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# Relation between preterm birth and sensory processing disorder

## A koraszülöttség és a szenzoros feldolgozási zavar kapcsolata

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**ABSTRACT**

According to epidemiological data, nearly one in ten children worldwide is born preterm. Owing to its high prevalence (8-9%), preterm birth constitutes a significant public health concern in Hungary as well. Based on the current literature and the presented case vignette, children born preterm are at increased risk for sensory processing difficulties and sensory integration dysfunction, commonly referred to as Sensory Processing Disorder (SPD). Therefore, routine screening for sensory processing difficulties is recommended in the case of preterm-born children, and early intervention should be initiated when indicated. Ayres Sensory Integration® (ASI) therapy may be considered as an evidence-informed intervention when clinically appropriate. It is essential that professionals (e.g., pediatricians, health visitors, teachers) as well as parents are informed about the potential association between prematurity and sensory processing difficulties. Furthermore, the provision of sensory-supportive or sensory-friendly environments at home, in kindergartens, and in schools is recommended to promote optimal developmental and educational outcomes for children born preterm.

**Kulcsszavak**
koraszülött, szenzoros feldolgozási zavar, szenzoros integrációs terápia

A statisztikai adatok alapján világszerte majdnem minden tizedik gyermek koraszülött. A magas prevalencia miatt (8-9%) Magyarországon is népegészségügyi problémának számít a koraszülés. A szakirodalom és az esetvignetta alapján a koraszülött gyermekek hajlamosak lehetnek szenzoros feldolgozási nehézségekre, szenzoros feldolgozási zavarra (SPD). Ezért a koraszülött gyermekek számára ajánlott az SPD szűrése és szükség esetén el kell indítani a korai intervenciót, Szenzoros Integrációs Terápia javasolt számukra. A szakembereket (gyermekorvosokat, védőnőket, tanárokat) és a szülőket is tájékoztatni kell a koraszülöttség és az SPD lehetséges kapcsolatáról. Szenzoros-barát, támogató környezet biztosítása ajánlott a koraszülött gyermekek számára otthon, az óvodákban és iskolákban is.

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## Introduction

Preterm birth is defined by the World Health Organization as birth before 37 completed weeks of gestation. According to epidemiological data an estimated 13.4 million babies were born preterm in 2020 (Zeng et al., 2024), approximately one in ten children worldwide is born preterm. Owing to its high prevalence (8-9%), preterm birth represents a significant public health concern in Hungary as well (KSH, 2017).

There are different sub-categories of preterm birth, based on gestational age: extremely preterm (less than 28 weeks), very preterm (28 to less than 32 weeks), moderate to late preterm (32 to 37 weeks).

Risk factors for preterm birth include maternal medical problems, diabetes, high blood pressure, multiple gestation, obesity, vaginal infections, smoking, and psychological stress. According to a Hungarian study (Pauwlik et al., 2025) adverse perinatal outcomes, among Roma women living in segregated settings, are closely associated with certain health behavioural factors (mainly smoking) and the access to antenatal care. Kornyicki and Fedor (2024) also found that lack of health visitor care and late prenatal care raise the risk of preterm births in Hungary.

Maternal age may also be relevant, as younger and older mothers are at increased risk (Rajia, 2024). Teenage pregnancy often leads to complications like preterm delivery (Nkiruka, 2020).

Prematurity is associated with increased risk for several medical complications, including retinopathy of prematurity (ROP), bronchopulmonary dysplasia (BPD), intraventricular haemorrhage (IVH), and

periventricular leukomalacia (PVL) (Balla & Szabó, 2013). Premature babies experience higher blood pressure in the early stages of life, weakened blood vessel growth, increased peripheral vascular resistance, and potential cardiomyocyte remodeling (Kornyicki & Fedor, 2024).

Longitudinal studies (Wolke et al., 2019) indicate that children born preterm are at elevated risk for motor impairments (e.g., coordination disorder, developmental coordination disorder [DCD], balance difficulties, cerebral palsy [CP]), cognitive deficits, and specific learning disorders. The prevalence of attention-deficit/hyperactivity disorder (ADHD) is also higher in this population, and the incidence of autism spectrum disorder (ASD) has been reported to range between 7-8%.

Preterm infants are considered high-risk due to the immaturity of their central nervous system at the time of exposure to extrauterine stimuli. Compared to full-term infants, premature newborns spend less time in the intrauterine environment, which may interfere with the maturation of early-developing sensory systems. Consequently, they are deprived of essential vestibular and proprioceptive stimulation typically experienced in utero, and the quality and intensity of tactile input are substantially altered.

Instead of the regulated, protective intrauterine milieu, the preterm infant is exposed to the sensory conditions of the Neonatal Intensive Care Unit (NICU), including invasive medical procedures, bright lighting, and mechanical noise. Such an environment may be overwhelming for the immature nervous system. In recent years, however, NICU practices have increasingly incorporated developmental care principles aimed at optimizing sensory input and supporting neurodevelopment. Positive sensory experiences—such as affectionate touch, rocking, close physical contact, and exposure to the mother's scent—play a critical role in early development.

Current family-centered care models allow mothers to remain with their infants in the NICU (Lee, 2024), actively participate in caregiving, and provide developmentally appropriate sensory stimulation. Kangaroo Mother Care (KMC) and early skin-to-skin contact have demonstrated beneficial effects, including stabilization of autonomic functions, helping with breastfeeding and facilitation of secure attachment formation between mother and infant (Boundy et al., 2016; Chan et al., 2016; Conde-Agudelo et al., 2011). Breastfeeding is recommended in case of premature infants as well, according to guidelines (WHO, 2003; Gárdos et al., 2017; Moravcsik-Kornyicki & R. Fedor, 2021).

Although the primary goal of NICU treatment is survival—and survival rates have improved substantially—ensuring optimal long-term quality of life for preterm children requires systematic developmental monitoring, follow-up, and early intervention.

## The Concept of Sensory Integration

The theory of sensory integration was developed by Anna Jean Ayres (1920-1988) and introduced in her seminal work *Sensory Integration and Learning Disorders*. Ayres conducted research at the Brain Research Institute of the University of California, Los Angeles, working with neurologically impaired children and adults. The therapeutic approach she developed, Ayres Sensory Integration® (ASI), is recognized as an early intervention method (Ayres, 1979).

Sensory integration refers to the neurological process by which sensory information from the environment and from the body is organized and interpreted by the central nervous system (CNS). The CNS selects, modulates, and integrates sensory input to produce adaptive responses. When sensory processing is inefficient or disorganized, adaptive functioning may be compromised (Ayres, 1979).

Sensory Integration Disorder is currently more commonly referred to as Sensory Processing Disorder (SPD) (Miller et al., 2007). According to Dunn's model (2007), four primary sensory processing patterns can be distinguished: sensation seeking, sensation avoiding, sensory sensitivity, and low registration.

The estimated prevalence of SPD in the general population ranges from 5% to 16% (Crasta et al., 2020). Children with sensory processing difficulties may demonstrate slower academic progress and increased rates of behavioral problems. ADHD frequently co-occurs with SPD. Furthermore, approximately 90% of children with ASD exhibit sensory processing abnormalities (Chang et al., 2014). Altered sensory reactivity is included among the diagnostic criteria for ASD in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5). However, SPD is not recognized as an independent diagnostic category in the DSM-5, as sensory processing difficulties typically co-occur with other neurodevelopmental disorders (e.g., developmental delay, learning disorders, ADHD, ASD, motor disorders).

In contrast, the DC:0-5 diagnostic classification system (Mulrooney et al., 2019), which applies to children under five years of age, includes Sensory

Processing Disorders as distinct categories: Sensory Over-Responsivity Disorder, Sensory Under-Responsivity Disorder, and Other Sensory Processing Disorder.

## Prenatal Development of Sensory Integration

The foundations of sensory integration emerge during intrauterine development. Ayres (1979) proposed that three primary sensory systems mature prenatally and serve as the basis for later integrative functioning. She referred to these as the “proximal senses”: the vestibular, tactile, and proprioceptive systems (Kiesling, 2014). These systems provide the neurobiological foundation for higher-order perceptual and motor functions.

If these early-developing systems do not mature or integrate adequately, children may present with hypersensitivity or hyposensitivity to sensory stimuli. For instance, tactile hypersensitivity may manifest as aversion to clothing textures or physical contact, whereas reduced tactile sensitivity may be associated with diminished pain perception and impaired tactile discrimination. Motor manifestations may include clumsiness or dyspraxia, and some children may exhibit persistent toe-walking.

Vestibular hypersensitivity may be characterized by fear of falling, intolerance of rotational movement, and avoidance of activities such as swinging. These children may achieve independent walking later than expected. Conversely, reduced vestibular sensitivity may lead to excessive movement seeking, engagement in risky activities, and diminished fear responses.

The vestibular system begins functioning prenatally. Its primary sources of stimulation include maternal movements, heartbeat, respiration, and visceral activity, all of which generate rhythmic motion. Fetal self-initiated movements further contribute to vestibular input (Kiesling, 2014). After birth, rhythmic vestibular stimulation continues to play a regulatory role, which may explain the soothing effect of rocking.

Tactile stimulation in utero is initially provided by the movement of amniotic fluid and later by contact with the uterine wall. The intrauterine environment offers optimal conditions for the maturation of cutaneous receptors responsible for perceiving touch, temperature, and pain. Sensory modulation abnormalities of the tactile system are frequently observed in children with behavioral and speech disorders (Kiesling, 2014).

Proprioceptive input is also acquired prenatally through fetal movements against the resistance of amniotic fluid and increasing intrauterine pressure as growth progresses. The birth process itself provides intense proprioceptive stimulation as the infant passes through the birth canal. Proprioceptive receptors located in muscles, tendons, and joints provide essential information about body position and movement.

Disruptions in prenatal development may compromise the maturation of these early sensory systems, and signs of dysfunction may become evident already in infancy (Kiesling, 2014).

## Signs of Sensory Integration Disorder

Children with sensory integration difficulties may demonstrate impaired attention despite intact peripheral sensory function (e.g., normal hearing). They may experience difficulties acquiring motor-based skills such as tying shoelaces or riding a bicycle, and gross motor coordination may appear clumsy. Frequent accidental injuries may occur despite normal muscle strength.

Academic difficulties may emerge despite average intellectual functioning. Motor milestones are often delayed; infants may show delayed rolling, sitting, standing, creeping, or crawling. Delayed speech and language development is also common and may represent an early indicator of sensory processing dysfunction (Kiesling, 2014).

Early identification of sensory processing difficulties and timely intervention are essential in order to prevent secondary academic, behavioral, and psychosocial complications.

## The Relationship Between Prematurity and Sensory Processing Disorder

Over the past decade, several studies (Bröring et al., 2017; Crozier et al., 2016; Gandara-Gafo et al., 2021; Machado et al., 2017; Mitchell et al., 2015; Niutanen et al., 2019; Previtali et al., 2023; Ryckman et al., 2017) have provided evidence that prematurity may constitute a significant risk factor for sensory processing disorder (SPD). Below, the findings of relevant systematic reviews and empirical studies published in the last ten years are summarized.

Mitchell and colleagues (2015) conducted a systematic literature review examining sensory processing in preterm infants between birth and three years of age. Their findings indicated that preterm infants are at increased risk for

sensory modulation disorders, particularly Sensory Over-Responsivity (SOR). This vulnerability may be associated with early exposure to aversive and intensive sensory stimuli in the Neonatal Intensive Care Unit (NICU), despite ongoing improvements in developmental care practices. However, some studies included in their review reported contradictory findings, particularly regarding sensory under-responsivity (Wickremasinghe et al., 2013).

Bröring et al. (2017) conducted another systematic review analyzing 18 studies. They identified several risk factors associated with atypical sensory processing, including lower gestational age, male sex, prolonged hospitalization, white matter injury, and lower socioeconomic status. Significant differences were reported in auditory, visual, vestibular, gustatory, and tactile processing in preterm children, which may contribute to behavioral difficulties and neurocognitive impairments.

Machado et al. (2017), in a further systematic review, reported that 75% of the analyzed studies found a positive association between prematurity and sensory processing difficulties. The authors concluded that prematurity may adversely affect the development of sensory processing.

Niutanen et al. (2019) reviewed 27 studies investigating sensory processing in preterm children from the neonatal period up to 9 years and 7 months of age. Their results consistently demonstrated that preterm children are at elevated risk for sensory processing difficulties compared to their term-born peers.

Several empirical studies have also reported specific findings. Crozier et al. (2016) assessed 160 four-year-old children born very preterm using the Short Sensory Profile (SSP). Nearly half of the sample (46%) exhibited atypical sensory processing patterns. Lower Apgar scores and longer NICU stays were predictive of atypical sensory processing profiles.

Ryckman et al. (2017) emphasized that preterm infants are exposed to multiple intense sensory stimuli shortly after birth, which may exceed their regulatory capacities and predispose them to SPD. In their study of 32 preterm children aged 4-6 years, 50% scored within the abnormal range on the Sensory Processing Assessment for Young Children (SPA), indicating clinically significant sensory processing difficulties.

Gandara-Gafo et al. (2021) examined 69 children aged 3-11 years diagnosed with SPD using the Sensory Profile-2 (SP-2). They found that 65.21% of the children had a history of stressful perinatal events. Children who experienced prenatal distress demonstrated statistically significant differences in visual

processing compared to children with SPD without such perinatal complications.

Previtali et al. (2023) conducted an Italian study involving healthy preschool-aged children. The sample included 37 caregivers of term-born children and 37 caregivers of preterm children, who completed the Sensory Processing and Self-Regulation Checklist (SPSRC-IT). Significant group differences were found, particularly in gustatory and olfactory processing, vestibular processing, and proprioceptive processing, with lower scores observed in the preterm group. Lower gestational age and lower birth weight were associated with increased risk. The findings suggest a relationship between prematurity and both sensory processing and self-regulation abilities, especially among children born with very low birth weight and very low gestational age.

In Hungary, Makó (2022) was the first to examine sensory processing characteristics in preterm children at the Early Intervention Centre in Budapest. Using the Sensory and Movement Experiences Questionnaire (Arató et al., 2019), she compared 30 preterm children with a control group of 50 term-born children. Significant differences were identified in tactile processing, movement-related processing, and gustatory/olfactory processing, whereas no significant differences were found in visual and auditory processing. The largest discrepancy between groups was observed in self-regulation abilities, with preterm children demonstrating greater difficulties (Makó, 2022).

## Case Vignette

In my clinical practice as a child psychologist, I assessed a boy born at 23 weeks of pregnancy with a birth weight of 550 grams. At four days of age, he experienced a stroke. At two years of age, he was referred for psychological follow-up assessment. Developmental functioning was evaluated using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III).

His cognitive development was appropriate for his corrected age. Expressive and receptive language abilities were age-appropriate, and he demonstrated fluent speech. However, gross motor development was delayed, and balance was unstable. He was unable to stand on one leg for an extended period and could not jump with both feet. Hypersensitivity was observed in the tactile and auditory domains.

Ayres Sensory Integration (ASI) therapy was recommended to support motor coordination and balance. Initially, he exhibited fear toward movement-based therapeutic equipment, but over time he became more confident, and significant improvement in balance was observed. According to parental report, he became more autonomous and began engaging in independent play at home, whereas previously he required constant parental involvement. He had no siblings and did not attend nursery school. Therapy was discontinued after three months due to the COVID-19 pandemic.

At six years of age, he was reassessed to determine school readiness. Attention difficulties were evident, with reduced task persistence. Fine and gross motor skills remained delayed; he was unable to hop on one leg and could not ride a bicycle. Intellectual functioning appeared to be within the average range. Further assessment and therapeutic intervention at the Pedagogical Special Service were recommended. Based on multidisciplinary evaluation, school entry was postponed until seven years of age, and he received targeted therapy for motor skill development.

Currently, he attends mainstream school (second grade). He does not present with a specific learning disorder, and his academic performance is adequate; however, sustained attention remains an area of difficulty.

## Recommendations

Based on the literature and the presented case, children born preterm are at increased risk for sensory processing difficulties and sensory integration dysfunction.

Several authors (e.g., Mitchell et al., 2015; Niutanen et al., 2020) recommend routine screening of preterm infants under three years of age for sensory modulation difficulties, particularly Sensory Over-Responsivity. Parent education regarding early signs of SPD and home-based supportive strategies is also essential.

Modifications to the NICU sensory environment should continue to be implemented in line with developmental care principles. Furthermore, pediatricians and health visitors should be informed about the association between prematurity and sensory processing difficulties to ensure appropriate follow-up and timely referral for early intervention. These professionals play a key role in screening and in providing psychoeducation to families. Early therapeutic intervention and parental consultation are crucial for optimizing

sensory processing and supporting neurocognitive development in preterm children.

## Conclusion

Routine screening for sensory processing difficulties in children born preterm is strongly recommended. Based on screening outcomes, early intervention should be initiated to prevent the development of secondary behavioral, academic, or psychosocial difficulties.

Parental counseling is essential to support the creation of a developmentally appropriate home environment (e.g., provision of vestibular stimulation through structured movement activities). Educators should also be informed about the specific needs of these children, and the implementation of sensory-friendly environments in kindergartens and schools is recommended to facilitate optimal functioning and learning outcomes.

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