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Araştırma Makalesi

Sensory-Motor-Cognitive Functions in Preschool Children with Autism Spectrum Disorder

Okulöncesi Otizm Spektrum Bozukluğu Olan Çocuklarda Duyu-Motor-Biliş Fonksiyonları

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ABSTRACT

Purpose: The aim of this study was to explore the relation between sensory, motor and nonverbal cognitive functions of children with Autism Spectrum Disorder (ASD). The study also aimed to explore whether these functions vary according to the autism severity. **Material and Methods:** The study included 30 children with ASD, 4-6 years. The Gilliam Autistic Disorders Rating Scale–2 Turkish Version (GARS-2-TV) for evaluating the autism severity, Sensory Profile (SP) for evaluating sensorial issues, Bruininks-Oseretsky Test of Motor Proficiency–2 Short Form (BOT-2) for measuring motor profile, and Primary Test of Nonverbal Intelligence (PTONI) for evaluating cognitive functions were used in this study. **Results:** The results showed that children with ASD displayed atypical sensory responses, lower cognitive and motor performances. The BOT-2 category was determined as “below average” and “well-below average” in 96.6% of the children with ASD. A moderate negative correlation was determined between the BOT-2 and GARS-2 (r = -.587) and PTONI and GARS-2 (r = -.402), and a moderate positive correlation was determined between the BOT-2 and PTONI (r = .442). Motor (39%) and IQ scores (27%) were differentiated according to the autism severity. **Discussion:** Owing to impairments in the sensory-motor-cognitive functions of the children, “individual education programs” should not focus only the core deficits of ASD, but they should also involve sensory-motor intervention in preschool period.

Key Words: Autism; Motor skills; Sensory disorders; Intelligence

ÖZ

Amaç: Araştırmanın amacı okulöncesi otizm spektrum bozukluğu (OSB) olan çocukların duyu, motor ve sözel olmayan bilişsel işlevleri arasındaki ilişkiyi incelemek ve otizmden etkilenme derecesine göre bu işlevlerin farklılaşıp farklılaşmadığını keşfetmektir. **Gereç ve Yöntem:** Çalışmaya 4-6 yaş 30 OSB’li çocuk dahil edilmiştir. Bu çalışmada otizm şiddetini değerlendirmek için Gilliam Otistik Bozukluk Derecelendirme Ölçeği 2 – Türkçe Versiyonu (GOBDÖ-2-TV), duyusal sorunları değerlendirmek için Duyu Profili (DP), motor profili ölçmek için Bruininks-Oseretsky Motor Yeterlik Testi 2-Kısa Form (BOMYT-2) ve bilişsel işlevleri değerlendirmek için Okulöncesi Sözel Olmayan Zekâ Testi (OSOZT) kullanılmıştır. **Sonuçlar:** Okulöncesi OSB’li çocukların atipik duyusal yanıtlar sergilediği, sözel olmayan biliş ve motor performanslarının düşük olduğunu göstermiştir. OSB’li çocukların % 96.6’sının BOMYT-2 kategorilerine göre ortalamanın altı ve oldukça altında olduğu tespit edilmiştir. BOMYT-2 ve GOBDÖ-2-TV arasında orta düzey negatif ilişki (r = -.587), OSOZT ve GOBDÖ-2-TV arasında orta düzey negatif ilişki (r = -.402) ve BOMYT-2 ve OSOZT arasında orta düzey pozitif ilişki (r = .442) tespit edilmiştir. Otizmden etkilenme derecesine göre motor performans % 39 ve sözel olmayan işlevler % 27 farklılaşmıştır. **Tartışma:** OSB’li çocukların duyu-motor-bilişsel işlevlerindeki yaygın bozukluğa rağmen, bireysel eğitim programları OSB’nin temel yetersizliklerine sadece odaklanmamalı, okulöncesi dönemde duyu-motor temelli müdahaleleri de kapsamalıdır.

Anahtar kelimeler: Otizm; Motor beceriler; Duyu bozuklukları; Zeka.

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Children with autism spectrum disorder (ASD) are characterized as having limitations in social communication and interactions, as well as restricted, repetitive patterns of behaviour, and interests (American Psychiatric Association, 2013). Although several studies in literature have determined some deficits and disorders in fundamental motor skills of children with ASD (Dewey, Cantell, & Crawford, 2007; Ghaziuddin & Butler, 1998; Green et al., 2002; Green et al., 2009; Hilton et al., 2007; Leonard et al., 2014; Matson, Mahan, Fodstad, Hess, & Neal, 2010), these motor dysfunctions are not considered as one of the core deficits of ASD (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Hilton, Zhang, Whilte, Klohr, & Constantino, 2012; Mosconi & Sweeney, 2015; Staples & Reid, 2010).

In the current version of the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5; APA, 2013), there are two main deficit areas in ASD, namely, “social interactions-communications” and “restricted, repetitive patterns of behaviour, and interests”. On the other hand, DSM-5 includes a new symptom of “hyper or hypo activity to sensory input or unusual interest in sensory aspects of the environment” under the restricted, repetitive patterns of behaviour and also the new diagnostic system includes only one category as ASD instead of the subcategories in DSM-4 such as Autistic Disorder, Asperger Disorder, and Childhood Disintegrative Disorder (APA, 2013). Thus, both clinicians and researchers have come across with children with ASD, who are more heterogeneous in terms of sensory profile as well as social-communication and interaction, and behaviours. Sensory activity is associated not only with social-communication functions, which are required for several skills such as coordinating non-verbal and verbal language, posture, facial gesture, eye contact, interpreting others’ behaviour and responding appropriately etc. but also motor skills and coordination (Hannant, Tavassoli, & Cassidy, 2016). Sensory functions are also essential to display a motor skill during stages of the idea, planning, and organisation of movements (Hannant, Tavassoli, & Cassidy, 2016). In addition, some gross and fine motor skills need sensory information from the internal and external body, to be able to make adjustments in initiation, timing, direction, and speed of a voluntary movement (Rinner, 2002).

Although motor development has impacts on social, communication, and cognitive areas in the first years of life and previous studies have shown that motor delay is associated with poor language (Dziuk et al., 2007; Iverson, 2010) and cognitive development (Lee, Lambert, Wittich, Kehayia, & Park, 2016; Leonard et al., 2014) during preschool ages, DSM-5 does not highlight the condition of motor deficit in children with ASD owing to the absence of motor impairment criteria (Bo, Lee, Colbert, & Shen, 2016). This under-estimated deficit reduces the awareness of specialists such as physical therapists about the necessity of early motor intervention for children with ASD (Bo, Lee, Colbert, & Shen, 2016; Downey & Rapport, 2012). A recent systematic review and meta-analysis (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010) reported that individuals with ASD show motor impairment when compared to control groups and the diagnostic group are poorly coordinated and display less motor capability in terms of movement preparation, upper limb motor function, gait, and balance. In the same study, an analysis of the influence of IQ on motor function in ASD was not possible owing to lack of specific information regarding IQ scores and also many studies in the meta-analysis included only participants with ASD with IQ>70. However, cognitive impairment and distribution of IQ scores in ASD have been widely reported (Bishop, Farmer, & Thurm, 2015). According to the Center for Disease Control and Prevention (CDC), 31.6% of children with ASD were classified (IQ≤70) in the range of intellectual disability (CDC, 2016), and lower cognitive and sensory performance in ASD is able to affect gross and fine motor skills (Green et al., 2009; Whyatt & Craig, 2013) due to mutual and parallel development of the cognition and motor ability (Iverson, 2010). Motor ability may also be associated with severity level in autism core symptoms and some studies have drawn attention to this relationship (Hellendoorn et al., 2015; Hilton et al., 2007; Leonard, Bedford, Pickles, Hill, & Team, 2015).

If the motor dysfunction is not treated in the preschool period, these issues will continue into adolescence and adulthood, resulting in chronic movement dysfunction, lack of independence and behavioural issues in individuals with ASD (Bo, Lee, Colbert, & Shen, 2016; Downey & Rapport, 2012; Mattard-Labrecque, Ben Amor, & Couture, 2013; Van Waelvelde, Oostra, Dewitte, Van Den Broeck, & Jongmans, 2010). Therefore, to understand and focus on all developmental issues of children with ASD, gross and fine motor difficulties have become a crucial condition (Bo, Lee, Colbert, & Shen, 2016). Several studies have explored sensory profile and motor skills of school-age children and teenagers with ASD within a subcategory and a wide age range before DSM-5 (Dewey et al., 2007; Dziuk et al., 2007; Ghaziuddin & Butler, 1998; Green et al., 2002; Green et al., 2009; Hilton et al., 2007; Jansiewicz et al., 2006; Kopp, Beckung, & Gillberg, 2010; Hilton, Zhang, Whilte, Klohr, Constantino, 2012; Liu, 2013; Mandelbaum et al., 2006; Manjiviona & Prior, 1995; Page & Bouchert, 1998; Staples & Reid, 2010; Travers, Powell, Klinger, & Klinger, 2013; Whyatt & Craig, 2012), but there are few studies in literature after DSM-5 (Hellendoorn et al., 2015; Leonard et al., 2014) which have investigated the sensory-motor-cognitive functions only in preschool children with ASD as a more heterogenic profile.

It is needed to add some new findings and evidence from evaluation studies to reach a better understanding of the relation between the sensory, motor, and cognitive functions of children with ASD within the preschool age range and to provide implications for the development of a comprehensive individual education program. Therefore, the purpose of this study was to investigate the relation among sensory responses, motor skills and nonverbal cognitive functions of preschool children with ASD. It was also aimed to explore whether the sensory-motor-cognitive functions of children with ASD are differentiated according to the autism severity.

MATERIAL AND METHODS

Children with ASD of preschool age between 4-6 years (n=30) were recruited from a university research institute for individuals with disability to participate in the present study (Table 1). The inclusion criteria for these study participants was a diagnosis of ASD identified by a licensed physician (i.e. a child psychiatrist or neurologist) based on clinical judgment and DSM V criteria (APA, 2013). Exclusion criteria were the presence of neurological disorders such as seizures, tumours, traumatic brain injury, lesions, or chronic medical conditions such as cardiopulmonary diseases, Rett syndrome, genetic disorders such as fragile x syndrome, or physical, visual and hearing impairments. Approval for the study was granted by the Ethics Committee of the University. Written informed consent was obtained from the parents of all the participants in compliance with the Declaration of Helsinki.

Table 1 Characteristics of participants

	n (30)	%	Mean (SD)	Range
Gender				
Male	26	86.7	-	-
Female	4	13.3	-	-
Chronological age (months)			58.6 (8.2)	48-75
Height (cm)			107.6 (8.9)	85-128
Weight (kg)			20.1 (3.3)	16-30
Drug use	9	27.0	-	-
Special Education Duration (months)		100	23.2 (13.2)	5-58
Kindergarten Duration (months)	27	76.7	19.6 (11.6)	6-41
Siblings				
None	16	53.3	-	-
Being	14	46.7	-	-
Disabled	2	6.7	-	-
ASD Severity (GARS-2)	30	-	84.9 (11.7)	73-118

The Turkish version of the Gilliam Autism Rating Scale 2nd Edition (GARS-2) was used to describe the characteristic behaviours of children with ASD in the present study (Diken, Ardıç, & Diken, 2011). GARS-2 is a norm-referenced instrument, which includes 42 items and is categorized into three subscales (social interaction, communication, and repetitive behaviours). An Autism index of 85 or higher means that it is "very likely", 70-84 "possible", and 69 or lower "unlikely" that the individual has autism (Gilliam, 2005). Internal consistency of the GARS-2 estimated by Cronbach's α, ranged from 0.77 to 0.88 for subscale, and test-retest reliability of all subsections of GARS-2 which indicated (>.98) excellent (Diken, Ardıç, & Diken, 2011).

The Turkish version of the Sensory Profile (SP) was utilized to evaluate the sensory processing abilities of children with ASD in this study (Kayihan et al., 2015). The SP includes 125 items for children aged 3-10 years, and is completed by a caregiver or a specialist who knows the information and has observed the child. SP measures sensory processing, modulation, behavioural and emotional responses (Dunn, 1999). Internal consistency of the SP estimated by Cronbach's α, ranged from 0.63 to 0.97 for subscale, and test-retest reliability of all subsections of SP which indicated excellent (>.90) in the Turkish version of the SP (Kayihan et al., 2015).

The Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) Short Form was utilized to assess gross and fine motor skills of the children with ASD in this study (Bruininks & Bruininks, 2005). The BOT-2 Short Form evaluates the motor proficiency of children and young adults (age range from 4:0 to 21:11 years/months). BOT-2 Short Form consists of eight subtests (fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper limb coordination, strength) and each subtest has at least one item from each subtest and contains 14 items. Internal consistency of the BOT-2 Short Form estimated by Cronbach's α, ranged from 0.82 to 0.87, and test-retest reliability of all subtests of BOT-2 Short Form was determined as from 0.80 to 0.87 for different age groups (Bruininks & Bruininks, 2005).

The Primary Test of Nonverbal Intelligence (PTONI) was utilized to evaluate the cognitive ability of the children with ASD in the present study (Ehrler & McGhee, 2008). PTONI is appropriate for testing children, who have not developed typically in terms of verbal and motor skills as it has minimal oral directions and a pointing response format, so PTONI was preferred in the current study to prevent any influence of the participant's language deficit on cognitive scores (Bishop, Farmer, & Thurm, 2015). PTONI can be applied to all children who are 3-9 years old, evaluate perception of the spatial-visual abilities, and the subsequent items of the PTONI assess higher-level reasoning skills such as analogical thinking, sequential reasoning, and categorical formulation. The internal consistency and test-retest reliability of the PTONI was determined as 0.93 and 0.97, respectively. The content, construct and predictive validity of the PTONI were evaluated as representing all requirements, respectively (Ehrler & McGhee, 2008).

The data collected to explore a relationship between sensory-cognitive-motor functions and the severity level of ASD in preschool children, were analyzed using the Statistical Package for Social Sciences version 21 software (SPSS 21.0, Chicago, IL, USA). Data about age, height, body mass index (BMI), prescribed medicine, duration of special education and kindergarten, and siblings were analyzed using descriptive methods. Descriptive statistics were applied to the GARS-2, SP (see Table 2), PTONI (see Table 3), and BOT-2 (see Table 4) scores of the participants. Normal distribution of the data was tested by skewness, kurtosis, histogram, and Shapiro-Wilk values. PTONI and BOT-2 data were not normally distributed, and the recommended LOG10 transformation was applied (Pallant, 2005; Tabachnick & Fidell, 2001). The relationship between GARS-2 and SP scores (total, section and factors) was analyzed via Pearson correlation. Partial correlation analyses (controlled for age) were conducted using the raw scores of the PTONI and BOT-2 data.

Multivariate analysis of covariance (MANCOVA) was conducted to answer the research question of "do the sensory processing ability, non-verbal IQ, and motor proficiency levels of the children with ASD differ according to autism severity after controlling for age?" Before the analysis, the data set was tested for assumptions in MANCOVA. Pallant (2005) recommended that the number of participants per cell for MANCOVA should be greater than the number of dependent variables. Since the analysis included three dependent variables and the minimum number of participants per cell was 7, the number of participants was found to be suitable for the analysis. To test for the presence of extreme values in the data set, the Mahalanobis distance was examined, and no extreme values were found in the data set. As the correlation coefficients between the dependent variables were <0.90, the assumptions of multiple linearity were met (Tabachnick & Fidell, 2001). The assumption of homogeneity of variance was assessed by the Levene test, and the variance of the data set was determined to be homogenous.

RESULTS

Typical and atypical ranges of the Sensory Profile of preschool children with ASD are shown in Table 2 as the mean scores and standard deviation. The total scores of the Sensory Profile ranged from 375 to 545, and the mean total score and standard deviation was determined as 446.03 and 54.07, respectively. In 11 items of the total 14 items in the sections of the Sensory Profile, the mean score was out of the typical range of the preschool children with ASD. In 8 items of the total 9 items in factors of the Sensory Profile, the mean score was out of the typical range of the preschool children with ASD (Table 2). A hundred percent (100%) showed atypical responses in at least one item of the sections (14 items) or factors (9 items) in Table 2.

Table 2 Sensory profile of participants

Sensory Profile	Raw score Mean (SD)	Norms for typical performance Range	ASD atypical response % (n)
Sections			
A. Auditory processing	**28.6** (5.2)	40-30	50.0 (15)
B. Visual processing	34.1 (5.9)	45-32	36.7 (11)
C. Vestibular processing	**45.3** (4.9)	55-48	63.3 (19)
D. Touch processing	**71.9** (9.9)	90-73	40.0 (12)
E. Multisensory processing	**23.8** (4.4)	35-27	83.3 (25)
F. Oral sensory processing	**38.6** (10.9)	60-46	76.7 (23)
G. Sensory processing related to endurance/tone	**35.9** (8.9)	45-39	56.7 (17)
H. Modulation related to body position & movement	**38.3** (6.4)	50-41	56.7 (17)
I. Modulation of movement affecting activity level	24.7 (4.1)	35-23	23.3 (7)
J. Modulation of sensory input affecting emotional responses	**13.5** (3.0)	20-16	83.3 (25)
K. Modulation of visual input affecting emotional & activity level	14.5 (2.3)	20-15	50.0 (15)
L. Emotional/social responses	**50.9** (17.8)	85-63	86.7 (26)
M. Behavioral outcomes of sensory processing	**16.0** (6.7)	30-22	70.0 (21)
N. Items indicating thresholds	**9.7** (3.8)	15-12	56.7 (17)
Factors			
1. Sensory seeking	**60.3** (9.5)	85-63	53.3 (16)
2. Emotional reactive	**44.9** (15.8)	80-57	80.0 (24)
3. Low endurance/tone	**36.0** (9.0)	45-39	56.7 (17)
4. Oral sensory sensitivity	**27.9** (9.1)	45-33	70.0 (21)
5. Inattention/distractibility	**24.6** (4.4)	35-25	46.7 (14)
6. Poor registration	**28.8** (6.0)	40-33	70.0 (21)
7. Sensory sensitivity	**15.9** (2,9)	20-16	46.7 (14)
8. Sedentary	15.8 (2.7)	20-12	6.7 (2)
9. Fine motor/perceptual	**7.9** (4.0)	15-10	56.7 (17)
	Mean (SD)	*Range*	
TOTAL SCORES	446.03 (54.07)	337-545	

Bold numbers illustrate means that fell in the atypical range. Atypical range is defined as a score <1 standard deviation Sensory Profile (SP

The mean raw scores, mean standard scores, standard deviation, range of the descriptive categories in PTONI, and percentage distribution in these categories of the preschool children with ASD are shown in Table 3. Mean raw score and standard deviation of the nonverbal IQ performance in PTONI was 17.8 and 7.8, respectively. The mean standard score and standard deviation of the nonverbal IQ performance was determined as 87 and 14.8, respectively. In respect of the mean standard score of PTONI, 60% of the participants were included in the “below average”, “low”, and “very low” categories of PTONI, and 40% were in the “average” and “above average” categories (Table 3).

Table 3 Nonverbal intelligence scores of participants

	Mean (SD)	Range
Total Raw Scores	17.8 (7.8)	4-31
Standard Scores	87 (14.8)	64-117
Descriptive Categories	*n (%)*	*Nonverbal Indexes*
Very Superior	-	131 or more
Superior	-	121-130
Above Average	1 (3.3)	111-120
Average	11 (36.7)	90-110
Below Average	5 (16.7)	80-89
Low	10 (33.3)	70-79
Very Low	3 (10)	69 or less

Nonverbal Intelligence Scores (PTONI)

The mean raw scores, mean standard scores, standard deviation, range of the descriptive categories in BOT-2, and percentage distribution in these categories of the preschool children with ASD are shown in Table 4. The mean raw score and standard deviation of the motor performance in BOT-2 was 6.7 and 9.3, respectively. The mean standard score and standard deviation of the motor performance was determined as 25.3 and 6.7, respectively. In respect of the mean standard score of BOT-2, 96.6% of the children were included in the “below average” and “well-below average” categories of BOT-2, and only 3.3% were in the “average” category (Table 4).

The results of the correlations between sensory response, motor performance, autism severity, and nonverbal IQ level are shown in Table 5. A moderate negative relationship was determined between the total raw scores of motor performance and autism severity ($r = -.587$, $p < .05$), and also between the nonverbal IQ level and autism severity ($r = -.402$, $p < .05$). A moderate positive relationship between the total raw scores of motor performance and nonverbal IQ level ($r = .442$, $p < .05$), but there was no relationship between the total raw scores of motor performance and the total raw scores of sensory response of the preschool children with ASD. There was a positive relationship between all subtests of BOT-2 and autism severity (from $r = -.428$ to $-.727$, $p < .05$), and a moderate positive relationship between the raw scores of two subtests ($r = .456$, $p < .05$ for balance and $r = .368$, $p < .05$ for upper limb coordination) of BOT-2 and the nonverbal IQ level (Table 5).

Table 4. Motor performance of participants

	Mean (SD)	Range
Fine Motor Precision	1,7 (2.8)	0-13
Fine Motor Integration	1.2 (2.5)	0-8
Manual Dexterity	1.2 (0.8)	0-3
Bilateral Coordination	0.3 (1.3)	0-7
Balance	1.5 (1.8)	0-7
Running Speed and Agility	0.2 (0.6)	0-2
Upper-Limp Extremities Coordination	0.2 (0.6)	0-3
Strength	0.3 (0.9)	0-4
Total Raw Scores	6.7 (9.3)	1-47
Standard Scores	25.3 (6.7)	20-57
Descriptive Categories	*n (%)*	*Typical Performance Range*
Well-Above Average	-	70 or more
Above Average	-	60-69
Average	1 (3.3)	41-59
Below Average	1 (3.3)	31-40
Well-Below Average	28 (93.3)	30 or less

Motor Performance (BOT-2 Short Form)

Table 5. Correlations between sensory profile-motor performances, ASD severity, and nonverbal intelligence of participants

	ASD severity GARS-2	Nonverbal Intelligence PTONI*
Sensory Profile		
Sections		
C. Vestibular processing	.369	
BOT-2 (Short form)*		
Total Raw Score	-.587	.442
Subtests		
Fine Motor Precision	-.428	
Fine Motor Integration	-.470	
Bilateral Coordination	-.449	
Balance	-.727	.456
Upper-Limp Extremities Coordination	-.440	.368
Strength	-.481	
GARS-2 (ASD severity)		-.402

The results of the multivariate analysis of covariance for the level of autism severity, sensory response, nonverbal IQ level, and motor performance are shown in Table 6. As expected, age was observed to have an influence on nonverbal IQ level and motor proficiency. Autism severity had large effect size [$F (2, 28) = 8.69$, $p < .05$, $\eta^2 = .39$] for the motor impairment (39%) and [$F (2, 28) = 4.91$, $p < .05$, $\eta^2 = .27$] for the low nonverbal IQ level (27%) when controlled for age (Table 6)

Table 6 Results of MANCOVA for the level of autism severity, sensory profile, nonverbal intelligence, and motor performance

Source	Dependent Variables	Sum of Squares	df	Mean Squares	F	PartialEta Square
Corrected Model	SP score	1003.992	2	501.996	.162	.012
	PTONI score	.428		.214	4.909*	.267
	BOT-2 score	2.413		1.206	8.691*	.392
Age (Covariance)	SP score	58.491	1	58.491	.019	.001
	PTONI score	.275		.275	6.307*	.189
	BOT-2 score	.941		.941	6.777*	.201
Autism severity	SP score	855.693	1	855.693	.276	.010
	PTONI score	.217		.217	4.972*	.156
	BOT-2 score	1.809		1.809	13.036*	.326
Error	SP score	83782.975	27	3103.073		
	PTONI score	1.176		.044		
	BOT-2 score	3.748		.139		

* p<.05 Autism severity (GARS-2), Sensory Profile (SP), Nonverbal Intelligence (PTONI), Motor Performance (BOT)

DISCUSSION

Preschool children with ASD displayed more atypical sensory responses, lower nonverbal IQ and motor performances compared to a normative sample. The present study also showed that there was a negative relationship between autism severity and the nonverbal cognitive level, and autism severity and motor proficiency level in preschool children with ASD. Moreover, the autism severity impacted the cognitive and motor functions of the children with ASD.

Motor impairment was observed to be extensive, in 4/5 (80%) of the preschool girls with ASD and it has been reported that autistic symptoms at younger age are predictive of more motor coordination problems (Kopp, Beckung, & Gillberg, 2010). Likewise, the present study revealed an extensive low motor function in the preschool children with ASD (96.6%). The findings of the study also detected a relationship between motor proficiency and autism severity in preschool children with ASD, which was consistent with previous studies (Hilton et al., 2007; Kopp, Beckung, & Gillberg, 2010; Hilton, Zhang, Whilte, Klohr, & Constantino, 2012; Piek & Dyck, 2004). Kopp, Beckung, & Gillberg (2010) reported a moderate negative relationship ($r = -.33$, $p < .001$) between autism severity and motor function of preschool children with ASD. Another study evaluated motor proficiency in children with ASD using BOT-2 and determined a substantial impairment, and a moderate negative correlation ($r= -.389$, $p=.0001$ for the BOT-2 total score, r ranged from – .26 to - .43 for the subtests of the BOT-2) between motor proficiency and autism severity (Hilton et al., 2012). In the present study, a moderate correlation was also found between autism severity and motor proficiency ($r= -.587$, $p < .05$ for the BOT-2 total score) and the subtests, including fine motor precision, fine motor integration, bilateral coordination, balance, upper-limp extremities coordination, and strength, which was consistent with the findings of Hilton et al. in 2012.

Motor development and motor skills have an impact on other developmental areas such as cognitive development during infancy and early childhood, and the relationship has been highlighted by researchers (Cameron et al., 2012; Diamond, 2000; Hill, 2010; Wassenberg et al., 2005). The importance of motor skills and cognitive performance has also been emphasized for monitoring and early intervention in preschool children with ASD (Berger, 2013; Bishop, Farmer, & Thurm, 2015; Bo, Lee, Colbert, & Shen, 2016; Downey & Rapport, 2012; Hellendoorn et al., 2015; Iwanaga, Kawasaki, & Tsuchida, 2000; Hilton, Zhang, Whilte, Klohr, & Constantino, 2012; Piek & Dyck, 2004). A recent meta-analysis examined the influence of IQ on motor function in ASD, and it was seen that many studies in literature have only included participants with ASD with an IQ of >70 (Fournier et al., 2010), whereas approximately 70% of individuals with ASD have and IQ <70 (Chakrabarti & Fombonne, 2005). Fournier et al. (2010) were unable to run analyses on the effect of IQ on motor function in ASD as there were not enough studies which included the IQ scores of the sample. In the current study, the preschool children with ASD were within a wide range of nonverbal IQ (64-117), and a moderate association was determined between motor proficiency and cognitive performance. Kopp et al. (2010) reported that motor coordination problems could be predicted by a low nonverbal IQ in preschool children with ASD, and the association between motor function and nonverbal IQ was detected as a moderate positive relationship ($r = .33$, $p < .001$). Similarly, Hilton et al. (2012) determined a moderate relationship between motor function and IQ scores ($r = .48$ to $.62$). Parallel to the conclusions of these studies, a moderate positive relationship was detected between the total motor performance and nonverbal IQ level ($r = .442$, $p < .05$) of the preschool children with ASD in the present study.

For optimal performance of a voluntary movement, sensory input from the interior and exterior of the body must be processed effectively (Ayres, 2000). Sensory and motor difficulties in children with ASD have been previously reported and discussed in literature (Baranek, 2002; Iwanaga, Kawasaki, & Tsuchida, 2000; Liu, 2013; Mandelbaum et al., 2006; Mosconi & Sweeney, 2015; Mulligan & White, 2012). Liu (2013) determined atypical sensory processing compared to a normative sample for preschool and school-age children with ASD. Jasmin et al. (2009) also reported more atypical sensory responses and motor delays compared to the norms in preschool children with ASD. In the present study, the very high percentage (100%) of atypical sensorial responses in at least one item of the Sensory Profile was detected among the preschool children with ASD, and was closer to the 94% reported by Jasmin et al. (2009). Likewise, Kayıhan et al. (2015) also reported intensive atypical sensory performance in the sections of the Sensory Profile for preschool and school-age children with ASD. The atypical sensory performance of preschool children with ASD could be associated to motor performance, and this relationship has been explored by researchers (Baranek, 1999; Hannant, Tavassoli, & Cassidy, 2016; Hochhauser & Engel-Yeger, 2010; Jasmin et al., 2009). Jasmin et al. (2009) also found a moderate positive relationship between gross motor skills and sensory responses ($r = .39$, $p = .03$ for sensory seeking, $r = .43$, $p = .01$ for touch processing) in preschool children with ASD, but in the current study, no sensory responses correlated significantly with the total motor score. This result was somewhat surprising in the light of the results of the previous studies.

Autism severity may affect not only motor function, but also the cognitive performance of children with ASD, and a few studies have explored the relationship between these domains in preschool children with ASD (Kopp, Beckung, & Gillberg 2010; Hilton, Zhang, Whilte, Klohr, & Constantino, 2012) for diagnostic purposes and approaches to interventions. In the present study, preschool children with ASD, who had higher autism severity, had tended to display the lower nonverbal IQ performance ($r = -.402$, $p < .05$). Hilton et al. (2012) reported that motor skills were serious affected, and highly correlated with autism severity and IQ in children with ASD. In their study, autism symptoms were a significant predictor of the motor performance ($r^2 = .433$, $p < .000001$ for BOT-2 total score) when controlled for age and gender, and both autism symptoms and IQ were significant predictors of the motor proficiency ($r^2 = .509$, $p = .011$ for BOT-2 total score), when controlled for age and gender. Similarly, Kopp et al. (2010) found that age, autism severity and nonverbal IQ were independent predictors and explained 35% ($r^2 = .35$) of the motor functions in children with ASD. In the present study, autism severity had large effect size ($\eta^2 = .392$) for the motor impairment score (39%) and for ($\eta^2 = .267$) for the low nonverbal IQ level (27%) when controlled for age, and thus it could be noted that autism severity has a large effect on the nonverbal cognitive performance and motor skills of preschool children with ASD (Cohen, 1988).

There were some limitations that needed to be taken into account while analysing the findings of the present study. The observational evaluation of the

Sensory Profile was based on the caregiver's responses. Raw scores of the nonverbal IQ test (PTONI) and motor test (BOT-2) were used for correlation analysis owing to lack of a norm data for Turkish children. Each dependent variable of this study was evaluated only by a measurement tool. These results can only be generalized for children with ASD of preschool age.

The present study contributes to the evidence in literature that preschool children with ASD very often have motor impairment (96%), low nonverbal IQ (60%), and atypical sensory responses (100%). The motor impairments were noticeably marked in children, with a higher level of autism severity. Nonverbal IQ performance in the preschool period was also associated negatively by autism symptoms. Evaluation of preschool children with ASD for autism symptoms, sensory reactions, and motor skills can provide useful tips for promoting functionally based interventions to address their weaknesses. This study revealed that an individual education program, which should cover both short and long-term targets related not only to deficits in social-communicative skills and restricted/repetitive behaviours, but also to impairments in motor proficiency such as bilateral coordination, balance, upper limb coordination, and strength for preschool children with ASD.

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