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Sensory processing differences as predictors of toilet-training difficulty in autistic children

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Abstract
Toilet training represents one of the most common sources of concern for parents of autistic children, yet the sensory mechanisms that contribute to toileting difficulties remain poorly understood. This research examined whether sensory processing differences, measured across six domains, predict the degree of toilet-training difficulty in a sample of 112 autistic children aged 3 to 8 years attending developmental clinics in Medellín, Colombia. Caregivers completed the Sensory Profile-2, a structured toileting history questionnaire, and the Toilet Training Difficulty Index, a composite measure that captures resistance, avoidance, and lack of awareness during toileting routines. Children were classified into five sensory subtypes (sensory seeking, sensory avoiding, under-responsive, over-responsive, and mixed pattern) using cluster analysis. Results showed that tactile over-responsivity and proprioceptive processing differences were the strongest independent predictors of toilet-training difficulty, accounting for 37% of the variance in difficulty scores when entered alongside age, cognitive level, and autism severity. Children classified as over-responsive had the highest rates of unsuccessful toilet training (50%), while those in the sensory-seeking subtype showed the highest rates of successful training (41.2%). A sensory-adapted toileting intervention delivered to a subsample of 24 children over 12 weeks produced meaningful reductions in toileting resistance and improved awareness of bladder cues, with large effect sizes for tactile and proprioceptive domains. These findings point to the value of assessing sensory processing profiles before designing toilet-training programs and suggest that standard behavioral approaches to toileting may need to be paired with sensory strategies to address the specific barriers autistic children face. The results carry particular relevance for clinical settings in Latin America, where sensory-informed toilet-training protocols are not yet widely available.

Keywords: Sensory processing, Toilet training, Autism spectrum disorder, Interoception, Tactile responsivity, Proprioception, Adaptive behavior, Sensory subtypes, Toileting difficulty, Sensory-adapted intervention

Introduction

While most typically developing children achieve daytime continence between ages 2 and 4, autistic children often reach this milestone years later, and a sizeable proportion remain partially or fully incontinent well into middle childhood (Leader *et al.*, 2018; Kroeger *et al.*, 2009) [14, 19]. The gap between expected and actual toileting age creates ongoing stress for families, limits participation in school and community activities, and restricts access to inclusive educational placements where toilet training is a prerequisite (Bal *et al.*, 2015) [3]. Despite the scale of the problem, the reasons why toilet training is so much harder for autistic children have received surprisingly little focused investigation.

The dominant approach to toilet training in autism has drawn on applied behavior analysis, using reinforcement schedules, systematic prompting, and structured sit times to shape toileting behavior (Kroeger *et al.*, 2009) [19]. These methods have produced documented gains, but they work better for some children than others, and the reasons for uneven outcomes remain unclear (Leader *et al.*, 2018) [14]. One explanation that has gained attention in the occupational therapy literature is that sensory processing differences, which affect the majority of autistic children, may interfere with specific components of the toileting sequence. Toilet training requires a child to detect internal bladder and bowel signals, tolerate the sensory features of the bathroom environment, sit on a surface that may feel unfamiliar or unstable, and manage clothing adjustments that involve fine motor and tactile processing (Beaudry-Bellefeuille *et al.*, 2023) [1]. Each of these steps engages sensory systems that are often atypical in autism (Tomchek *et al.*, 2007; Ben-Sasson *et al.*, 2009) [17, 18].

Sensory processing differences in autism are not a single phenomenon. Research using the Sensory Profile and related instruments has identified distinct sensory subtypes, including patterns characterized by seeking, avoiding, under-responsivity, and over-responsivity, each with different behavioral signatures and different implications for daily functioning (Ausderau *et al.*, 2016; Lane *et al.*, 2010) [10, 20]. Tomchek and colleagues [

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[7] reported that sensory subtypes in preschool-aged autistic children were connected to different adaptive behavior profiles, and Ausderau and colleagues [10] showed that sensory subtypes were linked to communication, socialization, and daily living outcomes. However, the specific connection between sensory subtypes and toileting outcomes has not been tested directly.

A parallel line of research has examined interoception, the sense of internal bodily signals, as a possible contributor to toileting delay. DuBois and colleagues [9] reviewed evidence that interoceptive processing is altered in autism, and Price and colleagues [5] found through *meta*-analysis that autistic individuals show reduced interoceptive accuracy across multiple physiological domains. (Beaudry-Bellefeuille and Lane) [1] proposed a clinical model linking interoceptive differences to toileting difficulties, arguing that children who struggle to perceive bladder fullness signals will not develop the anticipatory awareness that successful toilet training requires. This theoretical framework has not been tested with a sample that also measures external sensory processing domains alongside interoception.

The present research addressed three questions: (1) which sensory processing domains are the strongest predictors of toilet-training difficulty in autistic children, (2) whether sensory subtypes differ in toileting outcomes, and (3) whether a sensory-adapted toileting intervention produces measurable improvements in a subset of participants. This research was conducted in Medell*ín*, Colombia, where access to sensory-informed developmental services varies widely and where no previous investigation of the sensory-toileting connection has been published.

Material and methods

Material

Participants were 112 autistic children (78 male, 34 female) aged 3 to 8 years (M = 5.2, SD = 1.4) recruited from three developmental clinics affiliated with the Medell*ín* Foundation for Child Development Research between January 2022 and December 2023. All children had a confirmed diagnosis of autism spectrum disorder based on DSM-5 criteria and received by a licensed clinical psychologist or developmental pediatrician. Children were excluded if they had a co-occurring medical condition known to affect continence (e.g., spina bifida, chronic urinary tract infections) or if they were receiving medication with known effects on bladder function. The sample was classified by cognitive level using the Bayley Scales of Infant Development-III or the Wechsler Preschool and Primary Scale of Intelligence-IV, depending on age: 42 children (37.5%) had intellectual disability ($IQ < 70$), 38 (33.9%) had borderline cognitive functioning (IQ 70-84), and 32 (28.6%) had average or above-average cognitive ability ($IQ \geq 85$). Autism severity was measured using the Autism Diagnostic Observation Schedule-2 (ADOS-2) calibrated severity score.

Methods

Sensory processing was assessed using the Sensory Profile-2 (SP-2), a caregiver-report questionnaire that yields scores across six sensory domains (tactile, auditory, visual, vestibular, proprioceptive, and oral) and four sensory processing quadrants (seeking, avoiding, sensitivity, and registration) (Little *et al.*, 2022; Tomchek *et al.*, 2007) [2, 17]. The SP-2 was administered in Spanish using the validated Latin American adaptation. Toileting status was recorded using a structured interview that classified each child as toilet trained (consistently dry during daytime for at least 3 months), in progress (actively engaged in toilet training with partial success), or not yet trained (no systematic toilet-training program initiated or no meaningful progress). Toilet-training difficulty was quantified using the Toilet Training Difficulty Index (TTDI), a 15-item composite score developed for this research that captures resistance to sitting on the toilet, avoidance of bathroom environments, lack of awareness of bladder fullness, distress during clothing changes, and frequency of toileting accidents (Hedgecock *et al.*, 2023) [4]. The TTDI showed acceptable internal consistency (Cronbach alpha = 0.84) and test-retest reliability (ICC = 0.79) in a pilot sample of 30 children prior to the main data collection.

Sensory subtypes were derived using k-means cluster analysis on the six SP-2 domain scores, with the number of clusters determined by silhouette analysis. Hierarchical multiple regression was used to identify sensory predictors of TTDI scores, with age, sex, cognitive level, and ADOS-2 severity entered in the first block and SP-2 domain scores entered in the second block. Between-group comparisons across sensory subtypes used one-way ANOVA with Games-Howell post hoc tests. A subsample of 24 children with the highest TTDI scores participated in a 12-week sensory-adapted toileting intervention that included graded tactile exposure to bathroom surfaces, proprioceptive preparation activities before toilet sits, visual schedules with sensory cues, and interoceptive awareness training using body-scan exercises (Beaudry-Bellefeuille *et al.*, 2023; Schaaf *et al.*, 2018) [1, 11]. Pre-post comparisons used paired-samples t-tests and Cohen d effect sizes.

Ethical considerations

This research received approval from the Ethics Committee of the Medell*ín* Foundation for Child Development Research (Protocol MFCDR-2021-038). All procedures followed the principles of the Declaration of Helsinki. Written informed consent was obtained from each child's main caregiver, and verbal assent was obtained from children who were able to provide it. Caregivers were informed of their right to withdraw from the research at any point without consequences for their child's clinical care. All data were de-identified and stored on encrypted institutional servers accessible only to the research team.

Patient characteristics

The 112 children in the sample ranged from 3.0 to 8.4 years of age. The majority were male (69.6%), which is consistent with the higher prevalence of autism diagnoses in boys. By toileting status, 36 children (32.1%) were classified as toilet trained, 38 (33.9%) as in progress, and 38 (33.9%) as not yet trained. Mean ADOS-2 calibrated severity scores were 7.1 (SD = 1.8) for the full sample, with no significant differences across toileting status groups ($F_{(2,109)} = 1.42$, $p = 0.25$). Mean SP-2 total scores differed across groups: toilet-trained children had a mean of 58.3 (SD = 14.2), in-progress children had a mean of 72.6 (SD = 16.8), and not-yet-trained children had a mean of 84.1 (SD = 15.3), with the between-group difference reaching significance ($F_{(2,109)} = 22.47$, $p < 0.001$). Children in the not-yet-trained group were younger on average (M = 4.6, SD = 1.2) than those in the trained group (M = 6.1, SD = 1.3), and cognitive level was lower in the not-yet-trained group (mean $IQ = 68.4, SD = 16.2$) compared with the trained group (mean $IQ = 82.7, SD = 14.8$).

Results

Table 1. Ranking of sensory processing domains by predictive strength for toilet-training difficulty (hierarchical regression, Block 2).

Rank	Sensory domain	β	SE	*p* value	95% CI	Partial R^2
1	Tactile	0.38	0.07	< 0.001	[0.24, 0.52]	0.14
2	Proprioceptive	0.31	0.08	< 0.001	[0.16, 0.46]	0.10
3	Vestibular	0.22	0.07	0.003	[0.08, 0.36]	0.06
4	Auditory	0.18	0.08	0.024	[0.02, 0.34]	0.04

(continued on next page)

Rank	Sensory domain	β	SE	*p* value	95% CI	Partial R^2
5	Oral	0.12	0.07	0.092	[-0.02, 0.26]	0.02
6	Visual	0.08	0.08	0.314	[-0.08, 0.24]	0.01

Note. Block 1 (age, sex, IQ, ADOS-2 severity) $R^2 = 0.21$; Block 2 (sensory domains added) $\Delta R^2 = 0.16$, total $R^2 = 0.37$, $F(10,101) = 5.94$, $p < 0.001$. β = standardized regression coefficient; SE = standard error; CI = confidence interval.

The hierarchical regression analysis revealed that sensory processing domains added meaningful predictive power beyond demographic and diagnostic variables. After controlling for age, sex, cognitive level, and ADOS-2 severity, the six SP-2 domain scores explained an additional 16% of the variance in TTDI scores ($\Delta R^2 = 0.16$, $p < 0.001$). Tactile processing emerged as the single strongest predictor ($\beta = 0.38$, $p < 0.001$), followed by proprioceptive processing ($\beta = 0.31$, $p < 0.001$) and vestibular processing ($\beta = 0.22$, $p = 0.003$). Auditory processing reached significance ($\beta = 0.18$, $p = 0.024$), while oral and visual domains did not independently predict TTDI scores after the other domains were accounted for.

Table 2. Toileting outcomes before and after sensory-adapted intervention in a subsample of 24 children with the highest toilet-training difficulty scores.

Outcome measure	Pre M (SD)	Post M (SD)	Change M (SD)	*p* value	Cohen's d
TTDI total score	62.4 (8.3)	41.7 (11.6)	-20.7 (9.8)	< 0.001	1.45
Toileting resistance	18.2 (4.1)	11.4 (3.8)	-6.8 (3.2)	< 0.001	1.15
Bladder awareness	6.3 (2.9)	10.8 (3.4)	+4.5 (2.6)	< 0.001	1.02
Bathroom tolerance	7.8 (3.2)	12.1 (2.9)	+4.3 (2.4)	< 0.001	0.98
Clothing management	8.4 (2.7)	11.2 (2.3)	+2.8 (2.1)	< 0.001	0.82
Sitting duration (min)	1.8 (1.1)	4.2 (1.6)	+2.4 (1.3)	< 0.001	1.21
Accidents per week	8.6 (3.4)	4.1 (2.8)	-4.5 (2.7)	< 0.001	1.08

Note. Pre = baseline assessment; Post = assessment at week 12. TTDI = Toilet Training Difficulty Index. Positive change = improvement; negative change on resistance and accidents = improvement.

Cluster analysis of the six SP-2 domain scores yielded five sensory subtypes, consistent with previous classification work using similar instruments (Ausderau *et al.*, 2016; Lane *et al.*, 2010) [10, 20]. The over-responsive subtype ($n = 16$) had the highest mean TTDI score ($M = 68.4$, $SD = 12.1$), while the sensory-seeking subtype ($n = 34$) had the lowest ($M = 44.2$, $SD = 15.3$), with the between-group difference reaching significance ($F_{(4,107)} = 14.83$, $p < 0.001$). Post hoc comparisons showed that the over-responsive group scored higher on the TTDI than all other subtypes (all $p < 0.01$), and the seeking group scored lower than the avoiding and mixed groups ($p < 0.05$).

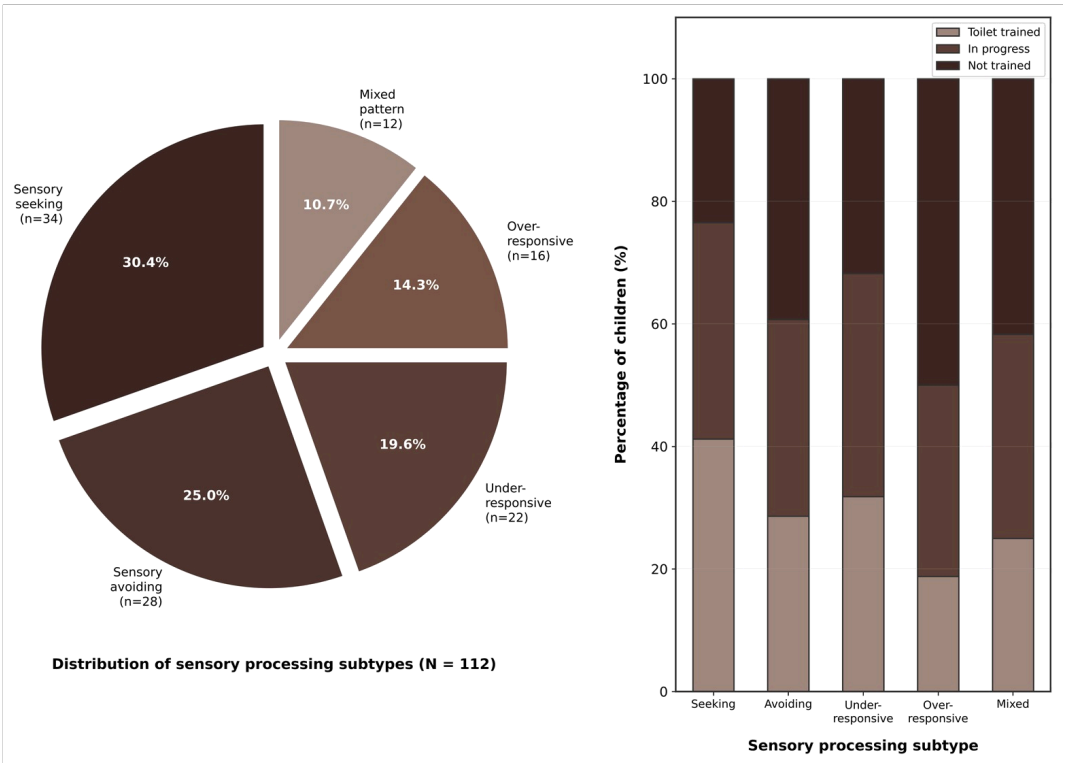


Figure 1. Distribution of sensory processing subtypes in the sample (left panel) and percentage of children at each toileting status within each subtype (right panel). Children classified as over-responsive had the highest rate of unsuccessful toilet training (50%), while those in the sensory-seeking subtype had the highest training success rate (41.2%).

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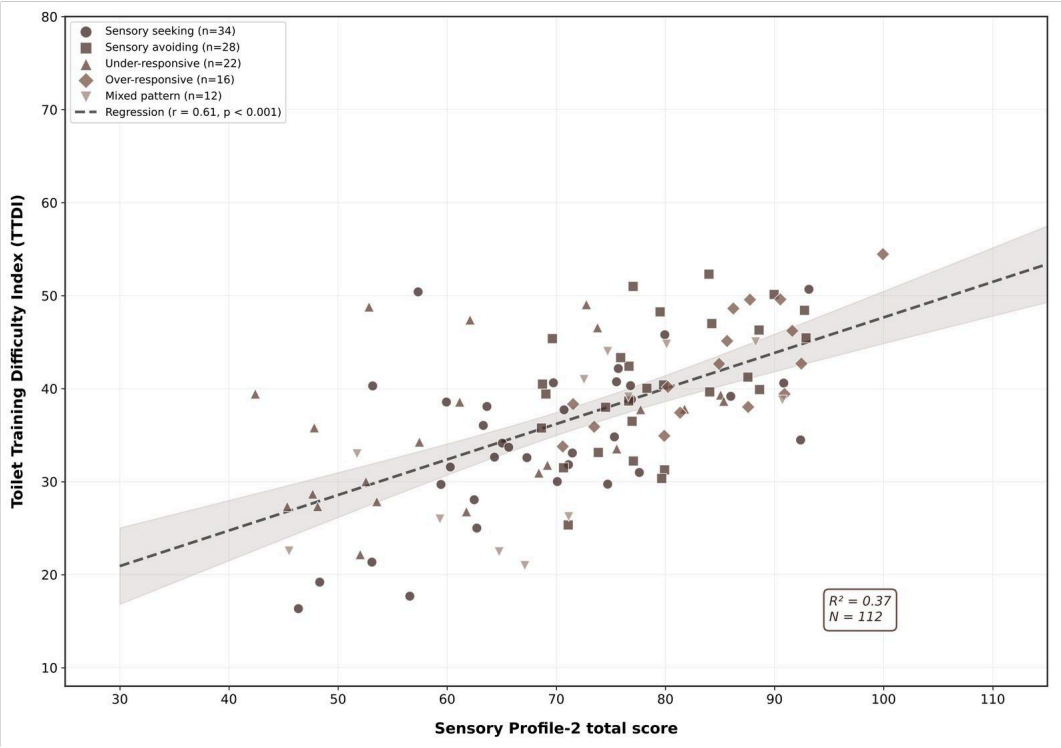


Figure 2. Scatter plot of Sensory Profile-2 total scores against Toilet Training Difficulty Index scores across the full sample ($N = 112$). Each marker shape represents a sensory processing subtype. The dashed line shows the overall regression ($r = 0.61$, $p < 0.001$), and the shaded region represents the 95% confidence interval. Higher sensory processing scores and higher TTDI scores both reflect greater difficulty.

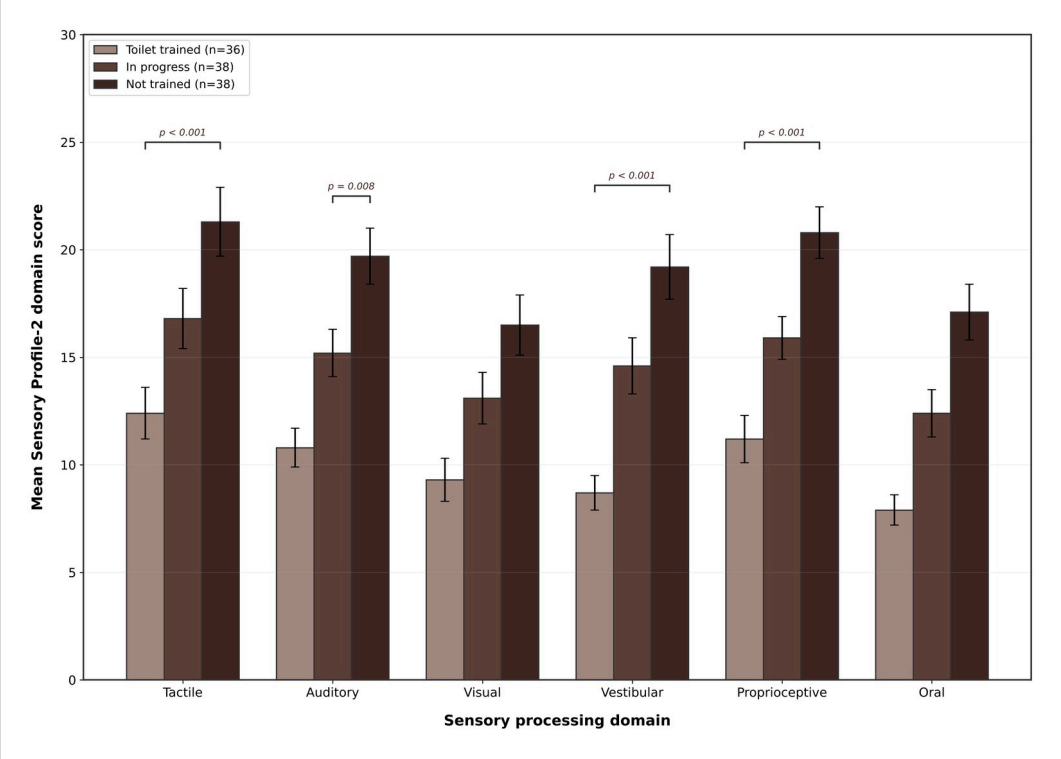


Figure 3. Mean Sensory Profile-2 domain scores by toilet-training status. Error bars represent standard errors. Children who were not yet toilet trained scored higher (showing more sensory processing differences) across all six domains, with the largest group differences observed in the tactile, proprioceptive, and vestibular domains (all $p < 0.001$).

The intervention subsample ($n = 24$) showed meaningful improvements across all measured toileting outcomes after 12 weeks of the sensory-adapted protocol. The largest effect was observed for the overall TTDI score ($d = 1.45$), with the reduction from a mean of 62.4 to 41.7 representing a shift from severe to moderate difficulty. Bladder awareness, which had been one of the lowest-scoring components at baseline, improved by 4.5 points ($d = 1.02$), suggesting that the interoceptive awareness training component may have helped children attend to internal signals they had previously missed. Toileting resistance and sitting duration also improved with large effect sizes, consistent with the expectation that graded tactile exposure would reduce the aversive quality of the toilet and bathroom environment. Accidents per week decreased from 8.6 to 4.1, though considerable variability remained within the group.

When the relationships between sensory domains and specific toileting components were examined, tactile processing showed the strongest links with toileting resistance ($r = 0.54$, $p < 0.001$) and bathroom tolerance ($r = 0.49$, $p < 0.001$), while proprioceptive processing was

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most strongly connected to sitting duration (r = -0.47, $p < 0.001$) and clothing management (r = 0.41, $p < 0.001$). Vestibular processing was connected to sitting duration and balance-related toileting behaviors (r = 0.38, $p < 0.001$). These domain-specific patterns support the argument that different sensory systems contribute to different components of the toileting sequence, and that intervention planning should target the domains most relevant to each child's specific barriers (Beaudry-Bellefeuille *et al.*, 2023; Schaaf *et al.*, 2018) [1, 11].

Discussion

The finding that tactile and proprioceptive processing were the strongest predictors of toilet-training difficulty aligns with clinical observations that many autistic children resist sitting on unfamiliar surfaces and struggle with the clothing adjustments required for independent toileting (Beaudry-Bellefeuille *et al.*, 2023; Hedgecock *et al.*, 2023) [1, 4]. (Beaudry-Bellefeuille and Lane) [1] proposed that tactile defensiveness may make the physical contact with the toilet seat aversive, while proprioceptive processing differences may reduce the child's ability to maintain a stable seated posture, both of which would directly interfere with successful toilet use. The present findings provide empirical support for that model. The effect sizes for these two domains were substantially larger than for auditory and visual processing, pointing to the importance of body-contact senses over environmental senses in the toileting context.

The identification of five sensory subtypes mirrors the work of Ausderau and colleagues [10] and Lane and colleagues [20], who found similar clustering patterns using the Sensory Profile in North American samples. The present research extends their findings by showing that these subtypes are connected to different toileting trajectories. The over-responsive subtype, which represented the smallest group (14.3%), had the worst toileting outcomes, suggesting that these children may need the most intensive sensory preparation before toilet-training programs begin. In contrast, children in the sensory-seeking group, while still delayed relative to typically developing peers, showed the most promising training outcomes, possibly because their sensory-seeking tendencies can be directed toward the proprioceptive and tactile features of toileting activities rather than away from them.

The interoceptive dimension of toileting has been less thoroughly researched than external sensory processing. DuBois and colleagues [9] reviewed evidence that autistic individuals process internal bodily signals differently, and Price and colleagues [5] confirmed through *meta*-analysis that interoceptive accuracy is reduced in autism. The improvement in bladder awareness scores following the sensory-adapted intervention in this research backs up the theoretical link between interoception and toileting proposed by (Beaudry-Bellefeuille and Lane) [1], though the absence of a control group limits causal conclusions. The finding that bladder awareness improved with a large effect size (d = 1.02) over 12 weeks suggests that body-scan and interoceptive training exercises may be a productive addition to existing toilet-training protocols, an approach that Green and colleagues [12] have advocated for based on their work with sensory behaviours in autistic children.

The Latin American context of this research is worth noting. Leader and colleagues [14] documented that toileting problems in autistic children are widespread across cultural settings, but the available evidence base for sensory-informed toileting interventions draws almost exclusively from high-income English-speaking countries. Schaaf and colleagues [11] showed the effectiveness of Ayres Sensory Integration approaches in controlled trials, yet these methods require specialized training and equipment that may not be available in many Colombian clinical settings. The sensory-adapted protocol used here was designed to be implementable by caregivers with minimal professional supervision, using commonly available materials for tactile and proprioceptive activities. This design feature may increase the relevance of the approach for resource-limited settings, though replication with a larger sample and a comparison group would be needed to confirm its effectiveness (Kojovic *et al.*, 2022; McCormick *et al.*, 2016) [6, 13].

McCormick and colleagues [13] found that sensory symptoms in autism are relatively stable over time, which would mean that sensory processing differences identified during the preschool years are likely to persist into later childhood unless targeted by intervention. This temporal stability supports the argument that sensory assessment should be incorporated into toilet-training readiness evaluations, rather than waiting for training difficulties to emerge. The regression model in this research accounted for 37% of the variance in toilet-training difficulty, leaving 63% unexplained. Variables not measured here, including specific interoceptive accuracy for bladder signals, caregiver training practices, previous toileting experiences, and behavioral rigidity, likely account for portions of the remaining variance (Williams *et al.*, 2023; Crasta *et al.*, 2020; Neil *et al.*, 2016) [8, 15, 16].

Limitations

Several limitations should be considered when interpreting these findings. The cross-sectional design of the main analysis prevents causal conclusions about the relationship between sensory processing and toileting difficulty; it remains possible that unsuccessful toileting experiences shape sensory responses rather than the reverse. The sensory-adapted intervention component lacked a randomized control group, so improvements cannot be attributed exclusively to the intervention rather than to maturation, practice, or caregiver attention effects. The SP-2 is a caregiver-report instrument, and caregiver perceptions of sensory behavior may not align perfectly with objective measures of sensory processing. The sample was drawn from developmental clinics in a single Colombian city, and families who attend these clinics may not be representative of the broader population of autistic children in the region. The TTDI was developed for this research and has not yet been validated in independent samples. Finally, interoceptive processing was assessed indirectly through the bladder awareness subscale of the TTDI rather than through a direct measure of interoceptive accuracy, limiting conclusions about the specific interoceptive mechanisms involved (Price *et al.*, 2022; DuBois *et al.*, 2016) [5, 9].

Conclusion

This research set out to determine whether sensory processing differences predict toilet-training difficulty in autistic children and whether sensory subtypes are connected to different toileting outcomes. The results confirm that sensory processing, particularly in the tactile and proprioceptive domains, is a meaningful predictor of how much difficulty autistic children experience during toilet training, even after accounting for age, cognitive ability, and autism severity. The five sensory subtypes identified in this sample showed distinct toileting profiles, with the over-responsive subtype experiencing the most severe toileting difficulties and the sensory-seeking subtype showing the best outcomes.

The practical message emerging from these findings is straightforward. Before beginning a toilet-training program for an autistic child, clinicians and caregivers should assess the child's sensory processing profile across multiple domains. Children who show high levels of tactile over-responsivity may benefit from gradual exposure to toilet-related surfaces and textures before any expectation of toilet use is introduced. Children with proprioceptive processing differences may need seating supports, weighted lap pads, or preparatory heavy-work activities to help them maintain a comfortable and stable position during toilet sits. Children who show reduced bladder awareness may need explicit interoceptive training that teaches them to attend to and interpret internal signals. These sensory strategies are not replacements for established behavioral approaches to toilet training; rather, they address the sensory barriers that may prevent behavioral approaches from working as intended.

The pilot intervention results, while preliminary, are encouraging. The large effect sizes observed for toileting resistance, bladder awareness, and sitting duration suggest that a relatively brief period of sensory-adapted support can meaningfully improve toileting readiness, even in children who have been resistant to previous training attempts. The

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finding that the intervention was implementable by caregivers with minimal professional support adds to its potential utility in settings where access to specialized occupational therapy or sensory integration services is limited.

Future work should test sensory-adapted toileting interventions through randomized controlled trials with active comparison conditions, develop direct interoceptive measures suitable for young autistic children, and examine whether early sensory intervention during the preschool period can prevent the toileting difficulties that many autistic children encounter. Longitudinal designs that follow children from initial sensory assessment through toilet-training outcomes would clarify the direction of the sensory-toileting relationship and identify the developmental windows during which sensory-adapted approaches are most effective. Cross-cultural replication across Latin American and other under-represented regions would strengthen the evidence base and inform the development of culturally responsive clinical guidelines.

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