ORIGINAL RESEARCH

Increased Prevalence of Sensory Processing Issues in Pediatric Gastrointestinal Patient Population

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Jessica K Wood, OTD, OTR/L, BCP, and Rebecca G Carey, CNSC, IFMCP, MD, contributed to the conception and design of the study. Kara E Garcia, PhD, performed the analysis and generated the figures. Jessica K Wood, OTD, OTR/L, BCP, led the first draft of the manuscript. Rebecca G Carey, CNSC, IFMCP, MD, and Kara E Garcia, PhD, wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Abstract

BACKGROUND: Sensory processing dysfunction in children has been linked to attention-deficit/hyperactivity disorder, autism, feeding disorders, and functional abdominal pain. However, little is known about sensory processing in the broader pediatric gastroenterology population.

OBJECTIVE: To characterize frequency and type of sensory processing dysfunction seen in pediatric gastroenterology compared to a general pediatric population.

METHODS: The Short Sensory Profile 2 was administered to the parents of children ranging 3–14 years, being seen in a pediatric gastrointestinal (GI) subspecialty clinic or general pediatric clinic. Short Sensory Profile 2 scores from age- and gender-matched groups were compared with nonparametric statistics.

RESULTS: Sensory processing dysfunction was increased in children seen in the GI clinic compared to children in the general pediatric clinic. Short Sensory Profile 2 quadrant analysis revealed greatest differences in avoiding, primarily in young females of the GI population.

CONCLUSION: Children presenting to a pediatric GI clinic demonstrate greater sensory processing dysfunction compared to children in a general pediatric practice.

Introduction

Ayres[1] defined sensory integration as the neurological process that organizes sensation and allows effective use of the body within a given environment. Commonly considered senses include vestibular, proprioceptive, and somatosensory,[2] as well as tactile.[3] Vestibular and proprioceptive senses contribute to the perception of active movement and development of posture responses, while the somatosensory sense processes input such as light touch, deep pressure, stretch, or vibration.[4] Together, these systems provide awareness in space, postural tone, coordination, and equilibrium, and they provide the foundation for the later developing sensory systems.[3,4] Interoception, another sense introduced by Ayres[1] but not given much attention until recently, is associated with pain, temperature, itch, muscular and visceral sensations, thirst, hunger, and the body's need for breathing.[5]

When sensory integration goes awry, sensations are experienced differently and can result in inappropriate reactions. When sensory difference negatively affects everyday functioning, it becomes sensory processing dysfunction.[6] To address the complexity of the neurological processes that regulate sensory dysfunction, several clinical definitions, and accompanying asseessments, have been developed to improve the validity and reliability of practice and research. Miller et al[7] proposed a new way of classifying or diagnosing sensory integration according to 3 main patterns: sensory modulation disorder, sensory-based motor disorder, and sensory discrimination disorder. Sensory modulation disorder includes sensory overresponsivity (SOR) and sensory underresponsivity (SUR), while sensory-based motor disorder is broken down into dyspraxia, the impaired ability to execute novel actions, and postural disorder, the impaired ability to stabilize the body at rest or during actions. Conversely, Dunn's Sensory Processing Framework[8] defined 4 quadrants based on low or high thresholds to sensory stimuli (SOR and SUR, respectively) and passive or active self-regulation in response to these stimuli: seeking (SUR with active self-regulation), avoiding (SOR with active self-regulation), sensitivity (SOR with passive self-regulation), and registration (SUR with active self-regulation).

Previous literature supports a link between sensory processing dysfunction and psychological or behavioral issues,[4,9–13] as well as a link between psychological and behavioral issues and gastrointestinal (GI) dysfunction in children.[14,15] Furthermore, sensory factors have been implicated in specific pediatric GI conditions, such as defecation disorders,[16] irritable bowel syndrome,[17] feeding difficulties,[18,19] Crohn's disease,[20] and functional abdominal pain.[17,21] However, additional studies are needed to understand the link between clinically defined sensory processing dysfunction and broader GI dysfunction.

The primary aim of this study was to characterize clinically observed sensory processing dysfunction in the broad pediatric gastroenterology population. To broaden the understanding of the relationship between sensory processing dysfunction and patients with GI diseases, this study assessed the frequency and type of sensory issues, specifically sensory responsivity, seen in a pediatric gastroenterology clinic compared to a general pediatric population. Specifically, this study focused on observations captured by the Short Sensory Profile 2 (SSP-2), a relatively short, validated survey based on Dunn's Sensory Processing Framework.[22,23]

Materials and Methods

PARTICIPANTS

A total of 201 surveys were distributed to parents or caregivers of children ages 3–14 years. Approval to conduct the study was gained from the Institutional Review Board at the University of Southern Indiana as well as the Institutional Review Board at St. Vincent's Evansville (St. Mary's) Hospital. Parents at both the GI subspecialty clinic (GI group) and the general pediatric outpatient clinic (PED group) completed verbal informed consent forms according to approved procedures. As per approved procedures, participants were permitted to not answer questions or stop testing.

Children who met the following criteria were included in the study. For the GI group: 1) between the ages of 3 and 14 years; 2) referred to the pediatric gastroenterologist for GI complaints. For the PED group: 1) between the ages of 3 and 14 years; 2) seeing a pediatrician for something other than GI complaints. Children who were seeing a pediatrician for a GI-related condition were excluded from the PED group, and surveys missing age or otherwise incomplete were excluded from the analyses.

PROCEDURES

The parents surveyed in this study came from populations at St. Vincent's Evansville (St. Mary's) Hospital. Parents who were visiting their pediatrician for an issue outside of GI issues and parents of children who were seeing a pediatric gastroenterologist for GI complaints completed questionnaires. The primary parent or caregiver completed questionnaires regarding their child's sensory processing based on behavior-related questions.

MEASURES

Short Sensory Profile 2: The original Short Sensory Profile was developed to screen for and assess sensory responsivity.[24] The SSP-2 was updated to include international relevance, no double negatives for improved readability, increased validity and reliability studies, and a strengths-based approach.[22,23] The 34-item parent rating scale examines sensory responsivity as it relates to participation in daily life activities in 4 quadrants: seeking/seeker, avoiding/avoider, sensitivity/sensor, and registration/bystander. The SSP-2 also assesses scores in terms of sensory questions and behavioral questions. For each category, the SSP-2 calculates a raw score, as well as classifications based on how responses compare to "the majority of others."[22,23] Those scoring greater than 1 standard deviation above the mean[22,23] were classified as "more than others," and those scoring greater than 2 standard deviations above the mean were classified as "much more than others." The instrument has strong interrater reliability (0.70–0.80) and test–retest reliability (0.83–0.97).[22,23]

STATISTICAL ANALYSES

In light of past studies suggesting age and gender effects,[25] statistical comparisons between cohorts in the GI and PED groups were age- and gender-matched as described in Table 1 and Figure 1. To further explore the differences between group and gender at younger ages, the authors also performed a separate comparison of age-matched females and males between 3 and 8 years of age. Mann-Whitney tests were used to compare total raw scores between 2 groups (age- and gender-matched GI vs PED), and effect sizes (r) related to SSP-2 categories (sensory, behavioral, and 4 quadrants) were calculated from raw scores for each category. Within each group and gender, linear regressions of the full cohort (prior to age- and gender-matching) were used to detect trends with respect to age. For comparison of age- and gender-matched groups, no covariates were considered. For all tests, p value < 0.05 was regarded as significant.

Cohort	GI clinic	PED clinic
Total participants enrolled	**90**	**111**
Exclusions	27	32
Inappropriate age for study	9	0
Incomplete SSP-2	10	9
Age (and gender) not recorded	9 (5)	23 (23)
Total participants analyzed	**62**	**79**
% female	60%	48%
Mean age (standard deviation)	6.9 (2.9)	8.9 (2)
Matched groups	**46**	**46**
% female	52%	52%
Mean age (standard deviation)	7.5 (3.0)	7.9 (3.1)

Table 1: Cohort description

GI clinic = gastrointestinal specialty clinic; PED clinic = general pediatric clinic; SSP-2 = Short Sensory Profile 2.

Results

A total of 201 surveys were completed by parents or caregivers in both the GI and PED groups. After exclusion criteria were applied, 141 surveys of children ages 3–14 years (62 GI, 79 PED) were included in the study. As illustrated in Table 1, the full PED group included 41 males (52%) and 38 females (48%), while the full GI sample included 25 males (40%) and 37 females (60%). For age- and gender-balanced comparisons, groups were refined to 46 participants (22 males and 24 females) each.

INCREASED PREVALENCE OF SENSORY OVERRESPONSIVITY IN PEDIATRIC GI CLINIC

In the GI cohort, 40% of children displayed atypically frequent behaviors (defined as "more" or "much more" than others) in at least 1 area, with highest frequencies in quadrants for sensitivity (36%) and avoiding (34%) (Figure 1). This is compared to a maximum prevalence of 18% in any 1 area in the PED cohort, which is consistent with past studies estimating sensory overresponsivity in 16% of school-aged children (7–15 years of age) in the general population,[26] as well as a slightly increased prevalence for younger ages (3–6 years of age).[25] While the authors observed a bias toward younger ages in the GI cohort (Table 1), increased dysfunction in the GI cohort persisted in age- and gender-matched groups (Figure 1B).

SENSORY PROCESSING DIFFERENCES ARE MOST PRONOUNCED IN SEEKING AND AVOIDING

While SSP-2 total raw score was significantly different between GI and PED cohorts prior to age- and gender-matching ($p = 0.032$), this difference did not reach statistical significance for matched groups ($p = 0.146$).

For matched groups, SSP-2 raw quadrant scores, as well as average scores for sensory or behavioral questions, were elevated across most categories, with most pronounced effects in avoiding ($r = 0.191$), seeking ($r = 0.166$), and sensitivity ($r = 0.158$) quadrants, and minimal effect in registration ($r = 0.008$).

Beyond the predefined quadrants of the SSP-2, several items on the questionnaire revealed a striking increase in frequency among GI patients, as described in Table 2. With the exception of item 5 (related to taste), these items do not reflect an obvious relationship to the GI system, though items 1–4 may reflect a cluster of related behaviors.

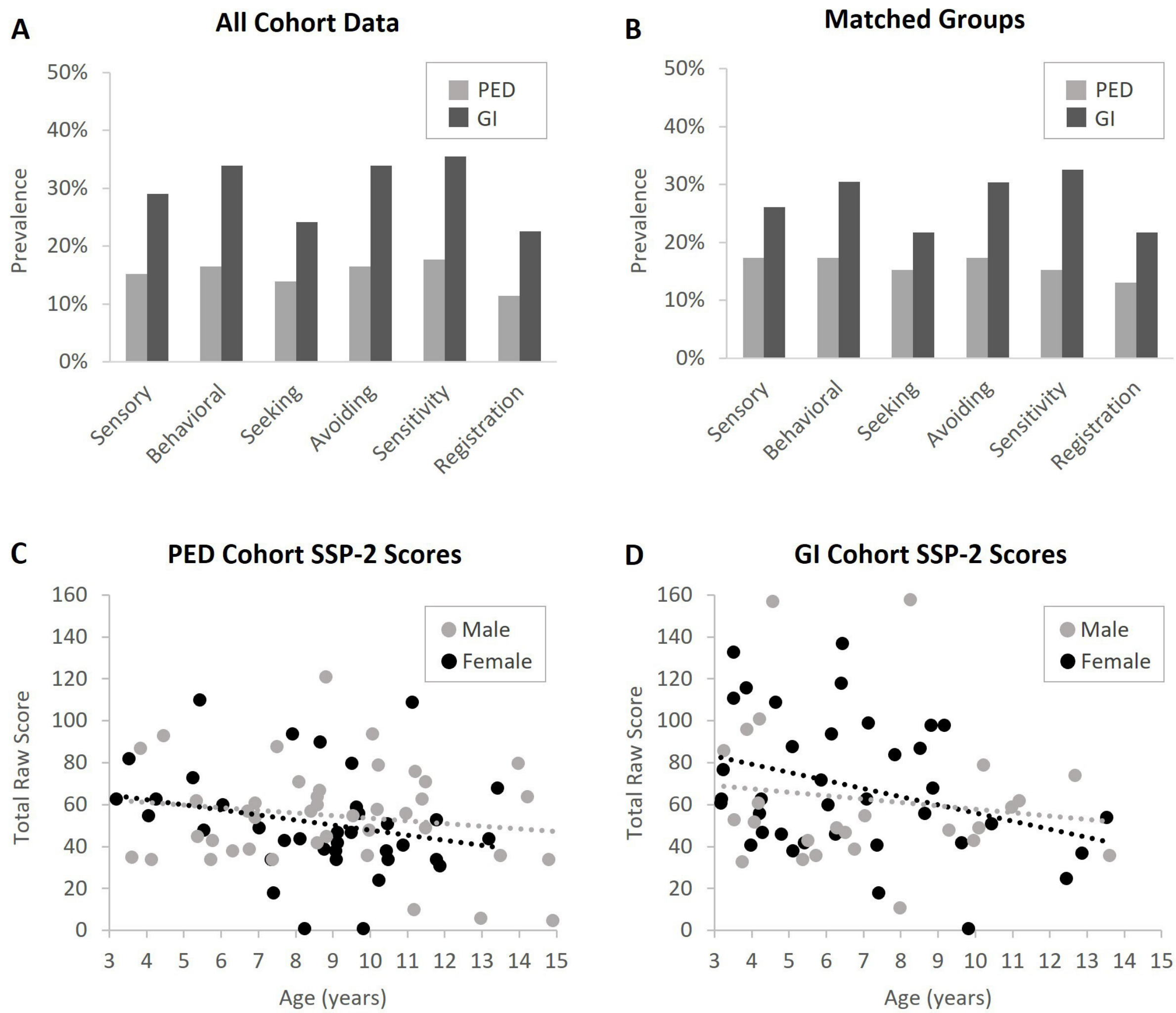

Figure 1: General characteristics of gastrointestinal specialty clinic (GI) and general pediatric clinic (PED) cohorts (A) for all participants with complete data for PED cohort (n = 79) and GI cohort (n = 62), percentage of participants classified as "more/much more than others" for each category within the Short Sensory Profile 2 (SSP-2); (B) results for age- and gender-matched groups (n = 46 per group); and (C, D) considering all participants, linear correlations observed between SSP-2 total raw score and age, separated by gender and group. Pearson's correlation coefficients: PED female r = 0.251, PED male r = 0.160, GI female r = 0.334, GI male r = 0.141.

SENSORY PROCESSING DIFFERENCES DEPEND ON AGE IN FEMALES

Considering all available data from GI and PED cohorts (Figure 1C–D), the authors noted greater sensory processing differences at younger ages, particularly in the GI cohort. Linear regression analysis revealed a significant decrease in overall SSP-2 score for females in the GI cohort ($p = 0.043$). This trend was observed to a lesser, nonsignificant degree for females in the PED cohort and was negligible for males of either cohort.

Individual SSP-2 questionnaire items	Quadrant	Effect size (r)
My child watches everyone move around the room. (item 31, behavioral)	Seeking	0.207
My child becomes anxious when standing close to others (for example, in a line). (item 5, sensory)	Sensitivity	0.182
My child gets frustrated easily. (item 22, behavioral)	Avoiding	0.172
My child has temper tantrums. (item 17, behavioral)	Avoiding	0.166
My child shows a strong preference for certain tastes. (item 11, sensory)	Seeking	0.165
My child becomes tired easily, especially when standing or holding the body in 1 position. (item 13, sensory)	Registration	0.161

Table 2: Behaviors of increased frequency in GI cohort

GI cohort = gastrointestinal specialty clinic cohort; SSP-2 = Short Sensory Profile 2.

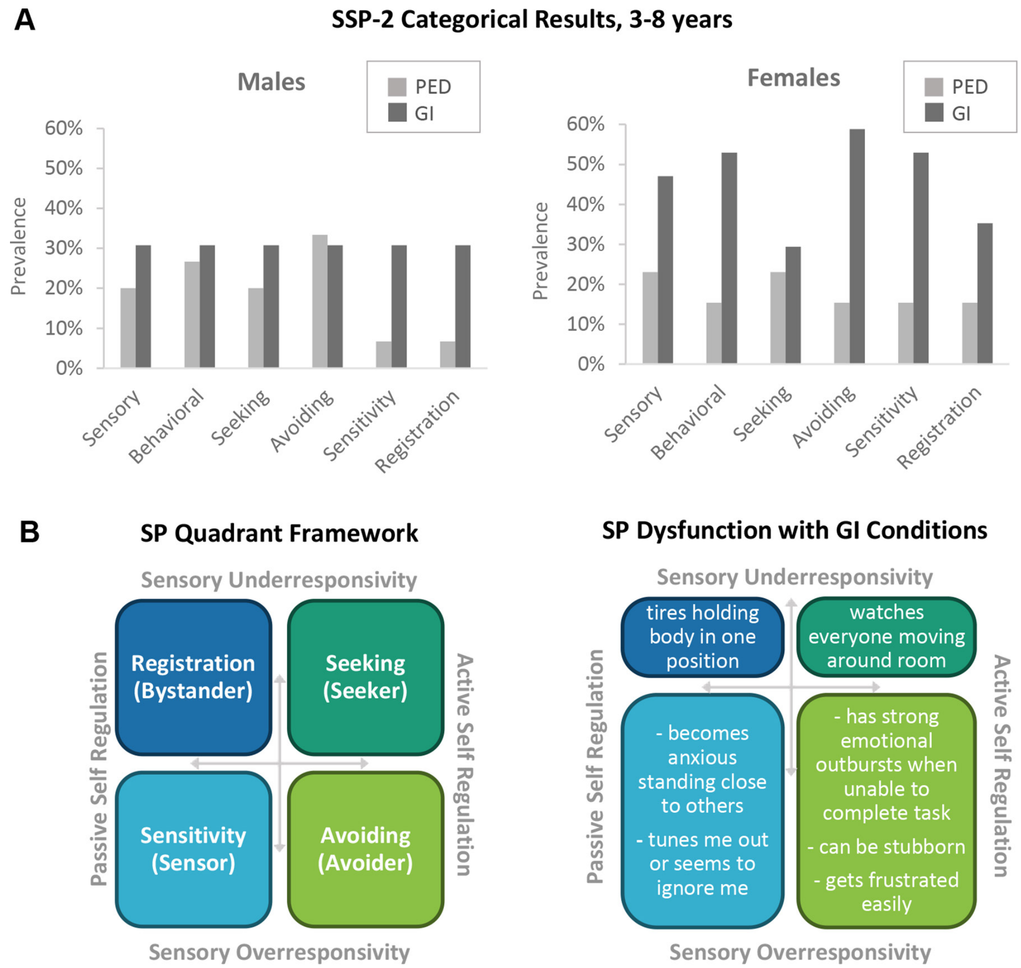

Figure 2: Gender-related differences in Short Sensory Profile 2 (SSP-2) scores at young ages (A) for younger subgroup (ages 3–8), percentage of participants classified as "more/much more than others" based on the SSP-2, separated by male (left) and female (right) for both the general pediatric clinic (PED) cohort (light bars) and gastrointestinal specialty clinic (GI) cohort (dark bars); (B) sensory processing (SP) dysfunction most commonly observed in GI cohort (right), relative to general quadrant framework for the sensory profile (left).

For comparisons focused on younger ages (3–8 years), differences were not statistically significant; however, young females of the GI cohort (n = 17, mean age 5.84 years) were nearly twice as likely to display atypically frequent behaviors in at least 1 area of the SSP-2 (59%) compared to young males (31%, n = 13, mean age 5.85 years). Conversely, rates were slightly lower for young females of the PED cohort (23%, n = 13, mean age 5.83 years) compared to young males (40%, n = 15, mean age 5.84 years). Differences with respect to specific areas of the SSP-2 are shown in Figure 2. Analysis of raw quadrant scores revealed most pronounced differences between females and males in avoiding (r = 0.260), followed by registration (r = 0.157), seeking (r = 0.157), and sensitivity (r = 0.138) for the young GI cohort.

When comparing young females only, differences between GI and PED groups were more pronounced, whereas no differences between young males of the GI and PED groups were noted. Similar to other comparisons between GI and PED groups, differences between GI females and PED females were most pronounced in avoiding (r = 0.325), in this case followed by sensitivity (r = 0.245), registration (r = 0.195), and seeking (r = 0.157).

Within the SSP-2 questionnaire, items of greatest difference between young females of the GI and PED cohorts were similar to those observed for the larger cohort, but with greater emphasis on avoiding, as described in Table 3.

Discussion

The results of the current study indicate an increased prevalence of sensory overresponsivity in children presenting to a pediatric GI clinic independent of GI diagnosis, as measured by the

Individual SSP-2 questionnaire items	Quadrant	Effect size (r)
My child becomes anxious when standing close to others (for example, in a line). (item 5, sensory)	Sensitivity	0.439
My child has strong emotional outbursts when unable to complete a task. (item 20, behavioral)	Avoiding	0.416
My child can be stubborn and uncooperative. (item 16, behavioral)	Avoiding	0.378
My child gets frustrated easily. (item 22, behavioral)	Avoiding	0.370
My child tunes me out or seems to ignore me. (item 3, sensory)	Sensitivity	0.332
My child becomes tired easily, especially when standing or holding the body in 1 position. (item 13, sensory)	Registration	0.325

Table 3: Behaviors of increased frequency in GI cohort among young females

GI cohort = gastrointestinal specialty clinic cohort; SSP-2 = Short Sensory Profile 2.

SSP-2. The sensory processing differences in the GI population compared to the PED group were most pronounced in the avoiding quadrant of Dunn's Sensory Processing Framework. Study results also indicate that the sensory differences depend on age and gender, with young girls (3–8 years old) exhibiting highest sensory processing dysfunction in the GI group.

CONNECTING SENSORY PROCESSING TO GI DYSFUNCTION

Recent evidence has demonstrated a correlation between sensory processing dysfunction and GI issues in children, ranging from sensory hyperactivity (overresponsivity) to sensory hypereactivity or poor perception (underresponsivity) to unspecified atypical reactivity.[27] Anecdotally, sensory hyperactivity[28–30] has been associated with GI issues including refusal to sit on the toilet, hiding to defecate, feeling pain when defecating, and discomfort surrounding bathroom sounds. Firestone Baum et al[31,32] have linked GI dysfunction to poor or atypical sensory perception, such as not feeling colonic contractions or perceiving this input as pain and not related to defecation.

Previous research has focused primarily on chronic constipation[33] and on feeding difficulties[34] in young children. In this study, the authors have applied the SSP-2 to a much broader diagnosis-independent GI population in children up to 14 years of age and have also found sensory processing difficulties. Although, it is possible this finding reflects only patients with constipation in the GI cohort, this is unlikely as functional constipation is more prevalent in males[35] and these findings were more pronounced in females. It does raise the important possibility that patients seen in subspecialty pediatric clinics have a higher incidence of sensory processing problems independent of diagnosis.

That common sensory processing dysfunction pathways may underlie multiple distinct GI diagnoses, is supported by the numerous functions that the enteric nervous system (ENS) plays in GI homeostais. Not only is the ENS the primary system that modulates sensory input in the GI tract, but it is also required for host digestion, absorption, movement of contents, and neuroimmune function.[36] Specifically, the ENS is involved in bidirectional regulation of the microbiome,[37] innate and adaptive immune cells, and various inflammatory mediators, including amines, cytokines, short chain fatty acids, and hormones.[38] The ENS operates both independently and dependently on central nervous system input and is potentially the pivotal pathway linking sensory processing dysfunction and GI tract function.

Recent research has implicated the ENS in functional gastrointestinal disorders (FGID). FGIDs are very common in pediatric gastroenterology. In a large Egyptian study, FGIDs accounted for approximately 30% of all outpatient visits, with irritable bowel syndrome, functional constipation, and dyspepsia being the most common.[39] Moreover, a large US-based nationwide online questionnaire found 23% of children and adolescents qualified for at least 1 FGID, with abdominal migraines and constipation being the most common.[35]

Although, the pathophysiology of FGID is not fully understood, it is well accepted that elevated sensitivity to gut stimulation mediated via the ENS, also termed visceral hyperalgesia, is a common characteristic of FGIDs. Across all analyses in this study, the SSP-2 revealed most dramatic differences in the avoiding quadrant, which Dunn's Sensory Processing Framework[8] attributes to low sensory thresholds (sensory overresponsivity) and active self-regulation response (Figure 2). These results provide a preliminary common pathway that sensory overresponsivity is linked to elevated gut sensitivity and visceral hyperalgesia, a core feature of FGIDs, feeding disorders, and chronic constipation. In the case of FGIDs, the patient is overresponsive to gut stimulation, including intestinal distension and pain pathway modulation. In feeding disorders it would manifest as oral and breathing overresponsivity to food being offered in the oropharyngeal space, and in constipation as withholding of stool in response to pain[27] and generalized bathroom avoidance.

SENSORY PROCESSING DIFFERENCES IN YOUNG FEMALES

The current study's results also note an age-dependent effect in which young females present with these behaviors more than young males, again with differences most pronounced in avoiding. Previously, females have been shown to avoid pain more readily compared to males,[40] while males are more likely to attend toward pain.[41] For the limited data points available, older females in the GI group appear more similar to the PED group, which may suggest the presence of new, female-specific clinical conditions entering the GI clinic[42,43] or adaptive behavior by females with sensory processing dysfunction such that they are less likely to be referred to the GI clinic.

Gender differences in other categories represent interesting avenues for future exploration. For example, scores for the registration quadrant—which includes questions related to balance, posture, and movement—were also somewhat higher in the GI cohort for females at young ages (Figure 2). A closer look at the 34-item SSP-2 questionnaire reveals interesting differences between parent observations of the GI and PED groups. Beyond items related to avoidance, and in some analyses taste, a large discrepancy between GI and PED groups was that GI parents more often reported that their child "becomes tired easily, especially when standing or holding the body in 1 position" (registration).

The current research on dyspraxia has placed its focus on full body motor, social, and communicative deficits,[44] but dyspraxia can affect many aspects of life, including feeding and voiding. Children may have difficulty with fine motor manipulation and oral motor activities, such as using utensils with eating.[7] Small children may feel unstable or fearful on the toilet, which lacks a solid base of support and leaves their feet dangling. The act of voiding also includes both unintentional and intentional motor movement, as well as tactile, vestibular, and proprioceptive sensations. Therefore, it is possible that a child could have dyspraxia in the ability to coordinate the muscle movement required to void. While past studies have linked sensory modulation to voiding,[28,29,31,32] the literature is sparse on sensory-based motor disorders as they relate to the ability to plan the movement of voiding, either urination or a bowel movement.

Pediatric occupational therapists evaluate and treat dyspraxia and sensory processing dysfunction. Occupational therapy treatment includes an individualized treatment approach focusing on dyspraxia, postural control, the child's unique sensory system, and how this dysfunction impacts the child and family's day-to-day life.[45] It is important to note that parent and/or caregiver participation and interaction within therapy sessions is vital to the therapy's success, in order to ensure carryover from the therapy clinic into the home and then into their outside world.

Limitations

While this study unveils valuable insights into the pediatric GI population, the authors also note several limitations.

First, this study employed the SSP-2, which relies on parent perceptions to flag potential sensory processing differences. This focus could bias results toward behaviors parents are most likely to pick up on, such as socially unacceptable behaviors. Furthermore, parents of children with sensory processing dysfunction may be more likely to exhibit similar dysfunction. In these circumstances, parents may not flag a child's behavior as "more than others" or "less than others," based on their own perception of what is typical.

Second, while the SSP-2 has been previously validated and used in the context of both over and underresponsivity,[22,23] the current study did not detect any instances of underresponsivity. However, the authors interpret this result cautiously, because the design of the SSP-2 may be less sensitive in this range. Additional tools may be needed to characterize underresponsivity in this population. Third, as the patient's diagnosis and reason for visiting the pediatric GI clinic were not captured in the data, any attempt to correlate this study's findings to the exact type of GI dysfunction is speculative. For the current study, the authors were also unable to collect additional demographic information, such as race, ethnicity, and socioeconomic status, limiting their ability to control for any effects related to these factors. Future work should include these factors as considerations.

Lastly, the authors note that 30% of surveys were excluded from the study due to incomplete or missing data (25%) or inappropriate age (4%). This relatively high rate of missing data is due to the design of the study, which prioritized parent convenience and did not provide incentives for survey completion. Overall, this approach allowed collection of large samples relative to previous studies.

Conclusions

There is already evidence to date to support the connection between sensory processing differences and specific GI dysfunction, including feeding disorders and defecation disorders. However, this is the first study to potentially demonstrate that sensory processing differences may be found in a much broader and diverse population of pediatric GI patients and that presentation may be age and gender dependent. Therefore, this study contributes to the small but growing body of literature connecting the pediatric GI population with the broader population dealing with sensory processing dysfunctions. The results from this study contribute to the further understanding of occupation, specifically the connection between toileting issues and sensory processing dysfunction.

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