term newborns N= 97	Olfactory	Exposed to mother's scent, flexion positioning administered for continuously for 24 hours).	A significant difference in hospitalization and mean weight was only significant in the "mother's scent" group, the intra-group difference between mean hospitalization and length was significant in the three groups. The outcome was positive: The flexion positioning and "mother's scent" interventions favored growth and shortened the duration of hospitalization in the NICU.
Johnston et al 2013	Pre-term newborns N= 55	Tactile	Therapeutic touch administered for a total of 10 minutes.	No significant differences were found between groups for the primary outcome (PIPP). The change in scores during the heel prick test was also non-significant. The outcome was negative: Therapeutic touch administered immediately before and after a painful procedure (heel prick) had no comforting effect on premature newborns.

Tandai et al 2014	Pre-term newborns N= 34	Acoustic	“Original sound” stimulation” administered 30 minutes per day.	Heart rate in the experimental group was positively correlated with exposure to the “original sound”, with a significant reduction on the second day and lower values on the first day. A reduction in respiratory rate was also found on the second day in experimental group, although the difference was not statistically significant. The reduction in both rates on the second day did not affect O ₂ saturation, as an improvement is expected in a situation of less stress. The outcome was positive: This study provided preliminary evidence of short-term improvements in the physiological stability of premature infants using acoustic stimulation with the use of the “original sound”
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4 DISCUSSION

Our objective with the present systematic review was to determine what sensory-motor stimulation techniques are administered to premature newborns in the NICU and analyze the impact of these strategies on neuropsychomotor development. This review was based on two theories regarding the process of human development, which demonstrate how developmental stages are influenced by external stimuli and address how to interpret the behavior of infants to determine the best technique to administer (how, when and why to stimulate newborns based on the responses they offer).

The Synactive Theory of Development was developed by psychologist Heidelise Als (2003) to help health professionals understand the behavior of newborns better. This theory puts forth the idea of contingent care for infants based on prior observations, an analysis of the real need for procedures, the use of procedures at the most adequate time for the infant and molded based on his/her responses, and presuming that the newborn will be calm at the end of the process. The theory is denominated synactive because subsystems develop independently in each stage of development and are continuously interacting with each other and the environment. Five subsystems are addressed in the Synactive Theory of Development: autonomic, which regulates physiological stability; motor, assessed by tone, posture and movements; behavioral states, representing states of being wake or sleeping; attention and interaction, which are related to the newborn's capacity to interact socially, emotionally and cognitively with the surrounding environment; and regulating, involving the newborn's behavioral efforts to maintain self-regulation. The development process is described as a set of concentric circles with each of the subsystems continually promoting feedback for the others. These subsystems are described as being independent, but function in an interlinked and interactive way with each other and the environment. Thus, the development of each in subsystem can either strengthen or overload the stability of the others, depending on its level of support and degree of intactness²³.

Human development can also be exemplified and understood through the Pyramid of Human Development put forth by Williams and Shellenberguer (1994), which establishes the development of human abilities arranged in layers, such that if a higher layer is compromised, there is a need for support from a lower layer. The base of the pyramid is the structure that gives meaning to the entire process: the central nervous system. In increasing order, the pyramid is divided into different developmental stages and the chronology of these stages: first year – sensory systems; one to three years – sensory-motor development; three to six years – perceptive-motor development; six to twelve years – development of superior processes. Each stage has levels/layers involving the main

stimuli and acquisitions. According to this theory, development occurs from the base to the apex of the pyramid resulting from personal and environmental elements that exert an influence on the acquisition of higher levels of development. Beginning with this base, the following development phases of the sensory systems are established in increasing order in the first year: first level – basic developmental stimuli (tactile, vestibular and proprioceptive); second level – vision, hearing, smell and taste²⁴.

The sensory systems begin developing in the uterus. This development initiates with the tactile system, followed in sequence by the vestibular, chemical (olfactory/gustatory), hearing and visual systems. The functioning of these systems begins prior to the complete maturation of the structures and the stimulation of one system can favor the onset of functioning of another system that is about to develop²⁵. Based on these theories, we structured our discussion by subdividing the results of the clinical findings of the present systematic review based on the type of sensory stimulation performed on premature newborns.

Touch therapy was the most widely used sensory stimulation. Among the 10 studies included in the present review, eight administered some type of tactile stimulation²⁶⁻³², either alone^{29,31,32} or in combination with other stimuli^{26-28,30,33}. Touch is considered one of the most important means of non-verbal communication and can send either positive or negative messages to the patient depending on the moment, form and place in which it occurs. Touch is intentional physical contact between individuals and is classified as either instrumental (deliberate physical contact necessary to the performance of a specific task) or expressive (spontaneous, affective contact not necessarily related to a particular physical task)^{31,32}.

In the NICU, the principle of “minimal touch” had prevailed since Long and colleagues (1980) demonstrated that handling premature newborns for medical purposes increased the risk of desaturation. However, subsequent studies indicated the opposite³².

The development of skin receptors begins in the seventh week of gestation. The body parts that react to tactile stimulation are around the mouth (8.5 gestational weeks), genital area (10.5 gestational weeks), palms of the hands (10.5 to 11 gestational weeks) and soles of the feet (12 gestational weeks). Skin receptors are found throughout the entire surface of the body at 20 gestational weeks³⁴. Thus, touch is the most common sensory stimulation performed on newborns and is considered essential to newborn development³⁵. It has also been demonstrated that, without the appropriate touch, infants can experience insufficient growth, a delayed bond with their parents and possible psychological disturbances. In turn, the appropriate tactile stimuli assist in the growth and development of premature newborns^{34,35}. This is a noninvasive technique that does not require

any specialized equipment and can be implemented without disrupting routine care procedures. For clinically stable premature infants, there appears to be no adverse effects.

Among the studies included in the present review that addressed tactile stimuli, most positive results involved the contribution to neuropsychomotor development^{26,27,30} and weight gain^{27,28,32}. There was also a favorable impact on reducing both stress²⁹ and hospital stay³². However, divergent results are reported regarding the effect of tactile stimulation on pain. One of the studies reported a reduction in pain, but the intervention involved the combination of acoustic and tactile stimulation rather than touch alone³³. In contrast, a study focused on only touch therapy found no positive effect on pain³¹. The premature infants in the study in question had allodynia, which is characterized by pain caused by a sensory stimulus that does not normally cause pain, resulting in a negative effect of tactile stimulation. This was also the only study in the present review to describe a negative outcome of sensory-motor interventions administered to premature newborns. It is therefore possible that a combination of sensory-motor interventions should be employed. For instance, QIU *et al.* (2017)³³ combined acoustic and tactile stimuli to minimize pain when handling this population. Pain is more intense in newborns due to the immature inhibition mechanisms, which limit the pain modulation capacity^{36,37}.

According to the pyramid of human development, tactile stimulation should be one of the precursors of therapy. As the administration of tactile stimuli is inspired by the sensory development of the infant still in the womb, these studies have a positive aspect, as the tactile system may be the most developed sensory component in premature infants²⁵. Moreover, if the stimulus also has its origin in the pyramid of human development, tactile stimulation should be one of the first strategies administered sensorially, together with vestibular and proprioceptive stimuli, depending on the needs of each infant. These two forms of stimulation (vestibular and proprioceptive) were used less frequently in the studies included in the present review and no conclusive responses were obtained with such interventions^{26,30}.

After touch, the second most frequently used stimulus was acoustic. Among the ten studies included in the present review, four administered some type of acoustic stimulation, three of which employed combined interventions^{26,30,33} and one employed acoustic stimulation alone³⁸. At about 25-26 weeks of gestation, the fetus can perceive and respond to sounds in its environment³⁹. When a premature birth occurs, the mother's low-frequency sounds in the amniotic environment are replaced with loud environmental noise. Therefore, premature infants are deprived of the physiological auditory stimulation necessary to their maturation and normal development, which can affect hearing development. Thus, we can state that hearing is one of the infant's means of

contact with the external environment in the first days of life. The only study that used an acoustic stimulation strategy alone created an original sound with the acoustic memory of the fetus during intrauterine life, reproducing sounds and rhythms that fetuses hear in the womb, such as the fetal heartbeat, breathing and blood flow. This type of stimulus was able to reduce the adaptative stress resulting from the premature birth³⁸.

The study that combined acoustic and tactile stimulation achieved positive results with regards to pain control. The hearing of the premature infants was stimulated with music, including lullabies and children's songs³³. Music therapy can assist in relieving processual pain in pre-term and full-term newborns because it provides an auditory stimulus that modulates the perception of pain, diminishing the need for pharmacological agents⁴⁰.

Taste, sight and smell are on the second level of development of the sensory systems. Randomized clinical studies that address taste stimuli are scarce in the literature and the few that do exist are mainly not characterized as clinical trials. In an analytical, double-blind trial, Medeiros *et al.* (2013)⁴¹ studied behavioral states (classified as deep sleep, light sleep, sleepiness, alert, agitated/irritated and crying) in 90 premature newborns after offering gustatory stimuli (water and 12% analytical sucrose). In the sucrose group, a strong correlation was found in the behavioral states of light sleep and alert during and after stimulation and a reduction in the correlation was found in the sleepiness, agitated/irritated and crying states. In the water group, an increase in the correlation in the agitated/irritated and crying states was found after stimulation⁴¹. Further studies involving this type of stimulus in premature infants are needed.

None of the 10 studies included in the present review employed visual or olfactory stimulation in an isolated manner; these stimuli were always administered in conjunction with other types of sensory-motor stimuli. Thus, studies addressing these stimuli separately are needed to determine their effects. Three of the 10 studies addressed visual^{26,30} and olfactory^{30,42} stimulation, the main outcome of which was the contribution to neuromotor development in premature infants^{26,30}.

The ofuro bath stands out among the early sensory-motor techniques used with this population. In a recent study, Çaka *et al.* (2017)⁴³ investigated the effects of two bathing methods on the duration of crying and physiological measures in 80 newborns in the NICU. Pre-bath and post-bath stress levels were measured using the Neonatal Infant Pain Scale. The authors recommend the bathing method with the infant wrapped in a sheet (ofuro) due to the reduction in stress behavior.

Nesting is another technique employed. Abdeyazdan *et al.* (2016)⁴⁴ investigated the effects of swaddling and nesting on the duration of sleep in 42 premature infants in the NICU. Both

swaddling and nesting led to significant increases in total sleep time and tranquil sleep time, which suggests that nesting is beneficial to this population in the hospital setting.

Analyzing the results of the clinical trials selected for the present review, sensory stimuli exerted a positive impact on the scores of the assessment tools used, with significant improvements in weight and length gains, sensory-motor development, muscle tone, behavioral state and pain as well as a reduction in hospital stay in several of the studies. These findings demonstrate the possible effectiveness of sensory-motor interventions in premature infants in the NICU. However, there are limitations that should be considered when interpreting the results of this review. Firstly, there is no specific protocol that establishes the best time to administer each technique or what stimulus generates the most positive responses in premature infants. Secondly, we are referring to healthy infants. Therefore, the safety and effectiveness of these stimulations should be investigated in premature newborns with associated comorbidities. The present results can be considered preliminary findings and further studies are needed, since humanization applied to the NICU setting is a concept in constant development. Moreover, studies with good methodological quality are scarce. Future investigations should carefully consider the best stimulation method to administer, how, when and why to stimulate newborns based on the responses they offer and the best application time for each technique.

5 CONCLUSION

Based on the findings of the present systematic review, premature newborns have the ability to interact with their environment and different sensory-motor stimulation methods are employed, the most frequent of which in the studies analyzed were tactile and acoustic. Such interventions generate both immediate and long-term benefits to neuropsychomotor development in this population, leading to weight gain and other improvements, such as a reduction in pain in this population.

The authors have no conflicts of interest.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

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