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Sensory processing disorder in Saudi children with and without neuro developmental disorders

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ABSTRACT

Background: Sensory processing disorder (SPD) is commonly associated with neurodevelopmental conditions such as attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and global developmental delay. This study aimed to evaluate the sensory profiles of Saudi children with and without neurodevelopmental disorders (NDDs) and to explore the influence of demographic factors such as age and gender on these profiles.

Methods: This cross-sectional study was conducted at Center for Developmental and Behavior Disorders from 1/9/2024 to 1/11/2024. It included 83 Saudi children, comprising 49 children diagnosed with NDDs and 34 typically developing (TD) children. SPD was assessed in the participants using the Short Sensory Profile.Statistical analysis included gamma coefficients to compare sensory dimensions between the two groups, as well as to assess the strength and direction of associations between gender and the ordinal sensory dimensions. Additionally, ANOVA was employed to examine associations between age groups and sensory dimensions.

Results: Among NDDs, ADHD was the most common diagnosis (25.3%), followed by autism (15.7%). Children with NDDs showed significantly higher rates of sensory processing challenges compared to TD children, with the strongest deficits observed in auditory filtering (gamma = -0.785, p = 0.0005) and under-responsiveness/seeks sensation (gamma = -0.764, p = 0.0005). Age had no significant effect on most sensory dimensions, except for under-responsiveness/seeks sensation in children with NDDs (p = 0.045). Gender was associated with movement sensitivity in TD children (p = 0.047) and taste/smell sensitivity in children with NDDs (p = 0.036).

Conclusion: The findings highlight significant sensory processing challenges in children with NDDs, particularly in auditory filtering and sensory seeking behaviors. Age- and gender-specific variations emphasize the need for tailored, collaborative interventions among parents, teachers, and healthcare providers to enhance sensory processing and improve developmental outcomes and quality of life.

Keywords: Sensory processing disorder, Neurodevelopmental disorders, Autism, Saudi children, Sensory profiles

BACKGROUND

Sensory Processing Disorder (SPD) is a neurodevelopmental condition that disrupts the brain's ability to effectively receive, process, and organize sensory input. These disruptions can result in inappropriate responses to sensory stimuli, significantly affecting functional participation in daily routines and quality of life(1). SPD is formally recognized in diagnostic frameworks, including the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood-Revised (2)and the Interdisciplinary Council on Developmental and Early Disorders (3). It is also integrated into the diagnostic criteria for Autism Spectrum Disorder (ASD) in the DSM-5, under "restricted, repetitive patterns of behavior, interests, or activities," reflecting its integral role in neurodevelopmental disorders(3, 4)

SPD is characterized by heterogeneous presentations, as it may involve multiple sensory systems, including tactile, auditory, vestibular, proprioceptive, and interoceptive pathways. This heterogeneity necessitates classification systems such as Miller's and Schaaf's frameworks. Miller's model categorizes SPD into three subtypes: sensory modulation disorder (SMD), sensory-based motor disorder (SBMD), and sensory discrimination disorder (SDD), which can coexist in varying combinations(5). Schaaf's model extends this by identifying specific sensory patterns, such as somaticdyspraxia and vestibular-bilateral integration deficits, which are detected using tools like the Ayres Sensory Integration Assessment (6).

SPD is prevalent in 3–16% of the general population and significantly more common in children with neurodevelopmental disorders (NDDs), where rates range from 20% to 95% depending on the condition and population studied (7, 8). For example, sensory processing challenges affect 80–90% of children with ASD, contributing to difficulties in communication, social interactions, and adaptability (9, 10). Approximately 60% of children with ADHD also exhibit sensory processing difficulties, such as sensory seeking or under-responsivity (5). SPD has been observed in 49% of children with Down syndrome(11) and is frequently associated with conditions such as epilepsy(12) and urinary incontinence (13).

Although the etiology of SPD remains unclear, several risk factors have been identified. Prenatal and perinatal complications, such as prematurity, low birth weight, and maternal substance use, are associated with an increased risk of SPD. Studies indicate that 46% of children born before 32 weeks of gestation display sensory processing difficulties by the age of four(14). Environmental factors, including parental stress, limited sensory stimulation, and substance use, also contribute to SPD development (15, 16). Genetic factors are implicated, with evidence suggesting heritability of sensory processing traits(17).

The impact of SPD on children is profound, affecting academic performance, motor coordination, and social participation. Hyperactivity, distractibility, and poor motor planning are common, often leading to secondary issues such as low self-esteem, anxiety, and social withdrawal (18-20). These challenges are particularly pronounced in school-aged children, where sensory difficulties can interfere with learning and peer relationships (21, 22). Despite its high prevalence and significant impact, SPD remains underdiagnosed due to the lack of validated biomarkers and reliance on observational assessments(8).

Comorbidity with other conditions further complicates SPD. For instance, sensory regulation problems in childhood have been linked to a higher risk of psychopathology, including anxiety and externalizing behaviors such as aggression (9). These associations underscore the importance of early identification and intervention to mitigate long-term impacts on developmental and psychosocial outcomes.

Current SPD assessments rely on behavioral observations and caregiver reports, with tools such as the Sensory Profile (SP) and Sensory Integration and Praxis Test (SIPT) being widely used(23). The Short Sensory Profile, a streamlined version of the SP, is frequently employed in research and epidemiological studies for its simplicity and reliability (7, 24, 25). Efforts to develop objective biomarkers, such as electroencephalography (EEG)(26) and diffusion tensor imaging (DTI)(27), have shown promise but require further validation for clinical use.

While significant progress has been made globally, research on SPD within the Saudi Arabian context is limited. Cultural practices, environmental factors, and healthcare access likely influence the presentation and management of SPD in this population. A study by Al-Heizan et al. (2015) highlighted a high prevalence of sensory difficulties in Saudi children with ASD, emphasizing the need for culturally tailored diagnostic and therapeutic strategies(28). Addressing these gaps is critical for improving the quality of care and outcomes for children with NDDs in Saudi Arabia.

The primary aim of the present study was to address these gaps by investigating sensory processing patterns in Saudi children with NDDs compared to TD children, using the short sensory profile to assess six dimensions: tactile sensitivity, taste/smell sensitivity, movement sensitivity, under-responsiveness/sensory seeking, auditory filtering, and low energy/weak sensitivity. A secondary aim was to examine the influence of demographic factors, such as age and gender, on these sensory profiles.

Methods

Study design and settings

This was a cross-sectional study conducted at Center for Developmental and Behavior Disorders from 1/9/2024 to 1/11/2024.The study was approved by Ministry of Healthat Taif Health Cluster (IRB: H-02-T-123). Each parent or caregiver provided informed consent before participation of his/her child in the study.

Inclusion and exclusion criteria

The study included 83 Saudi children: 49 diagnosed with NDDs, including ADHD, autism, Down syndrome, global developmental delay, learning difficulties, and mental retardation, and 34 TD children. Children whose parents or caregivers agreed to participate were included, while those who refused were excluded. Additionally, children with non-developmental disorders were excluded.

Assessment tool

The primary assessment tool utilized in this study was the Short Sensory Profile (SSP), a 38-item standardized questionnaire designed for parents/caregivers to recognize children with sensory processing challenges and associated behaviors. Each of the 38 SSP items is rated on a 5-point Likert scale, ranging from 1 for behaviors that occur "always" to 5 for behaviors that occur "never." Composite scores for seven domains (Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Under-Responsive/Seeks Sensation, Auditory

Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity) are derived from the raw scores. The SSP total score and the score on each of the instrument's seven subscales can be used to classify children into the categories of "Typical Performance," "Probable Difference," or "Definite Difference" (29). Validity and reliability studies have demonstrated the SSP's effectiveness. Initial validity assessments indicated over 95% discriminant validity in identifying children with and without sensory modulation difficulties (30). The SSP's internal reliability, measured by Cronbach's alpha, ranges from α = 0.82– 0.89 (29). These findings affirm the SSP's credibility as a valid and reliable tool for assessing sensory processing. **(Appendix 1)**

Data collection

Data collected in the study included participants' age, gender, and NDD type. The Short Sensory Profile(SSP) (29)was utilized to assess SPD among the participants based on their caregivers' responses. This list encompasses six dimensions: sensory touch disorder (seven items), sensitivity to taste or smell (four items), sensitivity to movement (three items), weak response/sensation seeking (seven items), auditory filtering (six items), and low/weak energy (six items). Each of these dimensions has defined scoring thresholds, which are detailed in (**Table 1**.)

Table 1. Dimensions of short sensory list and their degrees

Dimension	**Classification**
First dimension	
From 7 to 26	Definite difference
From 27 to 29	Possible difference
From 30 to 35	Typical performance
Second dimension	
From 4 to 11	Definite difference
From 12 to 14	Possible difference
From 15 to 20	Typical performance
Third dimension	
From 3 to 10	Definite difference
From 11 to 12	Possible difference
From 13 to 15	Typical performance
Fourth dimension	
From 7 to 23	Definite difference
From 24 to 26	Possible difference
From 27 to 35	Typical performance
Fifth dimension	
From 6 to 19	Definite difference
From 20 to 22	Possible difference
From 23 to 30	Typical performance
Sixth dimension	
From 6 to 23	Definite difference
From 24 to 25	Possible difference
From 26 to 30	Typical performance

Statistical analysis

All statistical analyses were performed using SPSS version 26. Descriptive statistics, including frequencies and percentages, were used to summarize categorical variables. Gamma coefficients were applied to compare sensory dimensions between the two groups, as well as to assess the strength and direction of associations between gender and the ordinal sensory dimensions. Additionally, ANOVA was employed to examine associations between age groups and sensory dimensions within each group. All analyses were conducted with a 95% confidence interval (CI), and a p-value ≤ 0.05 was considered statistically significant.

RESULTS

Clinicodemographic characteristics

The study included 83 participants, comprising 34 TD children and 49 children with NDDs. Among these disorders, ADHD was the most common diagnosis (25.3%), followed by autism (15.7%), while Down syndrome and learning difficulties were the least common, each accounting for 1.2% of the sample. The participants were distributed across three age groups: 3-5 years (32.5%), 6-10 years (35%), and 11-14 years (32.5%). Female participants made up 41% of the sample **(Table 2)**.

Table 2: Clinicodemographic characteristics of the study participants (N = 83)

Variable		**Frequency**	**Percentage**
Age	3-5 years	27	32.5%
	6-10 years	29	35%
	11-14 years	27	32.5%
Sex	Female	34	41%
	Male	49	59%
NDD	None	34	41%
	ADHD	21	25.3%
	Autism	13	15.7%
	Global developmental delay	8	9.6%
	Mental retardation	5	6.0%
	Down syndrome	1	1.2%
	Learning difficulties	1	1.2%

NDD: neurodevelopmental disorder; ADHD: attention deficit hyperactivity disorder

The distribution of participants by age and sex is summarized in **Table 3**. Among TD children, there was an equal distribution of males and females (50.0% each). The majority of TD children were aged 3-5 years (41.2%), followed by equal proportions aged 6-10 years and 11-14 years (29.4% each). In contrast, among children with developmental disorders, males were predominant (65.3%). The largest age group for children with developmental disorders was 6-10 years (38.8%), followed by those aged 11-14 years (34.7%) and 3-5 years (26.5%).

Table 3: Distribution of the study participants (N = 83) according to their age and sex

Variable		**NDD**	
		No (N = 34)	Yes (N = 49)
Age	3-5 years	41.2%	26.5%
	6-10 years	29.4%	38.8%
	11-14 years	29.4%	34.7%
Sex	Female	50.0%	34.7%
	Male	50.0%	65.3%

NDD: neuro developmental disorder

Sensory processing profiles

Children with NDDs demonstrated significantly higher rates of sensory processing challenges compared to TD children across multiple dimensions **(Table 4)**. For tactile sensitivity, 65.3% of children with NDDs exhibited definite difference, compared to 35.3% of TD children, while 61.8% of TD children showed typical performance. In movement sensitivity, 44.9% of children with NDDs had definite difference, compared to 14.7% of TD children, with most TD children (61.8%) showing typical performance. For under-responsiveness/seeks sensation, 69.4% of children with NDDs had definite difference, while 67.6% of TD children displayed typical performance.

In auditory filtering, 55.1% of children with NDDs showed definite difference, compared to 11.8% of TD children, with 79.4% of TD children demonstrating typical performance. In lowenergy/weak sensitivity, 57.1% of children with NDDs exhibited definite difference,compared to 29.4% of TD children, who mostly had typical performance (61.8%). For taste/smell sensitivity, while 38.8% of children with NDDs had definite difference, 79.4% of TD children exhibited typical performance.

Table 4: Comparison of sensory processing profiles between TD children (N = 34) and those with NDDs (N = 49)

Dimension	**NDD**		**Total**
	No (N = 34)	Yes (N = 49)	

Tactile sensitivity	Definite difference	35.3%	65.3%	53.0%
	Possible difference	2.9%	20.4%	13.3%
	Typical performance	61.8%	14.3%	33.7%
Taste/smell sensitivity	Definite difference	8.8%	38.8%	26.5%
	Possible difference	11.8%	16.3%	14.5%
	Typical performance	79.4%	44.9%	59.0%
Movement sensitivity	Definite difference	14.7%	44.9%	32.5%
	Possible difference	23.5%	26.5%	25.3%
	Typical performance	61.8%	28.6%	42.2%
Under-responsive/seeks sensation	Definite difference	20.6%	69.4%	49.4%
	Possible difference	11.8%	12.2%	12.0%
	Typical performance	67.6%	18.4%	38.6%
Auditory filtering	Definite difference	11.8%	55.1%	37.3%
	Possible difference	8.8%	18.4%	14.5%
	Typical performance	79.4%	26.5%	48.2%
Low energy/weak	Definite difference	29.4%	57.1%	45.8%
	Possible difference	8.8%	10.2%	9.6%
	Typical performance	61.8%	32.7%	44.6%

Comparison of sensory dimensions across both groups revealed significant negative associations were observed across all dimensions, indicating that children with NDDs were more likely to exhibit definite differences in sensory processing compared to TD children. The strongest associations were in auditory filtering (gamma = -0.785, p = 0.0005) and under-responsiveness/seeks sensation (gamma = -0.764, p = 0.0005), suggesting these are key areas of sensory challenges for children with NDDs. Other dimensions, such as tactile sensitivity (gamma = -0.625, p = 0.0005), taste/smell sensitivity (gamma = -0.638, p = 0.0005), and movement sensitivity (gamma = -0.573, p = 0.0005), also showed significant negative associations, reflecting consistent sensory deficits in these areas. The weakest association was observed in low energy/weak sensitivity (gamma = -0.501, p = 0.005), although it was still statistically significant (Table 5).

Table 5: Comparison between TD children (N = 34) and those with NDDs (N = 49) regarding different dimensions using gamma coefficients

Dimension	Gamma	p-value
Tactile sensitivity	-0.625	**0.0005***
Taste/smell sensitivity	-0.638	**0.0005***
Movement sensitivity	-0.573	**0.0005***
Under responsive/ seeks sensation	-0.764	**0.0005***
Auditory filtering	-0.785	**0.0005***
Low energy/ weak	-0.501	**0.005***

*: statistically significant

Effects of age and sex on sensory dimensions

ANOVA analysis revealed no significant effect of age on most sensory dimensions for the study groups. However, a significant age-related effect was observed in the under-responsive/seeks sensation dimension for children with NDDs (p = 0.045)**(Table 6)**. This suggests that while sensory processing remains largely consistent across age groups, sensory seeking behaviors may vary with age in children with NDDs, warranting further investigation and potential age-specific interventions.

Table 6: Effect of age on different sensory dimensions in TD children (N = 34) and those with developmental disorders (N = 49)

Dimension	**NDD**	
	No	Yes

	(N = 34)	(N = 49)
Tactile sensitivity	0.560	0.934
Taste/smell sensitivity	0.679	0.693
Movement sensitivity	0.735	0.856
Under responsive/ seeks sensation	0.68	**0.045***[*]
Auditory filtering	0.4	0.116
Low energy/ weak	0.929	0.797

NDD: neurodevelopmental disorder; *: statistically significant

Among TD children, a significant gender effect was observed for movement sensitivity (p = 0.047), whereas other dimensions showed no significant associations. In children with NDDs, gender had a significant effect on taste/smell sensitivity (p = 0.036), while other dimensionsdid not show significant differences**(Table 7)**. These findings suggest the presence of gender-related sensory variations in specific dimensions, which may be relevant for developing tailored sensory interventions.

Table 7: Effect of gender on different sensory dimensions in TD children (N = 34) and those with NDDs (N = 49)

Dimension	**NDD**	
	No (N = 34)	Yes (N = 49)
Tactile sensitivity	0.338	0.053
Taste/smell sensitivity	0.636	**0.036**[*]
Movement sensitivity	**0.047**[*]	0.312
Under responsive/ seeks sensation	0.216	0.159
Auditory filtering	0.185	0.779
Low energy/ weak	0.61	0.525

NDD: neurodevelopmental disorder;*: statistically significant

DISCUSSION

Sensory processing challenges are a defining feature of many NDDs, including ASD and ADHD. These challenges manifest in various ways, such as hypersensitivity, under-responsiveness, and sensory-seeking behaviors, impacting a child's daily functioning, social interactions, and learning. This study examined sensory processing differences between TDchildren and those diagnosed with NDDs using the SSP. Among 83 participants, comprising 49 children with NDDs and 34 TD children, significantly higher rates of sensory processing challenges were observed in the NDD group. Key areas of difficulty included auditory filtering and under-responsiveness/seeks sensation. Gender and age-related variations were also identified, with males showing greater deficits in taste/smell sensitivity and sensory-seeking behaviors varying across age groups. These findings provide a comprehensive understanding of sensory profiles in children with NDDs, offering insights for tailored interventions.

The results of this study align closely with prior research on sensory processing challenges in children with NDDs. For example, a study in Nepal reported heightened sensory impairments in children with ASD, with auditory filtering and sensory seeking among the most affected dimensions(31). Similarly, Al-Heizan et al. in Saudi Arabia observed significant sensory deficits in children with ASD, particularly in auditory filtering (73.9%) and under-responsiveness/seeks sensation (89.13%)(28). The overlap in findings reinforces the utility of the SSP as a reliable tool for identifying sensory difficulties and provides further evidence of sensory challenges as a hallmark feature of NDDs.

This study highlights the prominence of auditory filtering and under-responsiveness/seeks sensation as critical dimensions of sensory dysfunction, a finding corroborated by cluster analyses in ASD populations(32). Impairment of these sensations may be due to Saudi Arabia's environmental and educational settings, often characterized by structured classroom environments with a focus on auditory learning. The rigid structure and expectations in such settings can intensify sensory-related difficulties, making them more apparent to caregivers and educators.

Interestingly, the current study observed a statistically significant age effect on sensory seeking behaviors, suggesting developmental trends in sensory processing. Prior research, such as the ELENA cohort study, similarly noted consistent sensory difficulties across age groups in children with ASD and ADHD (33). This finding aligns with previous research indicating that as children with NDDs grow, their sensory processing patterns may evolve, potentially reflecting neurological maturation or adaptive changes influenced by environmental factors (23). However, the specific evolution of sensory behaviors with age warrants further investigation.This underscores the importance of longitudinal studies to better understand the developmental trajectory of sensory challenges.

Gender norms, deeply rooted in Saudi culture, may also influence the presentation and reporting of sensory processing challenges. For example, the finding that males with NDDs exhibited greater taste/smell sensitivity deficits may reflect societal expectations of male behaviors, where deviations from cultural norms of self-control and resilience may be more scrutinized. This aligns with previous observations of subtle gender-specific trends in sensory profiles across different cultural settings(34). This highlights the need for further exploration into gender-specific sensory challenges, which could enhance the personalization of therapeutic interventions.

Cultural and contextual factors in Saudi Arabia also play a significant role in shaping sensory profiles, as highlighted by differences observed in studies conducted in various regions. For instance, variations in caregiver-reported sensory processing behaviors across cultural contexts suggest that environmental influences and caregiver expectations may impact sensory outcomes(28, 35). This underscores the importance of developing culturally sensitive assessments and interventions tailored to the unique needs of diverse populations.

The findings of this study have significant clinical implications. The high prevalence of sensory challenges, particularly in auditory filtering and sensory seeking behaviors, calls for targeted interventions that address these dimensions. Multimodal therapies integrating auditory integration and proprioceptive-based activities could prove particularly effective. Additionally, the observed age and gender-related variations suggest that interventions should be customized based on demographic characteristics to optimize outcomes. For example, programs could focus on sensory seeking behaviors in younger children and address taste/smell sensitivity in male children with NDDs.

Finally, the diagnostic utility of the SSP is reinforced by this study, highlighting its potential in identifying sensory subgroups within NDD populations. Strong associations between sensory dimensions and specific neurodevelopmental conditions suggest that the SSP could serve as a valuable tool in differential diagnosis, particularly in distinguishing between ASD and ADHD. These findings align with prior research advocating for the use of sensory profiles in refining diagnostic criteria and tailoring interventions(32).

Overall, this study contributes to the growing body of evidence documenting SPD in children with NDDs. By elucidating key sensory dimensions, age-related trends, and gender-specific patterns, it provides a foundation for developing personalized, evidence-based interventions. The findings emphasize the need for culturally sensitive approaches and further research into the developmental trajectory of sensory processing challenges to enhance diagnostic precision and therapeutic outcomes for affected children.

The limitations of this study should be acknowledged. First, the sample size, while sufficient to detect group differences, may limit the generalizability of the findings, particularly for rarer conditions such as Down syndrome and learning difficulties, which accounted for only a small proportion of the sample. Future research should aim to include larger and more diverse samples to enhance the robustness and applicability of the findings.

Second, the reliance on caregiver-reported data through the SSP, while valuable, introduces potential biases related to caregiver perceptions and reporting accuracy. Incorporating objective measures such as neurophysiological assessments, including visual and auditory-evoked potentials, could complement the subjective data and provide a more comprehensive understanding of sensory processing in NDDs.

CONCLUSION

This study highlights significant sensory processing challenges in children with NDDs compared to typically developing TD children, with key deficits observed in auditory filtering and under-responsiveness/seeks sensation. Age-related variations in sensory seeking behaviors and gender-specific differences in taste/smell sensitivity emphasize the need for tailored, demographic-specific interventions. Furthermore, the study underscores the influence of cultural and environmental factors, necessitating culturally sensitive assessment tools and intervention strategies to address the unique needs of children within diverse settings.

The high prevalence of sensory challenges, particularly in auditory filtering and sensory seeking behaviors, calls for multimodal therapies that address these dimensions and incorporate age- and gender-appropriate strategies.

While this study improves understanding of sensory processing in NDDs, its limitations such as sample size, reliance on caregiver-reported data, and the cross-sectional design call for future research. Larger, more diverse samples are needed to enhance generalizability, particularly for less common conditions like Down syndrome and learning difficulties. The integration of objective measures, such as neurophysiological assessments, could complement caregiver-reported data and provide a more comprehensive picture of sensory processing. Additionally, longitudinal research is essential to explore the developmental trajectory of sensory challenges and their interaction with other developmental and psychosocial factors.

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