Differences in Function Among Children With Sensory Processing Disorders, Physical Disabilities, and Typical Development

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Purpose: To examine the capability and performance of children with sensory processing disorders (SPD) compared with children who are developing typically and those with physical disabilities (PD). **Methods:** Participants included parents/caregivers of 81 children ranging in age from 1 to 7.3 years; 57% were boys. The child's therapist interviewed the parents using the Pediatric Evaluation of Disability Inventory (PEDI) to measure functional performance. **Results:** Children with SPD demonstrated significant differences from children in the other groups in functional skills and caregiver assistance within 3 domains (self-care, mobility, social function). **Conclusions:** The PEDI can be used to (1) identify functional delays in young children with SPD, which can affect participation in age-appropriate self-care, mobility, and social skills, and (2) determine appropriate referrals for early intervention. **(Pediatr Phys Ther 2013;25:315–321)** *Key words: activities of daily living, child, child development, child development disorders, disability evaluation, female, male, motor skills disorders/diagnosis, neuropsychological tests, psychomotor disorders, sensory disorders*

INTRODUCTION

Children younger than 3 years who do not meet their motor milestones within the expected period are often referred for early intervention (EI) services. The referring diagnosis is typically "developmental delay." Infants initially diagnosed as developmentally delayed may be reclassified by the EI evaluation team to a diagnosis of a physical disability (PD)/central nervous system disorder, or a diagnosis related to a sensory processing disorder (SPD). Sensory processing disorder is the diagnostic term for children who have dysfunction in processing and using sensory information for behavior regulation, motor performance, and function.[1,2] It was first identified as a clinical condition by Jean Ayres in 1972 while studying children with learning disabilities.[1] Diagnoses associated with SPD include developmental coordination disorder, autism spectrum disorder (ASD), and attention deficit hyperactivity disorder.[2] Assessment results can be used to identify children who qualify for EI services as well as identify those whose primary delay in functional skills is related to SPD versus neuromotor impairments.

Studies that report prevalence of SPD show a variety of ranges for both children who are developing typically (DT) and those with autism or other developmental delay disorders. In one parent survey of kindergartners, 13.7% of the children were identified on the Short Sensory Profile as having SPD.[3] Other researchers revealed that 3.2% of children who were DT and 83.6% of those with autism demonstrated SPD on the basis of the Short Sensory Profile.[4] Baranek et al used a different measure, the Sensory Experiences Questionnaire, to compare children with autism, other developmental delays, and children who were DT.[5] They found that 39% of children with autism and 22% with other disorders showed a definite difference from children who were DT in overall sensory symptoms. The high

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prevalence of SPD illustrates the importance of identifying and appropriately diagnosing children with SPD.

Current assessments used to identify and classify children with SPD measure behavior in response to sensory processes. One measure often used in research is the Short Sensory Profile, a parent questionnaire.[6] This instrument is based on previously hypothesized sensory constructs and includes subtests related to oversensitivity of the tactile, taste/smell, movement, and auditory/visual systems. Additional subtests include auditory filtering and active and passive undersensitivity (sensation seeking and low energy/weak).[7] While these measures are appropriate for identifying and classifying children with SPD based on the sensory system, they are not practical for determining a child's daily functional skills capability or performance levels.

The 2009 revision of the Individual with Disabilities Education Act (IDEA) provides guidelines governing education and related services for children with special needs.[8] One component of the guidelines involves provision of related services in the child's natural home or school environments.[9] The IDEA addresses the need for assessment instruments to identify children who are eligible for EI. These instruments must effectively discriminate, predict, and evaluate children's function. The Pediatric Evaluation of Disability Inventory (PEDI) is one of the measures identified to meet the criteria as a discriminative, predictive, and evaluative measure.[10] This tool enables the therapist to determine the child's ability to function in a natural environment be it in the home, community, or school. The PEDI provides both norm-referenced discriminative and criterion-referenced evaluative scales.[11]

The IDEA requires a comprehensive assessment of the child's ability to perform and participate in a natural environment and in normal activities of daily living. This is consistent with the International Classification of Functioning, Disability and Health (ICF) model developed by the World Health Organization.[10] The ICF model is composed of 3 major components: body function and structure, activities (execution of task), and participation (life situations). The PEDI assesses children's capabilities and performance on the basis of ICF concepts.[12] Ostensjo et al conclude that the PEDI not only is conceptually congruent with the ICF model but also incorporates environmental factors into assessment of functional performance.[12]

Specifically, the PEDI is a measure of a child's functional performance within 3 domains: self-care, mobility, and social function. Each domain includes 2 scales; the *functional* scale based on scores without taking into account caregiver assistance and the *caregiver* assistance scale, which integrates the amount of caregiver assistance required to perform tasks. In addition, use of modifications may be necessary for performance of daily activities. Types of modifications can include child or rehabilitation equipment and extensive environmental adaptations. The functional skills scale measures capability (what the child can do in his/her environment), whereas the caregiver assistance scale measures performance of daily activities (what the child actually does).[13,14] Environmental factors may facilitate or challenge performance of activities of daily living.

Although research exists on identification and classification of children with SPD by assessing the sensory systems,[1,4,5] no studies could be found that focused on assessment of functional skill capability and performance to identify children with SPD. Research to date has not explored the effect of SPD on function. Proper functional skill assessment of children with SPD can assist in qualification and clinical decision-making for appropriate intervention.

The purpose of this study was to examine how the PEDI can be used to discriminate functional performance of children with SPD with respect to children with physical disorders or children who are DT and to understand the similarities and differences between each group. We sought to identify specific areas of functional delay and how early these delays can be detected using the PEDI. Assessing complex functional activities in 3 domains was hypothesized to reveal similarities and differences in capability and performance between young children with SPD and PD. The study is important to determine if functional delays in children with SPD can be identified early so that children may receive EI services.

METHODS

Participants

A power analysis was performed a priori to determine sample size. Using 0.90 power, 0.40 effect size, and 0.05 α level of significance, the minimal number of participants per group is 27. A purposive sample of convenience was used. Sampling continued until 27 children per group were examined. Parents/caregivers of 81 children were recruited from 6 clinics and surrounding communities by physical therapy clinicians and the primary investigator. The clinics included outpatient services at 2 hospitals and 4 private pediatric physical therapy practices. Inclusion criteria consisted of children between the ages of 1 and 7.5 years, who were DT (ie, no history of disability or major medical conditions) or having central nervous system dysfunction such as cerebral palsy, or SPD. Children were excluded if they had only vision or hearing deficits, or medical conditions without developmental delay.

The Institutional Review Boards at Western University of the Health Sciences and the 2 participating hospitals approved the study. The child's parent/caregiver signed an informed consent and the child signed an assent form if they were capable of understanding it.

Procedures

Children were assigned to 1 of 3 groups, those with primary SPD, those with PD/central nervous system disorders, and children who were DT. Two children in the SPD group were diagnosed by their physician as having ASD. No other diagnoses were indicated as either

primary or secondary disorders. Classifications of SPD and PD were based on the therapists' assessments. Measurement instruments commonly used at the clinics included Peabody Developmental Motor Scales-2, Bailey Scales of Infant Development-II/III, Bruininks-Oseretsky Test of Motor Proficiency-2, Short Sensory Profile, and Visual Motor Inventory. At least 1 standardized measurement instrument and clinical observations were used to determine whether children were given a primary diagnosis of PD or SPD. The most significant differentiating characteristics of children assigned to the SPD group were motor planning impairments and over-/underresponsiveness to environmental stimuli.

The investigators trained physical, occupational, and/or speech therapists at the clinics to administer the PEDI. The primary investigator was available by phone to answer questions related to specific test items. The therapists directly observed the children and conducted in-person interviews with the parent/caregivers. Interviews were conducted at the clinic or in the child's home. Interrater reliability tests were not conducted because research demonstrates that the instrument is highly reliable and valid.[15-18]

Instrumentation

The PEDI functional skills scale is scored 0 for unable to perform the task and 1 for capable of performing the task. The caregiver assistance scale is rated from 0 (maximal assist) to 5 (independent, no assistance). Items within each PEDI domain are grouped into complex functional activities consisting of (1) self-care: eating, grooming, bathing, dressing upper body, dressing lower body, toileting, bladder management, bowel management; (2) mobility: chair/toilet transfers, car transfers, bed mobility/transfers, tub transfers, indoor locomotion, outdoor locomotion, stairs; and (3) social function: functional comprehension, functional expression, joint problem solving, peer play, safety.[13] Complex functional activities were examined in this study to reveal similarities and differences in more specific tasks as well as overall domain scores among children with SPD, those who were DT, and those with PD.

The development edition of the PEDI reports 3 types of reliability as well as content, concurrent, and discriminative validity.[13,15,18] Using the interclass reliability coefficient (ICC), Berg et al[16] demonstrated high interrater and intrarater reliability (ICC = 0.95-0.99), as well as interrespondent reliability (ICCs ranging from 0.64 to 0.74). The test developers reported moderately high concurrent validity (r = 0.70-0.80) between PEDI scores and the Battelle Developmental Inventory Screening Test.[18] They also demonstrated that the PEDI is a better discriminator between children with and without disabilities than the Battelle Developmental Inventory Screening Test. Other researchers tested concurrent validity between the PEDI and Functional Independence Measure for Children (WeeFIM)[19] and Peabody Developmental Motor Scales.[17] The PEDI is reported to show a high correlation with the WeeFIM ($r = 0.88$)[19] and with the Peabody Developmental Motor Scales (r = 0.64-0.94),[17] excluding gross motor reflexes.

Data Analysis

Subject characteristics comprising categorical data were analyzed with a chi-square test; continuous data were analyzed using a 1-way analysis of variance (ANOVA) with the Tukey Highly Significant Difference (HSD) post hoc test. The PEDI includes a software program to calculate and convert raw scores into a normative standard (age-adjusted) scale and scaled Z scores (not age-adjusted). The Z scores were used primarily for between-group comparisons of functional skills and caregiver assistance scores. These results were compared with the normative standard scale results to reveal possible discrepancies related to age. Both were analyzed with an ANOVA and the Tukey post hoc test. Raw scores were grouped to comprise complex functional activities and were analyzed using age as a covariate with an ANOVA and Bonferroni adjustment for multiple comparisons.

RESULTS

Participants included 81 children between the ages of 1.3 and 7.3 years. Mean age in years was 3.98 (SD = 1.67), and 46 (56.8%) were males. No significant differences among groups for age, gender, race, and birth delivery method were shown; groups differed significantly ($P = .001$) with respect to birth weight and gestational age. Children with PD had lower birth weights and younger gestational ages than did children in the other groups. See Table 1 for participant characteristics.

The PEDI standard scores for functional skills and caregiver assistance in the 3 domains were compared among the groups. Analysis of variance revealed significant differences for the 6 sets of comparisons ($P = .001$ each). Tukey post hoc tests revealed children who were DT scored significantly higher in self-care functional skill and caregiver assistance scales than children in the SPD and PD groups. The SPD and PD groups did not differ significantly in self-care functional skills but did differ significantly in caregiver assistance. In the mobility domain, no significant differences in functional skills and caregiver assistance occurred between children in the SPD and DT groups. Both groups were significantly different from the PD group in both scales of the mobility domain. Children who were DT also scored significantly higher than children in the other 2 groups on both functional skill and caregiver assistance scales in the social function domain. No significant differences were found on the social function scales between the SPD and PD groups. See Table 2 for between-group post hoc comparisons.

Performance results were based on standard scores, which do not take into account the children's ages. When using the N-scale (age-adjusted), significant differences ($P = .001$) were found between the DT and SPD groups

TABLE 1

Mean (SD) or Number (%) of Child Characteristics by Group (N = 81)

Characteristic	Typical (n = 27)	Sensory (n = 27)	Physical (n = 27)	*P*
Age, y	4.29 (1.88)	3.66 (1.33)	3.99 (1.75)	.396
Range	1.3-7.3	1.6-6.4	1.3-7.3	
Gender, %				.703
Male	15 (32.6)	17 (37.0)	14 (30.4)	
Female	12 (34.3)	10 (28.6)	13 (37.1)	
Race, %				.103
Caucasian	11 (34.4)	14 (43.8)	7 (21.9)	
Hispanic	7 (22.6)	10 (32.3)	14 (45.2)	
Other	9 (50.0)	3 (16.7)	6 (33.3)	
Gestational age, wk	38.99 (1.04)	38.39 (2.23)	34.88 (5.93)	.001
Birth weight, g[a]	3465.3 (579.41)	3034.41 (636.63)	2443.66 (1170.26)	.001
Delivery method, %				.215
Vaginal	18 (41.9)	12 (27.9)	13 (30.2)	
C-section	9 (23.7)	15 (39.5)	14 (36.8)	

[a]N = 61 total, 20 typical, 21 sensory, 20 physical.

TABLE 2

Differences in Functional Skills and Caregiver Assistance Standard Scores Between Groups

	Sensory/Typical		Sensory/Physical		Typical/Physical	
Domain	Mean Difference	*P*[a]	Mean Difference	*P*[a]	Mean Difference	*P*[a]
Functional skills						
Self-care	14.87	.002[a]	9.19	.073	24.06	.001[a]
Mobility	9.29	.187	26.51	.001[a]	35.79	.001[a]
Social function	13.19	.002[a]	8.23	.085	21.41	.001[a]
Caregiver assistance						
Self-care	18.31	.001[a]	12.94	.028[a]	31.26	.001[a]
Mobility	11.87	.059	22.43	.001[a]	34.31	.001[a]
Social function	22.02	.001[a]	8.42	.305	30.44	.001[a]

[a]Tukey post hoc test significant at .05 level.

in mobility for both functional skills and caregiver assistance. Adjusting for age, no difference was found between SPD and PD groups in the amount of caregiver assistance required for self-care. All other comparisons using the N-scale revealed similar results to those using the standard Z-scale.

This study emphasized assessment of functional performance of children with SPD. A more in-depth investigation of complex functional activities was conducted. Using an analysis of covariance with age as a covariate, comparisons were made between the SPD and DT groups and between the SPD and PD groups in functional activities within each PEDI domain. Initial analysis of group comparisons showed a significant difference ($P = .001$) for all comparisons; that is, 8 activities in self-care domain, 7 in mobility, and 5 in social function.

Further analysis using a Bonferroni adjustment for multiple comparisons demonstrated that SPD and DT differed significantly in self-care (grooming, dressing upper body, bladder, and bowel; $P = .021$, .026, .008, and .013, respectively) and social function (peer play and safety; $P = 0.016$ and 0.001, respectively). See Tables 3 and 4. The 2 groups did not differ in any of the complex activities within the mobility domain (see Table 5). The results for the SPD and PD groups reveal significant differences in all complex activities in the mobility domain ($P = .001$). These groups differed significantly in 5 of 8 activities in the self-care domain (eating, grooming, bathing, dressing lower body, and toileting; $P = .001$, .016, .001, .001, and .001, respectively) and 3 of 5 activities in social function (expression, joint problem solving, peer play; $P = .001$, .023, and .033, respectively). See Tables 3 and 4.

DISCUSSION

In the 1960s, Jean Ayres described behavior patterns in school-aged children with learning disabilities. She identified immature behavior and motor patterns that interfered with the child's participation primarily in the school setting. These children demonstrated behaviors such as distress with face washing, bathing routines and dressing; they avoided jumping and climbing; exhibited an irrational fear of falling; were apt to be stubborn and uncooperative; and showed speech development problems that affected socialization.[20] Ayres related symptoms of sensory dysfunction to the child's daily tasks.[21] Even today, children diagnosed with SPD display these behaviors.

TABLE 3

Differences Between Groups in Age-Adjusted Self-Care Complex Functional Activities[a]

	Sensory/Typical			Sensory/Physical			Typical/Physical		
Activity	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b
Eating	−1.30	−3.03, 0.44	.212	2.57	0.85, 4.28	.001[c]	3.86	2.15, 5.58	.001[c]
Grooming	−1.93	−3.63, −0.23	.021[c]	1.98	0.29, 3.67	.016[c]	3.91	2.22, 5.60	.001[c]
Bathing	−1.32	−2.72, 0.07	.069	2.80	1.42, 4.18	.001[c]	4.12	2.74, 5.50	.001[c]
Dressing upper body	−1.75	−3.33, −0.16	.026[c]	1.44	−0.13, 3.01	.083	3.19	1.62, 4.76	.001[c]
Dressing lower body	−0.90	−2.37, 0.58	.423	2.36	0.90, 3.83	.001[c]	3.26	1.80, 4.72	.001[c]
Toileting	−0.58	−1.52, 0.36	.402	1.46	0.53, 2.39	.001[c]	2.04	1.11, 2.98	.001[c]
Bladder	−1.30	−2.31, −0.28	.008[c]	0.62	−1.63, 0.39	.406	1.92	0.91, 2.93	.001[c]
Bowel	−1.24	−2.27, −0.21	.013[c]	0.58	−0.44, 1.60	.513	1.82	0.80, 2.84	.001[c]

[a]Covariate value for age evaluated at 3.979.
[b]Bonferroni adjustment for multiple comparisons.
[c]Pairwise comparisons significant at .05 level.

TABLE 4

Differences Between Groups in Age-Adjusted Social Function Complex Functional Activities[a]

	Typical/Sensory			Sensory/Physical			Typical/Physical		
Activity	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b
Comprehension	−1.02	−2.60, 0.56	.356	1.56	1.01, 3.12	.052	2.58	1.01, 4.14	.001[c]
Expression	−0.95	−2.70, 0.80	.565	2.95	1.22, 4.68	.001[c]	3.90	2.17, 5.63	.001[c]
Joint problem solving	−1.27	−2.82, 0.28	.145	1.71	0.18, 3.25	.023[c]	2.98	1.45, 4.51	.001[c]
Peer play	−1.59	−3.00, −0.23	.016[c]	1.44	0.09, 2.79	.033[c]	3.03	1.68, 4.38	.001[c]
Safety	−4.64	−7.67, −1.60	.001[c]	2.93	−0.09, 5.94	.060	7.56	4.55, 10.57	.001[c]

[a]Covariate value for age evaluated at 3.979.
[b]Bonferroni adjustment for multiple comparisons.
[c]Pairwise comparisons significant at .05 level.

TABLE 5

Differences Between Groups in Age-Adjusted Mobility Complex Functional Activities[a]

	Sensory/Typical			Sensory/Physical			Typical/Physical		
Activity	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b	Mean Difference	95% CI	P^b
Chair/Toilet transfers	−0.30	−0.92, 1.51	1.000	3.35	2.14, 4.55	.001[c]	3.64	2.44, 4.84	.001[c]
Car transfers	−0.51	−1.40, 0.36	.457	1.64	0.77, 2.51	.001[c]	2.16	1.29, 3.03	.001[c]
Bed mobility transfers	0.07	−0.52, 0.65	1.000	1.13	0.55, 1.71	.001[c]	1.06	0.49, 1.64	.001[c]
Tub transfers	−0.16	−0.93, 0.62	1.000	1.69	0.92, 2.46	.001[c]	1.84	1.07, 2.61	.001[c]
Indoor locomotion	−0.30	−2.06, 1.45	1.000	4.76	3.03, 6.50	.001[c]	5.07	3.33, 6.80	.001[c]
Outdoor locomotion	−0.09	−2.09, 1.91	1.000	6.09	4.11, 8.08	.001[c]	6.18	4.20, 8.16	.001[c]
Stairs	−0.13	−1.69, 1.43	1.000	4.47	2.92, 6.01	.001[c]	4.59	3.05, 6.14	.001[c]

[a]Covariate value for age evaluated at 3.979.
[b]Bonferroni adjustment for multiple comparisons.
[c]Pairwise comparisons significant at .05 level.

Our intent was to investigate functional skills and amount of caregiver assistance in children between 1 and 7 years. We examined specific daily living skills to determine whether the SPD group's capability matched children DT and/or with PD. We also analyzed caregiver assistance scores to determine differences between the groups. An exhaustive search of the literature found few studies that investigated functional performance in young children (younger than 5 years) with SPD. One previous study that focused on functional performance was conducted on school-aged children with developmental coordination disorders.[22] A few researchers examined motor performance in children with ASD that included SPD.[23-25]

Our data revealed that the SPD group demonstrated lower performance in the self-care domain when compared with children who were DT. Children with SPD fell behind in self-care activities of grooming, dressing upper body, bowel, and bladder. These findings are similar to Ayres' observations of children with learning disabilities.[20] The SPD group did not differ significantly from children in the

PD group on 3 of these activities (dressing upper body, bowel, and bladder), suggesting that children with SPD have similar limitations in self-care capability as children with PD. Further investigation including item analyses of self-care issues for SPD and PD groups may demonstrate whether the limitations are sensory or motor driven.

Mobility performance was similar for the SPD and DT groups, except when scores were adjusted for age. Both groups differed significantly from the PD group in all complex functional activities; that is, chair/toilet transfers, car transfers, bed mobility/transfers, tub transfers, indoor and outdoor locomotion, and stairs. These findings are comparable to results of other studies, which indicated that children with autism might not demonstrate significant gross motor abnormalities early in life. Ozonoff et al[24] used home videos and 2 standardized tests to compare motor behaviors of children aged 24 to 61 months with autism, developmental delays, and those who were DT. Motor behaviors included supine, prone, roll, sit, crawl, and walk. Their findings were inconsistent with previous research and indicated that gross motor skills are not an early indicator of autism. Like our results, their investigation demonstrated no significant differences between children with autism and those who were DT and also showed that children with developmental delays exhibited more movement abnormalities than the other 2 groups.[24] The authors did note a pattern of slower motor development in the autism and developmental delay groups as compared with the children who were DT. When scores were adjusted for age, our data showed that younger children (3 years old) exhibited lower performance than the DT group but appeared to be at a similar level as they aged (>4.5 years). This suggests that younger children with SPD show more delay than children of the same age who are DT.

The PEDI domain of social function includes performance in language, cognitive skills, and social interaction. Children in the SPD group show less capability in social function than children who are DT, specifically in the areas of peer play and safety. Results show no difference between the SPD and PD groups in safety and comprehension. Much of the current research investigating language delay and behavioral issues appears to consist of case studies of children suspected of having autism. One case study described behaviors of a child diagnosed as having "mixed receptive and expressive language delay and disruptive behavior disorder with sensory processing problems."[26] Some of the behaviors exhibited by this 27-month-old child included difficulty with bathing and sleeping through the night, dislike of loud noises, difficulty expressing self and following commands, and preference to play with 1 child rather than in a group. The latter trait (peer play) is similar to our findings.

A unique feature of the PEDI is that it can be used to assess the level of caregiver assistance and number and types of modifications required for performance.[14] In our study, children with SPD were less independent; that is, they required more caregiver assistance with self-care skills than children who were DT, but less caregiver assistance than the PD group. The amount of caregiver assistance required for mobility by the SPD and DT groups were similar and significantly less than the amount required by the PD group. Differences in caregiver assistance in social function were significant only for the PD group, suggesting that these children were less independent than the DT and SPD groups. We were unable to locate previous studies that compared children with SPD to those with PD and those who were DT in the amount of caregiver assistance required to perform functional skills. With the need for caregiver assistance, children are reliant on others, which may limit their participation in age-appropriate activities. Additional research is needed to provide an in depth analysis of the amount of caregiver assistance and environmental modifications required for young children with sensory or physical disorders to perform daily functional activities.

Study Limitations

Children in the SPD and PD groups were recruited from clinics where they were receiving therapy interventions. Consequently, the effect of therapy on developmental levels may limit the generalizability of our results. Results may not apply to a similar population not receiving intervention or receiving different intensities of therapy. Often children with sensory processing problems are not identified early and therefore do not receive therapy until a later age. A second limitation of our study was the lack of clear criteria for diagnoses made by the therapists. Children were placed into groups depending upon the description provided by each therapist; that is, if sensory processing was the primary issue and developmental delay was secondary, they were placed in SPD group. Caution should be used when interpreting results of age-adjusted mobility scores because the distribution of ages for SPD and DT groups was not equal.

CONCLUSIONS

Children with SPD exhibit sensory impairments, social issues, and slower development of mobility skills. The PEDI can be used to assess the effect of those impairments on the child's participation in age appropriate self-care, mobility, and social skills and can be used to qualify them for intervention. Further research to investigate and track progress in functional skills in older children with SPD is recommended.

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