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Analysis of sensory processing in preterm infants

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ABSTRACT

Background: Premature birth suggests condition of biological vulnerability, predisposing to neurological injuries, requiring hospitalization in Neonatal Intensive Care Units, which, while contributing to increase the survival rates, expose infants to sensory stimuli harmful to the immature organism.
Aims: To evaluate the sensory processing at 4 and 6 months' corrected age.
Subjects and methods: This was a descriptive cross-sectional study with a sample of 30 infants divided into an experimental group composed of preterm infants ($n = 15$), and a control group composed of full-term infants ($n = 15$). The infants were assessed using the Test of Sensory Functions in Infants.
Results: The preterm infants showed poor performance in the total score of the test in reactivity to tactile deep pressure and reactivity to vestibular stimulation. When groups were compared, significant differences in the total score ($p = 0.0113$) and in the reactivity to tactile deep pressure ($p < 0.0001$) were found.
Conclusion: At 4 and 6 months of corrected age, the preterm infants showed alterations in sensory processing. These changes were most evident in reactivity to tactile deep pressure and vestibular stimulation.

1. Introduction

Interaction with the environment requires interpretation and responses to sensory stimuli. It involves the ability to process stimuli from all systems (tactile, olfactory, gustatory, visual, auditory, proprioceptive and vestibular), and then interpret them and respond to them adaptively [1]. This process allows individuals to direct attention and continually responds to demands from the environment. Thus, all actions, not only in terms of body movements, but also those of learning processes and concept formation, are dependent on the ability to interpret sensory information [1].

Children that do not process sensory information properly, manifesting maladaptive responses, may have sensory processing disorders [2]. The cause of these disorders is still unknown, but they are more common and evident in children with a history of prematurity, low birth weight and neonatal complications, i.e., the so-called high-risk infants, who often require treatment in Neonatal Intensive Care Units (NICUs).

The implementation of NICUs was a milestone in the care of preterm newborns, because they reduced neonatal morbidity and mortality, especially among extreme preterm and very low birth weight infants [3–6]. Thus, the long-term stays by preterm infants in NICUs is frequently associated with factors that cause discomfort and pain, which may have negative impact on their psychological, sensory and motor development in the short, medium and long term [7]. Thus, the NICU environment may be a major factor contributing to the increased incidence of behavioral and learning alterations in individuals with histories of prematurity and low birth weight, due to the immaturity of the central nervous system (CNS) and the excessive sensory stimulation during the hospitalization period [3,8].

The organization phase of the CNS occurs at a time of vulnerability in preterm infants. Despite CNS organization continuing into adulthood, it enters a critical period between the 5th and 6th month of gestation up to 1 year of age [9], when CNS organization is determined by sensory inputs that influence the neuronal selection/maintenance. Thus, the first sensory inputs experienced by infants in the NICU and later in their home environment will affect cerebral development. This means that excessive sensory inputs from the hospital environment may strengthen some neuronal connections that will be retained, but that will no longer be the most appropriate for further development. During intrauterine life, the development of the sensory system occurs in a specific sequence. Touch is the first system to be developed, while vision is the last one [10]. Thus, the exposure of preterm infants to these stimuli alters the natural process of this sequence [11–13]. Therefore, infants in a NICU are exposed to a condition of multiple risks in which one risk potentiates another.

During this critical phase of brain development, excessive exposure to stimuli must be controlled so that there is no interruption of the normal development sequence [14]. Taylor et al. [15] examined performance predictors of children with very low birth weight (<1500 g) at school age, for cognitive function, neuropsychological abilities, academic performance and behavior. Their results showed that, even after controlling for socioeconomic risk factors, the neonatal risk

Abbreviations: CNS, central nervous system; NICUs, Neonatal Intensive Care Units; TSFI, Test of Sensory Functions in Infants.

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influenced the cognitive performance and neuropsychological abilities of the children evaluated, and the greater the neonatal risk (intracranial hemorrhage, necrotizing enterocolitis, and chronic lung disease), the higher the level of developmental disability assessed at school age.

The association between the changes in sensory processing and the gross motor development was verified by Cabral et al. [16]. The authors used the TSFI to evaluate the sensory processing and the AIMS to evaluate the motor development of preterm and term infants aged 4–6 months. The results showed that all infants who scored abnormal in the total score, subdomain 1 and subdomain 5 on TSFI presented motor performance at or below the 5th percentile on the AIMS scale. This date suggests that one risk factor appears to potentiate another, that is, tactile defensiveness (subdomain 1), associated with poor postural control (subdomain 5) implies an alteration in sensory processing (total score), which may reflect the in global delay motor Development (AIMS).

No estudo de Chorna et al. [17] os autores observed abnormal sensory reactivity on TSFI score in 82% of preterm infants evaluated at 4–12 months corrected age, and at 2 years old, these children were found to have poor adaptive motor function in early childhood and worse scores on motor and language acquisition.

According to Rugolo [18], the major sequelae found in preterm newborns are severe neurosensory disorders, including blindness, deafness, and cerebral palsy. These sequelae are detected in 6–20% of preterm infants with extreme low birth weights at a frequency that is inversely proportional to gestational age. Thus, in preterm infants with 23–25 weeks of gestational age, the incidence of serious sequelae reaches 30% or more, and half of these infants show sensory and/or neurodevelopment abnormalities.

Preterm infants are more vulnerable to alterations in neurosensoriomotor development. Inadequate stimulation during the hospitalization period may be related with these alterations. Hence, to verify the impact of inadequate stimulation of the immature organism is important to establish which sensory systems may show greater alterations on responses to the environment.

Sensory changes can negatively influence parent-child interactions in the short term because the infant care involves constant changes in the level of the tactile system, which may result in irritability, excessive crying, and difficulties with sleeping, feeding and calming down. In the long term, sensory changes may lead to sudden changes in mood, difficulties to adapt to general changes (e.g. environmental changes), language difficulties, attention disorders, and inability to play alone or with other children [19]. These factors could have a substantial impact on global development and social interaction.

In the study by Wiener et al. [20], the authors determined the differences in sensory processing among typical full-term infants, full-term infants with a regulatory disorder, and prematurely born infants. The Test of Sensory Functions in Infants (TSFI) was administered to 329 infants, aged 7 to 18 months. The infants with regulatory disorders had problems with sleep and eating, high irritability and sever separation anxiety. Prematurely born infants or those with a regulatory disorder scored lower than the typical infants on the test. Thus, the results suggest differences in sensory processing of infants with regulatory disorders are evident when compared to children born prematurely.

According to DeGangi e Greenspan [21], infants with poor sensory processing typically exhibit delays in fine and gross motor skills, poor balance, and incoordination, compromising academic performance. In addition, behaviours associated with poor sensory processing in these children include distractibility, tactile defensiveness, and problems with language and visual–spatial skills.

The impact that early sensory processing capacities on later learning and emotional development lacks clarity, mainly because of difficulty in defining consistent constructs within the field and an absence of assessments to detect infants with sensory dysfunctions reliably and adequately [22]. Thus, the evaluation of sensory processing is important to understand the characteristics of these infants. During hospitalization and after discharge, new treatments may be proposed for secondary prevention, health promotion and rehabilitation of this population, aiming at a differential diagnosis, which would allow the development of individualized intervention programs. Despite this importance, there are few studies evaluating the sensory processing of at-risk infants in the literature.

Therefore, the aim of this study was to evaluate the sensory processing at 4 and 6 months' corrected age. We hypothesize that preterm infants will present alterations of sensory processing in the reactivity to tactile deep pressure, and the reactivity to vestibular stimulation.

2. Methods

This was a descriptive cross-sectional study with a sample of 30 infants divided into two groups: an experimental group composed of preterm infants ($n = 15$), and a control group composed of full-term infants ($n = 15$) aged between 4 and 6 months (22.2 ± 1.3 weeks and 19.8 ± 1.2 weeks, respectively), corrected for preterm infants. The characteristics of the infants studied are shown in Table 1.

Preterm infants were selected from the follow-up service, and the control group through the waiting list for daycare and by referral by individuals known to the researcher. Inclusion criteria to the preterm infants were: parental consent to participation in this study evidenced by signing an Informed Consent Form, gestational age lower than 37 weeks [23], hospitalization in a NICU for at least 1 day, and within the age range of 4 to 6 months corrected age. Infants diagnosed with CNS alterations, congenital musculoskeletal abnormalities, genetic syndromes, sensory deficits (visual or auditory) reported in medical records, and those whose parents or guardians dropped out of in the research were excluded.

Infants in the full-term group had a gestational age equal to or >37 weeks [23], an Apgar score equal to or >7 in the first and fifth minutes, adequate weight for gestational age and an age between 4 and 6 months.

The sample composition is found in Fig. 1.

This study was approved by the Ethics Committees of Institutional Research, of the Municipal Health Bureau and "Santa Casa de Misericórdia" Hospital. Written informed consent was received from subjects' consenting to their children's participation.

Perinatal characteristics were extracted from the medical record. The Brazilian Criterion for Economic Classification [24] was used for economic characterization of the sample. The Test of Sensory Functions in Infants – TSFI [21] was used to evaluate the sensory processing of infants.

The Test of Sensory Functions in Infants was developed to measure the sensory integration behavior of infants aged 4–18 months in the

Table 1
Characteristics of the groups: number of the sample (N), sex, mean gestational age, mean birth weight, mean Apgar score (1 and 5 min), and average hospital days.

Group	N	Sex		Gestational age (weeks)	Birth weight (grams)	Apgar		Hospital (days)
		F	M			1st min	5th min	
PTN	15	8	7	31.3 (±1.8)	1506 (± 386.5)	6.9 (± 1.6)	8.7(±1)	16.4 (±13.0)
FTN	15	7	8	39.2 (±0.8)	3047.3 (±412.7)	6.8(±3.5)*	7.7(±4)*	

PTN = Preterm newborn; FTN = Full-term newborn, N = number of sample; F = female, M = male.
* For three infants, the Apgar scores were not recorded in their respective baby records.