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Comparing Predictive Effects of Sensory Processing and Executive Functions on Self-care Activities in Pre-school Children with Autism Spectrum Disorder

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Abstract

Background: Children with autism spectrum disorder (ASD) face some challenges with performing self-care. Many performance components, including sensory and cognitive functions, are effective in performing self-care.
Objectives: This study aimed to compare the role of sensory processing and executive functions in performing self-care among preschool children with ASD.
Methods: In this cross-sectional study, 70 children with ASD aged 3-6 years were selected and investigated by adopting convenience sampling. The instruments included the Short Sensory Profile-2 (SSP-2), Behavior Rating Inventory of Executive Function (BRIEF), and Pediatric Evaluation of Disability Inventory (PEDI). The data were analyzed using Pearson correlation and linear regression tests.
Results: The results of the correlation revealed that executive functions ($P \leq 0.01$) and sensory processing ($P \leq 0.005$) had a small yet significant inverse relationship with performing self-care activities. The results of stepwise linear regression showed that executive functions and sensory processing were equally capable of predicting self-care activities.
Conclusions: It was recommended that therapists should pay enough attention to both executive functions and sensory processing in order to solve the self-care problems of preschool children with ASD. Due to the low correlation between variables, it was also suggested that a multifactorial approach to self-care activities should be employed as well as the role of other factors along with sensory processing and executive function should be considered.

Keywords: Autism, Self-care, Sensory Processing, Executive Functions

1. Background

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by the presence of persistent deficits in social communication and interaction as well as by restricted and repetitive behavior (1). The global prevalence of ASD has been increasing over the past years, and it was estimated to be at least 1.5% in 2017 (2). These children have significant problems with self-care activities, such as personal hygiene, toileting, and eating (3). Self-care can play an important role in people's independence. These activities are included in the category of "basic activities of daily living" in occupational therapy, and "adaptive behaviors" or "daily living skills" in psychology. Therefore, this area accounts for a significant portion of rehabilitation interventions.

There is abundant evidence suggesting that several performance components (e.g., sensory processing and executive functions) affect self-care activities (4-6). Sensory processing and executive functions are regarded as the lower level and higher levels of the central nervous system (CNS), respectively (7).

Sensory processing refers to receiving, modulating, integrating, and organizing sensory inputs that can affect behavioral responses to sensory stimuli and overshadow adaptive behaviors (8). Sensory problems in children with ASD include intolerance of new sensory experiences, sensory avoidance, overexposure to sound and touch, sensory seeking, hypo-, and hyper-responsivity to sensory stimuli (9). Self-care activities, such as grooming, oral health care, hair and nail trimming, bathing, eating, dressing, and toileting, can be affected by sensory processing problems in children with ASD (10).

At the higher levels of the CNS, cognitive factors may also affect the self-care activities. One of the three cognitive theories proposed in ASD is the theory of executive dysfunction. Executive functions is an umbrella term for high-level cognitive skills and activities like the executive director of the brain (11). These critical cognitive functions can affect the participation in activities, playing roles, social life, independence, and quality of life (12). Common prob-

lems in children with ASD in executive functions include impaired attention, inhibition, working memory, flexibility, and planning. Some skills of executive functions, such as planning, inhibition, flexibility, and problem-solving, are important skills that can affect performing self-care activities (11).

A review of the literature on these areas showed that some studies on the relationship between the above-mentioned factors and self-care activities in ASD had investigated individuals at different age groups from early childhood to adolescent and higher. Regarding the relationship between sensory processing and self-care activities in children with ASD, Dellapiazza et al. conducted a systematic review of 11 studies on individuals aged 2 - 18 years (13), and Baker et al. carried out a study on children aged 2 - 8 years (14), and found a moderate correlation between these two variables. Kojovic et al. also examined children aged 3-6 years and discovered a weak correlation (15), and Lane et al. suggested that sensory processing was not able to predict self-care activities in children aged 3 - 9.5 years (16). Regarding the relationship between executive functions and self-care activities in these children, the study by Peterson et al. found a weak to moderate relationship in the 4 - 19 age group (17), and the study by Tsermentseli et al. found no relationship in the 6 - 16 age group (18). Zingerevich and Patricia D compared these two factors and indicated that executive functions may have had a greater impact than sensory processing when investigating school participation (e.g., self-care activities at school) of children with ASD (12).

Given the different age groups and inconsistency in the findings of the current studies, it is not possible to judge the effects of sensory processing and executive functions on the self-care of children with ASD in early childhood. Our recent study showed that the mean of minimum age in children with ASD referred to rehabilitation was about three years (19). It is important to consider the early childhood as a critical stage in which health professionals can make early intervention and prevent the secondary effects of the disorder. On the other hand, as Ben-Sasson et al. argue in their meta-analysis, the complexities of ASD, especially in the field of sensory processing, are so great that the findings of large age groups seem unreliable scientifically, and it is better to study this disorder in narrower age groups (9).

Today, ASD is diagnosed at a younger age, and early intervention is necessary. The sensory-based treatment approaches are the most widely-used therapies in ASD, but they fail to promote participation in life situations due to low-to-moderate evidence (20, 21). Despite the fact that several studies have explored the effectiveness of cognitive interventions in ASD, moreover, the uncertainty about the generalizability of the results still exists for various reasons, especially due to the different cognitive profiles of these people (22). Self-care is a multifactorial life area that the child is involved in from the first days of his/her life. Identification of the factors affecting it in early childhood can greatly contribute to prioritizing the treatment and early intervention. The previous studies on the role of sensory processing and executive functions in self-care activities mostly focus on the children aged 6 or over (i.e., middle and late childhood), and their results are also contradictory (16, 18, 21, 23). To the best of our knowledge, no study has compared the predictive effects of sensory processing and executive functions on performing self-care activities.

2. Objectives

This study aimed to determine the extent to which sensory processing and executive functions contribute to self-care abilities of children with ASD aged 3 - 6 years.

3. Methods

3.1. Subjects

In this descriptive-analytical and cross-sectional study, a total of 75 children were initially selected between August 2020 and July 2021 by adopting convenience sampling, of who five children were excluded due to their failure or their parents' failure to complete the questionnaires, and only 70 children were investigated. The inclusion criteria were children aged 3 - 6 years and those diagnosed with ASD by a psychiatrist and through the Gilliam Autism Rating Scale-3 (GARS-3). The exclusion criteria were comorbidities, including intellectual developmental disorder, attention deficit/hyperactivity disorder, developmental coordination disorder, anxiety disorders, and depressive disorders. A written informed consent form was obtained from the parents to ensure their consent to include their children in the study.

3.2. Instruments

3.2.1. Demographic Questionnaire

This researcher-made questionnaire included items, such as age, sex, parents' educational level, as well as the child's history of medication and rehabilitation.

3.2.2. Gilliam Autism Rating Scale-3

The Gilliam Autism Rating Scale-3 (GARS-3) consists 56 questions and is scored by 4-point Likert scale. It has six subscales that inquire about the repetitive/restrictive behaviors, social interactions, emotional responses, social communication, cognitive style, and maladaptive speech

scales. All scales have shown high validity and reliability in the psychometric studies (24). The Cronbach's alpha coefficients of Persian version is 0.95, and the range of correlation coefficients is from 0.37 to 0.80 (25).

3.2.3. Short Sensory Profile-2 (SSP-2)

This parent-report assessment tool contains 34 items and is scored by a 6-point Likert scale (i.e., almost always, frequently, half of the time, occasionally, almost never, and not applicable). Internal consistency in the original version was 0.95 - 0.98, and Cronbach's alpha coefficient was 0.94 - 0.96 (26). In psychometrics of the Persian version of this tool, the range of internal correlation coefficients for test-retest reliability was 0.72 - 0.95, and Cronbach's alpha coefficients was 0.61 - 0.91 (27).

3.2.4. Behavior Rating Inventory of Executive Functions (BRIEF)-Pre-school Version

This tool containing five scales and 63 items, was completed by parents. In this study, the composite score (i.e., sum of the scales scores) was used. The scoring is a 3-point Likert scale (i.e., never, occasionally, and often). The Cronbach's alpha coefficient of the original version was between 0.82 - 0.98 (28). The Persian version of this questionnaire has a good match in terms of cultural and face validity. Content Validity of the Persian Version has shown that almost all items of the questionnaire achieve content validity score of over 0.79 (29).

3.2.5. Pediatric Evaluation of Disability Inventory

The Pediatric Evaluation of Disability Inventory (PEDI) includes the functional skills, caregiver assistance, and modification scale. The functional skills scale includes three domains: self-care, mobility, and social functioning. In this study, the self-care domain of functional skills scale was used. This domain contains 73 items, and each item is scored as '0 = unable' or '1 = capable', thus, the range of change in scores is 0 - 73, and a higher score indicates more independence in performing self-care. Intraclass Correlation Coefficients of the original version was 0.95 - 0.99 (30), and Cronbach's alpha was found to be high (0.94 - 0.98). The results of test-retest reliability of the functional skills and caregiver assistance scale were 0.96, modification scale in self-care and social performance (0.99,1), and good in mobility dimension 0.66 (31).

3.3. Procedure

Sampling was performed in the pediatric rehabilitation centers in 2021, Tehran. After reviewing the sampling criteria, the purpose and method of the study were explained to the parents of children with ASD. The demographic questionnaire, PEDI, SSP2, and BRIEF were completed by the parents when the children were brought to the clinic to receive rehabilitation services. According to the inclusion criteria concerning the age, some of these children were newly diagnosed and had not started rehabilitation, and some had been receiving rehabilitation (Table 1). Since the questionnaires were somewhat lengthy and time-consuming, some parents completed them in two shifts when they attended the clinics. The questionnaires were completed in the presence of the researcher providing the parents with the necessary explanation to remove the ambiguity in the questions. According to the BRIEF administration instructions, moreover, the two scales of inconsistency and negativity had to be calculated because the subject had to be excluded if the desired score was not obtained; in the present study, however, no sample was excluded for this reason.

Table 1. Demographic and Clinical Characteristics of the Subjects (n = 70)

Demographic Variables	No. (%)
Sex	
Female	23 (32.9)
Male	47 (67.1)
Severity level of autism disorder	
1	26 (37.1)
2	32 (45.7)
3	12 (17.1)
Parents' educational level	
High school	12 (17.2)
Diploma	15 (21.4)
Bachelor	24 (34.3)
Bachelor's degree	19 (27.1)
History of Rehabilitation	
Yes	57 (81.4)
No	13 (18.6)
History of drug use	
Yes	26 (37.1)
No	44 (62.9)

3.4. Statistical Analysis

In order to calculate the sample size using Green's (1991) rule, the sample size had to be equal to or more than 66 with medium effect size while there were two variables based on $N \geq 8k + 50$ formula (32). Therefore, the sample size was considered to include at least 70 subjects.

Statistical analysis was performed using SPSS® Version 18 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine the normality of the variables. Pearson correlation test was carried out to investigate the relationship between sensory processing/executive functions and self-care activities. Significant variables in Pearson correlation were entered into multiple linear regression analysis and enter and stepwise method. Adjusted R^2 was used to determine the variance of Self-care performance. P-value of 0.05 was considered statistically significant.

4. Results

Table 1 shows the descriptive characteristics of 70 children with autism and aged 3 - 6 years (mean ± SD: 4.75 ± 0.954) in this study. Majority of these children had received rehabilitation services, and 26 of them received the medication.

According to the descriptive statistics, the mean ± standard deviations of independent variables for sensory processing and executive functions were 72.10 ± 22.48 and 117.47 ± 23.68, respectively, and that for self-care as the dependent variable was 47.41 ± 13.29.

Correlation analysis through Pearson correlation coefficient revealed that executive functions (r = -0.3, P = 0.011) and sensory processing (r = -0.3, P = 0.010) had a significant inverse correlation with self-care activities in children with ASD. Since BRIEF and SP measure impairment, a lower score achieved by them is indicative of less impairment in executive and sensory functioning. In contrast, PEDI assesses child's skills so that a higher score in the PEDI is suggestive of a higher ability in self-care. Therefore, the significant inverse correlation here means that good sensory processing and executive functions contribute to ability and independence in self-care.

The sensory processing and executive functions were independent variables for linear regression analysis with enter method (Table 2). The multiple regression (R) was 0. 164, and the adjusted R^2 was 16.4% ($F[2,67] = 6.57$ P = 0.002). The enter regression model was as follows: PEDI = 79.480 - 0.16 (BRIEF) – 0.174 (SSP), which revealed that both executive functions and sensory processing had the potential to predict the self-care in ASD. In order to find the best model by using stepwise regression, the two independent variables of executive functions and sensory processing were incorporated into regression model step-by-step to construct the final regression model. In this method, potential explanatory variables are added to or removed from the model consecutively, and the statistical significance is analyzed after each repetition.

Analysis of stepwise linear regression with significant variables showed that the effects of executive functions and sensory processing on the model were significant ($P \leq 0.05$). Since the T values were almost equal, it was determined that these two variables were equally capable of predicting self-care activities. As shown in Table 3, the explanatory contributions of each variable indicated by the standardized coefficients were almost equal.

5. Discussion

This study aimed to compare the predictive effects of sensory processing and executive functions on self-care activities in children with ASD and aged 3 - 6 years. To be more precise, this study aimed to determine the extent to which these two variables influenced self-care in ASD pre-school children. The results showed that both variables had weak correlation with the self-care rate of children with ASD. In the following section, these connections are first discussed separately, and then are compared with each other.

The results showed that sensory processing in children with ASD was weakly associated with self-care activities, which was consistent with the results of the study by Kojovic et al. exploring the same age group (15). In the study by Baker et al., however, this relationship was reported to be moderate, which may have been due to the higher age range of the participants (2 - 8 years) (14). According to a systematic review performed by Dellapiazza et al., 11 studies investigating children with ASD and aged 2 - 18 year revealed a moderate relationship between sensory processing and self-care activities (13). According to our findings and the results from these studies, it was determined that this relationship was likely poor at a younger age, but it was a relatively moderate relationship at an older age, which may have been attributed to the fact that sensory stimuli are managed by parents at an organized home environment when children with ASD attempt to perform self-care in the pre-school ages. Upon entering the school, children are expected to perform independent self-care – in other words, to manage the situation by himself/herself. On the other hand, children are exposed to more diverse self-care activities (33) and sensory experiences in an environment other than home environment. Therefore, it seems that sensory processing plays more prominent role in the activities of elementary school children compared to preschool children.

Our study findings also demonstrated that the executive functions in children with ASD was poorly associated with self-care ability and may have predicted the child's ability to perform self-care activities, which was suggestive of the fact that the independence in performing self-care activities is promoted to some extent if the child's ability

Table 2. Linear Regression Analysis of Self-care Level

Model	Non-standard Correlation		Standard Correlation	*t*	P-Value
	B	SD	Beta		
	79.480	9.099		8.735	0.000
Sensory processing	-0.174	-0.072	-0.273	-2.427	0.018
Executive functions	-0.161	0.068	-0.266	-2.367	0.021

Table 3. Analysis of Stepwise Linear Regression for Self-care

	Model	Non-standard Coefficients		Standard Coefficients	*t*	P-Value
		B	SD	Beta		
1	Constant	62.094	5.547		11.195	0.000
	Sensory processing	-0.195	0.073	0.307	-2.657	0.001
2	Constant	77.480	9.099		8.735	0.000
	Sensory processing	-0.174	0.072	-0.273	-2.427	0.018
	Executive functions	-0.161	0.068	-0.266	-2.367	.021

in carrying out executive functions is increased. This association, according to Gardiner and Iarocci, was strong in middle and late childhood stages (23). Furthermore, the study by Rosenthal et al. showed that the problems of executive functions in children aged 5 - 18 years, as well as the rate of involvement in self-care activities, were increased by age (33, 34). Therefore, it can be argued that an increasing trend emerges from a very young age (i.e., three years onwards) in terms of executive function problems, which may have a greater impact on self-care ability as the age increases.

Taking into account the finding, it was recommended that various factors affecting self-care activities should be determined at a younger age. IQ, for example, plays a key role in the self-care of children with ASD. It should be noted that low IQ in ASD is not necessarily a sign of intellectual developmental disorder, but it is, in this context, only suggestive of intellectual impairment. As Gardiner and Iarocci argued, there was a strong association between executive functions and self-care from middle childhood to adolescence among children with ASD and with an IQ above 85 (23). In the study by Tsermentseli et al. investigating the subjects falling in the same age range and with IQ below 70, however, it was found that executive functions were not associated with self-care. Other studies have also found the role of IQ in increasing the child's ability to develop the adaptive behaviors (18). In the present study, about 83% of the samples were at severity levels 1 and 2, and probably had moderate and higher IQ (Table 1). Therefore, it was argued that IQ was less likely a confounding factor and barrier to show the effect of executive functions on self-care in this study.

This study mainly aimed to compare the contributions of sensory processing and executive functions to self-care activities in children with ASD. The findings showed that executive functions and sensory processing were equally capable of predicting self-care activities. The study by Zingerevich and Patricia D was the only study investigating the children with ASD as well as the effects of executive functions and sensory processing on the participation in school activities among primary school children by using the School Function Assessment (SFA), part of which was self-care at school (12). Contrary to our findings, their results showed that executive functions, compared to sensory processing, may have predicted greater participation in school activities. Predictability in their study was higher than that in our study, which may have attributable to the fact that the child's self-care activities in pre-school ages are performed at home and guided by parents, but these activities are performed by the child him/herself at school environment where more executive function abilities are required. Therefore, the effect of executive functions on these activities was more pronounced. In addition, the dependent variable in their study was 'participation', that is a higher-level concept than 'performance' assessed in our study. A student needs more self-direction and executive functions for participating in self-care activities than for performing a skill as a small part of participation in an activity (the PEDI assesses functional skills in performing self-care).

Despite the fact that the sensory processing approach was the most widely adopted treatment approach for chil-

dren with ASD worldwide at the time of our study (19), it was recommended that the possibility of several factors in addition to sensory processing and executive functions should also be considered when examining self-care abilities of these children. The factors such as age, autism severity, IQ, family-related variables (e.g., the number of siblings or the amount of support in self-care), and environmental factors may influence a child's adaptive behaviors, including self-care (35). Taking into account our study findings, it was also suggested that the role of sensory and cognitive factors in performing self-care activities should not be overlooked because the cumulative effect of these factors ultimately leads to low participation of children with ASD in everyday activities. This implies that when the goal of the rehabilitation is to promote self-care abilities in children with ASD, a bottom-up approach can be employed to enhancing sensory processing and executive functions (as performance components) although a top-down approach including environmental adaptations, task modifications, or behavioral interventions might contribute to achieving therapeutic goals in the given regard more quickly.

This study faced few limitations. First, it was difficult to find and collect the required subjects for this study since it was conducted during the outbreak of COVID-19. Therefore, it is recommended that further studies should be conducted to develop more effective treatment strategies by considering all factors (e.g., environmental and cultural factors) involved in self-care activities. It was also suggested that longitudinal follow-up studies should be carried out in order to examine the changes in the impacts of factors on sample groups with higher age ranges. As for the sampling method and sample size, it was recommended that our study findings should be generalized cautiously.

5.1. Conclusions

In sum, there was a relationship between sensory processing/executive functions and self-care activities in children with ASD, so these two variables may have equally predicted self-care abilities. Therefore, early assessment and intervention in the field of sensory deficits and executive dysfunction may have facilitated promoting the independence in self-care and reducing long-term disabilities. It was recommended that scientific therapeutic reasoning should be used to accurately recognize the contribution of sensory and cognitive therapy approaches to treating children with ASD at different ages.

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Footnotes

Authors' Contribution: The study supervision: SKS; Concept and design: SKS, SFH, and MA; Gathering data SFH; Analysis and interpretation of data: MA; Drafting of the manuscript: SFH and SKS; Edition and critical revision of the manuscript: SKS, MA, and SFH.

Conflict of Interests: This study was extracted from a master's thesis in occupational therapy and supported scientifically by Iran University of Medical Sciences. The authors included the student, supervisor, and advisor of this thesis. There was no financial interference from any organization/institution or personal financial interest. The authors declare that they have no conflict of interests in reporting the results of this study. They also declare that two of the authors (second and third authors) cooperate with the editorial board as reviewers. However, the journal has confirmed that the given authors with CoI were completely excluded from all review processes. These authors were introduced to CoI during the submission as opposed reviewers.

Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after its publication. The data are not publicly available due to privacy.

Ethical Approval: This study was approved under the ethical approval code of IR.IUMS.REC.1398.1340. Link: ethics.research.ac.ir/EthicsProposalView.php?id=123540.

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