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Investigation of neurological status, motor performance and sensory processing in children with attention deficit hyperactivity disorder

Dikkat eksikliği ve hiperaktivite bozukluğu olan çocuklarda nörolojik durum, motor performans ve duyusal işlemenin incelenmesi

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ABSTRACT
Aim: The aim of this study was to investigate neurological status, motor development, and sensory processing in children with attention deficit hyperactivity disorder (ADHD).
Method: The study included a total of 50 children; 25 with ADHD and 25 typically developing children. The Touwen Examination assessed the status of Minor Neurologic Dysfunction (MND). Motor development was assessed with the Peabody Motor Development Scale 2. Sensory processing skills were assessed using the Dunn Sensory Profile.
Results: In the ADHD group, the prevalence of MND was higher than in the typically developing group. 36.0% of children with ADHD had complex MND, while 52.0% had simple MND. Gross motor, fine motor, and total motor scores were lower in the ADHD group. Children with ADHD had significantly lower sensory processing scores compared to their typically developing peers ($p<0.05$). There was a significant relationship between motor development and MND in children with ADHD ($p<0.05$).
Conclusion: Compared to their typically developing peers, children with ADHD had delayed motor development and sensory processing skills. Children with ADHD were at risk for MND, and this was associated with their motor development. Children with ADHD should be assessed for MND. Intervention programs should focus on improving their sensory processing, motor development, and neurological status.

Anahtar Kelimeler: Attention deficit; hyperactivity disorder; minor neurological dysfunction; neurodevelopmental disability

ÖZ
Amaç: Bu çalışmanın amacı, dikkat eksikliği ve hiperaktivite bozukluğu (DEHB) tanılı çocuklarda nörolojik durum, motor gelişim ve duyusal işlemleme becerilerini incelemektir.
Yöntem: Çalışmaya toplam 50 çocuk dahil edilmiştir; bunların 25'i DEHB tanılı, 25'i ise tipik gelişim gösteren çocuklardan oluşmaktadır. Minör Nörolojik Disfonksiyon (MND) durumu Touwen Muayenesi ile değerlendirilmiştir. Motor gelişim, Peabody Motor Gelişim Ölçeği-2 kullanılarak; duyusal işlemleme becerileri ise Dunn Duyusal Profil Ölçeği ile değerlendirilmiştir.
Bulgular: DEHB grubunda MND prevalansının, tipik gelişim gösteren gruba kıyasla daha yüksek olduğu belirlenmiştir. DEHB'li çocukların %36.0'ında kompleks MND, %52.0'ında ise basit MND saptanmıştır. Kaba motor, ince motor ve toplam motor puanlarının DEHB grubunda daha düşük olduğu bulunmuştur. Ayrıca, DEHB'li çocukların duyusal işlemleme puanlarının, tipik gelişim gösteren akranlarına göre anlamlı düzeyde düşük olduğu saptanmıştır ($p<0.05$). DEHB'li çocuklarda motor gelişim ile MND arasında istatistiksel olarak anlamlı bir ilişki olduğu belirlenmiştir ($p<0.05$).
Sonuç: DEHB tanılı çocukların, tipik gelişim gösteren akranlarına kıyasla motor gelişim ve duyusal işlemleme becerilerinde gecikme gösterdiği belirlenmiştir. Ayrıca, bu çocukların MND açısından risk altında olduğu ve MND'nin motor gelişim ile ilişkili olduğu saptanmıştır. DEHB'li çocukların MND açısından kapsamlı bir şekilde değerlendirilmesi önerilmektedir. Müdahale programlarının ise duyusal işlemleme, motor gelişim ve nörolojik durumu geliştirmeye yönelik olarak planlanması gerektiği düşünülmektedir.

Keywords: Dikkat eksikliği; hiperaktivite bozukluğu; minör nörolojik disfonksiyon; nörogelişimsel bozukluk

Introduction

According to the American Psychiatric Association, ADHD is a neurodevelopmental disorder characterized by persistent and developmentally inconsistent levels of inattention, disorganization, and/or hyperactivity/impulsivity. ADHD is diagnosed after a multidisciplinary assessment that includes medical, developmental, educational, and comprehensive psychological evaluations (American Psychiatric Association, 2022). Inattention and impulsivity can sometimes lead to problems in gross and fine motor skills

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(D’Anna et al., 2024). ADHD is a childhood neurodevelopmental disorder that is more prevalent in males, with a male-to-female sex ratio ranging from 2:1 to 10:1 between childhood and adolescence (10–18 years) (Mowlem et al., 2019). Children with ADHD often experience problems such as cognitive impairment, self-harm, sensory impairments, and reduced social integration with peers (Sayal, Prasad, Daley, Ford & Coghill, 2018). Hyperactivity and impulsivity problems usually begin at the age of 4 and reach their peak at 7-8 years of age (Krull, 2015).

Minor Neurological Dysfunction (MND) defines neurological pathology in children who do not develop cerebral palsy but still have some neuromotor impairments (Hadders-Algra, 2002). MND is classified as simple (s-MND) and complex MND (c-MND) according to the severity of neurological, behavioral, and cognitive functions. (Hadders-Algra, 2002). S-MND is related to a moderately increased risk of learning and behavioral problems (Kikkert, De Jong & Hadders-Algra, 2011). C-MND affects approximately 5% of children and is highly associated with perinatal, learning, and behavioral problems (Hadders-Algra, 2002). MND rates increase as children start school (Hadders-Algra, 2002). MND negatively impacts a child's daily living activities and can also lead to cognitive, emotional, and behavioral disorders, as well as a decline in academic performance (Hamad, Caldas & Nunes, 2025).

Ayres defined sensory processing as the ability to process sensory information in order to respond appropriately to responses, taking into account not only sensory skills but also motor-sensory development and motor responses (Ayres, 1977). Sensory processing disorder (SPD) “affects the way the brain interprets incoming information and the subsequent response, resulting in inappropriate and excessive emotional, motor, and other reactions” (Bowyer & Cahill, 2018). Children with ADHD may not be able to receive and process sensory information properly, and as a result, they may have difficulty producing correct adaptive responses at school, at home, and in social environments (Cheung & Siu, 2009).

Motor development involves the acquisition of motor skills involving movements of one or more body components. It is very important for children's health and growth (Salehi, Sheikh & Talebrokni, 2017). Motor problems are observed in 30-50% of children with ADHD. These problems can significantly affect daily activities such as riding a bicycle, dressing, tie-up shoes, and writing (Fliers et al., 2010).

In order to prevent the problems mentioned above, it is important to investigate children with ADHD in the preschool period in terms of sensory processing, motor development, and MND. In the literature, studies on children with ADHD generally include school-age children (Goulardins, Marques & De Oliveira, 2017; Molagholamreza Tabasi, Aliabadi, Alizade Zarei, Qorbani & Rostami, 2016). This study, unlike previous research, examined the relationship between sensory processing and motor development in preschool children with ADHD. The findings indicate a high risk of sensory processing, delayed sensory-motor development compared to peers, and variable motor development depending on the neurological condition. Not assessing these children early may cause them to miss vital inputs during critical developmental periods, when interventions provided by families, physiotherapists, and occupational therapists can improve outcomes. Our primary aim is to investigate the neurological status, sensory processing, and motor performance of children with ADHD. Our secondary aim was to determine how the motor development of children with ADHD is affected by the addition of MND.

Methods

Setting

The study group consisted of 48–70-month-age children diagnosed with ADHD who were not taking medication in the pediatric psychiatry department of Gazi University Training and Research Hospital. The control group was recruited by telephone contact and consisted of people (friends and siblings) who lived in the same region as the study group, had similar demographic characteristics, and volunteered to participate in the study. Data for this study were collected between January and April 2023.

Participants

A total of 50 children aged 48–70 months—25 diagnosed with ADHD and 25 typically developing children—were included in the study (Figure 1). Individuals in both groups were investigated by a physiotherapist at Gazi University's Faculty of Health Sciences, Pediatrics Unit. The study group included children diagnosed with ADHD according to DSM-5 diagnostic criteria, aged 4-5 years (48–70 months), and able to follow instructions. Children with neurological diagnoses, genetic and chromosomal anomalies, and other serious health problems (such as congenital deformities) were excluded. The control group included children aged 4-5 years (48–70 months) who were able to follow instructions. Children with ADHD, neurological diagnoses, genetic and chromosomal anomalies, and other serious health problems (such as congenital deformities) were excluded. None of the children had language or intellectual difficulties (Stanford-Binet Intelligence Scale scores > 85; Caruso, 2001). The control group and study (ADHD) group were matched as closely as possible in respect of age, height, and weight. A structured form was used to record demographic information and verify compliance with inclusion and exclusion criteria.

Data Sources

Neurological Assessment

Neurological development was assessed using standardized and age-specific neurological examinations, according to Touwen (Hadders-Algra, 2010). This assessment comprehensively assesses developmental factors in eight areas, including posture, muscle tone, movement openness, discinesia, reflexes, sensory function and cranial nerve dysfunction, balance and coordination, fine hand skills, and combined responses in different positions. A child with no impairment in any of the eight domains is considered neurologically normal, but a child with dysfunction in at least one domain is classified as s-MND, and a child with dysfunction in at least three domains is classified as c-MND (Hadders-Algra, 2002).

Sensory Processing Assessment

The Dunn sensory profile is used to assess the sensory processing of children aged 3 to 10 years. This scale helps us to fully understand sensory stimuli and how the child responds to them in everyday life. This scale consists of 125 items (Critz, Blake & Nogueira, 2015). The child's parent reports on a 5-point Likert-type scale how often their child exhibits the behavior described in each item (1 = always, 2 = often, 3 = sometimes, 4 = rarely, and 5 = never). A higher score indicates that the child performs better (Dunn, 2014).

Motor Devoplement Assessment

The Peabody Motor Development Scale-2 (PMDS-2) was used to assess motor development. The assessment includes six subtests that assess motor skills related to reflexes, body control and balance, movement, object manipulation, grasping, and visual-motor integration in children aged 0-72 months (Connolly, McClune & Gatlin, 2012). The PMDS-2 uses a three-point scale to score each item, and each item is scored between 0 and 2. 0 children cannot do it, one child partially meets the criteria, and 2 children can fully perform the given task. The scoring system is used as a tool to assess levels of motor development and to make comparisons between a child and his or her peers (Gill et al., 2019). To calculate the scores for the subgroups in PDMS-2, the pure scores are summed and converted to standard scores. The generated standard scores are collected and converted into a section with a total of 100 and standard scores of 15. Total motor score, gross motor score, and fine motor score are calculated. The scores obtained from each area are classified as excellent (131-165), very good (121-130), above average (110-120), average (90-109), below average (80-89), low (70-79), and very low (35-69). The test takes an average of 45-60 minutes. The PDMS-2 Software Scoring and Reporting System is available (Zanella, Valentini, Copetti & Nobre, 2021)

All assessments were completed in a single session, following a standard sequence. To minimize fatigue and maintain attention, short breaks were taken between tests as needed. When the child showed signs of unwillingness, inattention, or fatigue, the assessment was halted and started again after a short rest period. All assessments were completed when the child was ready to continue.

Study Size

In the analysis performed based on the reference study (Duda, Casey, O'Brien, Frost & Phillips, 2019), using the G*Power program (version 3.1.9.2; Universität Düsseldorf, Düsseldorf, Germany), the minimum sample size required to achieve 85% power at a 95% confidence level was determined to be 50 children in total, with 25 children per group.

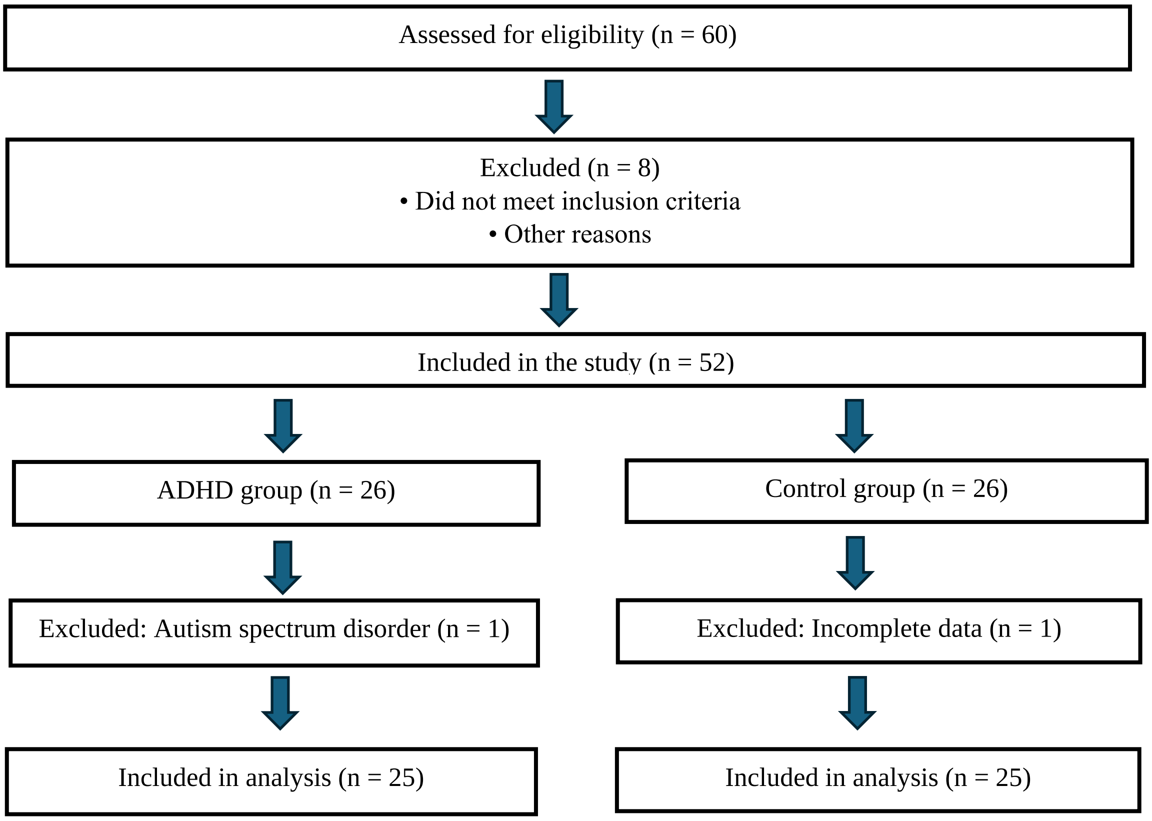

Figure 1. Flow chart of the participants

Bias

To minimize bias, all assessments were performed under the same environmental conditions using a standard assessment protocol. To ensure consistency, all measurements were taken by the same physiotherapist trained in pediatrics. Appropriate statistical methods were used in data analysis to ensure objective interpretation of the results.

Ethical Consideration

This study was a cohort, observational, prospective and comparative study. This study was conducted according to the principles of the Helsinki Declaration and was approved by the Ethics Committee of Gazi University (Approval Number:E-77082166-302.08.01-358533, letter dated May 10, 2022). Written informed consent was obtained from all participants. This manuscript was prepared in accordance with the STROBE checklist to ensure transparency and comprehensiveness in reporting observational studies (von Elm et al., 2007).

Statistical Anaylses

SPSS (version 20.0, SPSS Inc., Chicago, Illinois, USA) was used for all the statistical analyses. The Shapiro-Wilk test and kurtosis-skewness tests were used to assess the normal distribution of the numerical data. Categorical variables were analyzed using frequency and percentage values, while metric variables were analyzed using mean ± standard deviation. A chi-square test was used to assess the differences in neurologic status between the groups. If the data met the requirements for a normal distribution, the independent sample t test was used to compare two independent groups. Since the sensory processing values did not meet the normal distribution criteria, the Mann-Whitney U test was used to compare two different groups. A post-hoc test was used to assess MND and motor development in the ADHD group after ANOVA analysis. In the analyses, the statistical significance level was considered to be p<0.05

Results

In total, 26 children with ADHD and 26 typically developing children were evaluated for eligibility to participate in the study. 2 individuals were excluded from the study because they did not meet the inclusion criteria. Data from 50 participants were collected and analyzed.

The study group consisted of 20 boys (80.0%) and 5 girls (20.0%), and the control group consisted of 14 girls (56.0%) and 11 boys (44.0%) (p = 0.009). There were no statistically significant differences in age (p = 0.60), height (p = 0.55), and body weight (p = 0.19) between the study group and the control group. Sociodemographic characteristics are shown in Table 1.

Table 1. Sociodemographic characteristics and birth information

	ADHD group n=25		Healthy group n=25		p
	Median(Range)	SD	Median(Range)	SD	0.601[a]
Chronological age (months)	64.8	6.4	63.8	7.4	0.550[a]
Height (cm)	22.9	18.3	18.08	2.4	
Body Weight (kg)	108.7	19.4	111.1	5.4	0.199[a]
Gender (F/M)	5/20		14/11		0.009[b]
Mode of delivery (normal/surgical)	13/12		17/8		0.248[b]
Consanguineous Marriage (present/absent)	1/24		1/24		1.00[b]

a: Independent samples t test, b: Chi-square test, *p<0.05 n: number of samples, F: female, M: male, kg: kilogram, cm: samtimeter, SD: standard deviation, ADHD: attention-deficit/hyperactivity disorder

In children with ADHD, 3 (12.0%) had normal neurologic findings, 13 (52.0%) had s-MND, and 9 (36.0%) had c-MND. In the healthy group, 21 (84.0%) children had normal neurologic findings, and 4 (16.0%) had s-MND. Children with ADHD had a higher prevalence of MND was higher in children with ADHD compared to those without ADHD (p<0.001). The prevalence of MND in the healthy group and the study group is shown in Table 2.

Table 2. MND prevalence rates in ADHD and healthy children

	ADHD group		Healthy group		p
	n	%	n	%	
Neurologically normal	3	12.0	21	84.0	<0.001
Simple MND	13	52.0	4	16.0	
Complex MND	9	36.0	0	0	

ADHD: attention-deficit/hyperactivity disorder, Chi-square test, p < 0.05 n:number of samples, %: percentage

The most common impairment in children with ADHD was in balance-coordination, followed by fine dexterity. The distribution of MND in children with ADHD according to dysfunctional areas is shown in Table 3.

Table 3. Distribution of MND according to dysfunctional areas in ADHD group

Dysfunctional area	Incidence rates
Fine manual skills	%44.0
Balance-Coordination	%84.0
Posture and muscle tone	%20.0
Involuntary movements	%36.0
Combined reactions	%0.0
Sensory functions	%28.0
Cranial nerve function	%16.0
Reflexes	%0

A significant difference was found in favor of the control group in PMDS-2 gross motor (p<0.001), fine motor (p<0.001), total motor (p<0.001), subtests of fixed movements (p<0.001), locomotion (p<0.001), object manipulation (p=0.001), and visual motor integration (p<0.001) scores. No difference was found only in the grasping (p = 0.128) score. PDMS-2 results between the groups are shown in Table 4.

Table 4. Comparison of Peabody Developmental Motor Scales (PDMS-2) Scores Between Groups

	ADHD group (n=25) Mean-SD	Healthy group (n=25) Mean-SD	p
GROSS MOTOR	88.3±8.9	103.8±9.1	<0.001
Fixed Movements	51.6±4.4	56.9±3.2	<0.001
Locomotion	165.2±7.6	173.4±3.9	<0.001
Object Manipulation	38.9±4.1	43.3±4.3	0.001
FINE MOTOR	93.4±9.08	110.9±9.6	<0.001
Grasping	49.4±2.02	55.0±17.9	0.128
Visual-Motor Integration	135.0±4.3	140.4±4.3	<0.001
TOTAL MOTOR	88.3±7.4	107.8±6.7	<0.001

* n: sample size, SD: standard deviation, ADHD: attention-deficit/hyperactivity disorder

A significant difference was found in favor of the control group in sensory processing scores in all 14 domains, including sensory processing, sensory modulation, and behavioral and emotional responses (p<0.05). Sensory processing scores are shown in Table 5.

Table 5. Dunn Sensory Profile Scores

	ADHD group Median (%25-75 IQR)	Healthy group Median (%25-75 IQR)	p*
Auditory processing	32 (29.5-36.5)	36 (34.5-38.5)	0.008
Visual processing	37 (37-49)	41 (39-44)	0.007
Vestibular processing	73(65.5-82.5)	52 (51-55)	<0.001
Touch processing	44 (39-52)	85 (83-88)	<0.001
Multisensory processing	29 (27.5-32.5)	34 (32-35)	0.003
Oral sensory processing	44(39-52.5)	51 (45-59)	0.013
Sensory processing related to endurance and tonus	38 (34-45)	43 (43.5-45)	0.001
Regulations related to movement and body position	37 (32.5-42)	44 (40.5-49.5)	<0.001
Movement arrangements affecting activity level	24 (22-27)	30 (29-34.5)	<0.001
Regulation of sensory inputs affecting emotional responses	16 (15-18)	19 (18-20)	0.002
Regulation of visual stimulus affecting emotional responses and activity level	15 (13-16)	17 (16-20)	0.001
Emotional-social responses	64(56-72)	74 (69.5-80.5)	0.001
Behavioral consequences of sensory processing	5 (0-15)	1 (0-0)	0.028
Items defining the response threshold	13(11.5-15)	14(14.5-15)	0.001

*Mann-Whitney U test, p < 0.05 ADHD: attention-deficit/hyperactivity disorder

In the ADHD group, children with c-MND had statistically lower fine motor (p = 0.002) and total motor (p = 0.001) scores compared to children without MND (p<0.05). When neurologically normal children were compared with children with s-MND and c-MND, there was no difference in gross motor scores (p = 0.069). Motor development scores according to MND status in children with ADHD are shown in Table 6.

Table 6. Motor development results according to minor neurological dysfunction status

	Neurologically normal Median-SD	Simple MND Median-SD	Complex MND Median-SD	p*
Gross Motor	(98±3.4)[a]	(88.7±7.4)[a]	(84.5±10)[a]	0.069
Fine Motor	(103±9) [a]	(96.3±6.7)[a]	(86±7.03)[b]	0.002
Total Motor	(98.6±7.7) [a]	(90±4.2)[b]	(82.2±5.9)[c]	<0.001

*ANOVA One-Way Analysis of Variance-Post-Hoc Bonferonni Test SD: standard deviation - a,b,c: The same letters in the row indicate that there is no significant difference between the two groups

Discussion

This study aimed to assess the occurrence of MND in preschool children with and without ADHD. Furthermore, the study investigated the relationship between MND, motor development, and sensory processing in these preschool children. To our knowledge, this is the first study to investigate the link between MND and motor development in preschool children with ADHD.

In the literature, ADHD and MND are known to be associated. ADHD has been shown to be associated with MND in term-born healthy children and adolescents (Batstra, Neeleman & Hadders-Algra, 2003). Similar findings were found in a cohort study of children of school age born extremely prematurely (Broström, Vollmer, Bolk, Eklöf & Ådén, 2018). S-MND has no perinatal etiology and is related to a moderately increased risk of learning and behavioral problems. In C-MND, perinatal factors play a prominent role, and they are closely related to ADHD (Hadders-Algra, 2002). Dysfunctions in the cortico-striato-thalamo-cortical and cerebello-thalamo-cortical pathways are related to c-MND. These regions are responsible for sensory-motor functions in motor programming, movement planning, and motor memory, as well as cognitive processes related to learning. Dysfunction in these regions may affect cognition and coordination (Alexander & Crutcher, 1990). Decreased dopaminergic activity in the nigrostriatal dopamine system can lead to walking, balance, and laterality problems along with clumsiness and contribute to impairment of both gross and fine motor control (Pillay, Meyer & Mokobane, 2019). The results of our study were similar to those in the literature. The prevalence of MND was significantly higher in children with ADHD than in those without ADHD. Contrary to existing research (Hadders-Algra, 2002), our study revealed that the rate of s-MND was higher in children with a history of ADHD. It is known that motor problems decrease and more effective use of sensory-motor integration is achieved with physiotherapy approaches (Watemberg, Waiserberg, Zuk & Lerman-Sagie, 2007; Jung et al., 2019). At the time of the evaluation, 10 children with ADHD were participating in a regular exercise program and sports activities. The physiotherapy and sensory intervention approaches that some children received may have reduced the rate of c-MND, which is more associated with motor planning and sensory-motor problems. In addition, the small sample size may also have caused this difference.

Children with neurodevelopmental problems lag behind in terms of motor coordination and balance compared to typically developing children (Yasunaga, Miyaguchi, Ishizuki, Kita & Nakai, 2024). One study investigated eight subtypes of MND and the cognitive status of term infants. It was found that children with fine manipulative disorders and coordination problems had lower scores in attention, memory, learning, and language (Kikkert, de Jong C & Hadders-Algra, 2013). Our study showed that the areas most affected by MND in the ADHD group were coordination (84%), and fine manual skills (44%), consistent with the existing literature. It was hypothesized that this may be a result of impaired attention function in individuals with

ADHD. It may also be explained by the fact that MND leads to dysfunction in the cortico-striato-thalamo-cortical and cerebello-thalamo-cortical pathways, which primarily causes functional problems in fine grasping and coordination (Alexander & Crutcher, 1990). Neurodevelopmental impairments, such as a history of ADHD, play a significant role in the development of MND. However, MND is usually diagnosed after reaching school age. A lack of early diagnosis can result in these children missing vital inputs during critical developmental periods, when interventions provided by families and physical and occupational therapists can improve outcomes (Alkan et al., 2021). The fact that this study included preschool children is important in this aspect. We must remember that MND can lead to issues in children's academic performance, motor development, cognitive abilities, and socio-emotional aspects. It is critical to take the necessary precautions, diagnose these children, and identify dysfunctional areas. Therefore, children with a history of ADHD are at risk for MND. We thought that it may be important to evaluate the neurologic status of children with ADHD in the preschool period.

Children with ADHD have problems compared to their typically developing peers in various areas related to the development of motor control abilities such as speed, timing, balance, and contralateral flow movements (Demircioğlu et al., 2023). A recent meta-analysis study showed that fine and gross motor skills are greatly affected, with executive functions also being affected. (Gandotra et al., 2021). In a study conducted on children with ADHD, it was reported that these children demonstrated poor manual dexterity and had poor handwriting performance (Flapper et al., 2006). In another recent study, it was shown that young adults with ADHD may have deficits in manual dexterity but not in hand strength (Fietsam et al., 2022). Our findings were similar to those in the literature; we found that children with ADHD were behind in all areas of motor development compared to their typically developing peers. While there was no difference between the groups in the grasping area, which is a sub-area of the fine motor area, we found that children with ADHD were behind in the visual motor integration area. This may be explained by the fact that the grasping area, which constitutes the fine motor area, is more related to hand strength, while the visual motor integration area is more related to manual dexterity.

In our study, we investigated how motor development was affected by the addition of the presence of MND in the ADHD group. To our knowledge, no previous similar study has been presented in the literature. In the ADHD group, the total motor and fine motor scores of children with complex MND were found to be lower than in neurologically normal children and children with s-MND. There was no difference in neurological condition and gross motor. Children with ADHD have difficulty focusing and paying attention (Erdem & Pak, 2012). As fine motor skills require more intense focus and attention, this may lead to lower fine motor skill scores in children with ADHD. In addition, participation in fine motor skills increases with increasing age (Marr, Cermak, Cohn & Henderson, 2003). The study included a preschool age group, and the limited participation of children in this age group in fine motor skills may explain the weakness of fine motor skills compared to gross motor skills.

There are many studies in the literature on the co-occurrence of ADHD and sensory processing disorder (Kalig-Amir, Berger, Rigbi & Bar-Shalita, 2019; Delgado-Lobete, Pértega-Díaz, Santos-del-Riego & Montes-Montes, 2020). However, there are very few studies investigating sensory processing disorders in preschool children with ADHD. Children with ADHD have sensory sensitivity and experience more difficulty with sensory processing. Deficits in sensory processing are linked to functional, social, behavioral, and learning difficulties (Sanz-Cervera, Pastor-Cerezuela, González-Sala, Tárraga-Mínguez & Fernández-Andrés, 2017). Studies show that children diagnosed with ADHD have significantly lower total and daily functioning scores in sensory processing compared to healthy children (Mimouni-Bloch et al. 2018). Sensory processing impairments in children with ADHD are seen in their daily activities (Mimouni-Bloch et al., 2018). As a result of sensory profile scores, we found lower sensory processing scores in 14 of 14 domains, including sensory processing, sensory modulation, and behavioral and emotional responses, in the ADHD group compared to the typically developing group. We think it is important to assess children with a history of ADHD for sensory processing and provide appropriate sensory integration therapy or various developmental approaches to avoid problems such as academic difficulties and destructive behavioral disorders.

Strengths and Limitations

One of the strengths of our work studies in the literature have generally analyzed sensory processing and motor development factors independently in children with ADHD. Our study not only focused on motor development and sensory processing but also investigated the effect of neurological status on motor development in individuals with ADHD. Another strength is that the sample of our study consists of preschool children. This study has several limitations First, any sensory intervention children are exposed to affects both motor and sensory development. In this study, there was no information on whether children were exposed to any sensory intervention during the assessment. Second, we included children with ADHD who were not taking medication, so these results may not reflect children with ADHD who were taking medication.

Conclusion

Children with ADHD have more problems with motor and sensory development than typically developing children. It is very important to follow preschool children in this environment and provide them with sensory and physiotherapy treatments to improve their neurological, motor, and sensory development, as well as their cognitive abilities and activities of daily living. When planning an intervention program for children with ADHD, it is important to consider that they are at risk for MND and may lag behind their peers in sensory processing skills and motor development.

Acknowledgement: We would like to thank our research participants.

Ethics Committee Approval: This study was conducted according to the principles of the Helsinki Declaration and was approved by the Ethics Committee of Gazi University (Approval Number: E-77082166-302.08.01-358533).

Informed Consent: Written informed consent was obtained from all participants

CRediT Author Statement: **Ç.Ö.D.** Conceptualization, Methodology, Writing – original draft, Supervision **D.O.** Conceptualization, Methodology, Writing – original draft **B.O.** Methodology, Writing – original draft **E. İ.** Supervision.

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