Balance and Gross Motor Skills Impairments Characterize Young Children With Autism Spectrum Disorders

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder. Recent studies indicate that motor impairments may be the one of the first signs of atypical development in ASD. The aim of the present study was to examine the motor function of young children with ASD, aged 4 to 6 years, in comparison to two groups of age- and gender-matched intellectually disabled (ID) and typically developing (TD) children. In total, 60 children, (20 ASD, 20 ID and 20 TD) participated in the study. The motor skills of the participants were assessed on eight subtests of the Movement Assessment Battery for Children (M-ABC) and seven clinical tests on fine and gross motor skills as well as on balance. Children with ASD had statistically significant lower performance than the TD children and children with ID in tests that examine gross motor skills and balance. Additionally, both ASD and ID groups presented significantly lower performance than TD group in fine motor tasks, but there was no significant difference between the two clinical groups. This study highlighted the specificity of motor impairment in ASD comparing the performance of children with ASD with a clinical group (ID) and a non-clinical group (TD). The present findings align with previous studies which support specific motor impairments of children with ASD and contribute to a better understanding of the specific and subtle motor impairments in ASD as well as to early diagnosis, clinical stratification, and treatment targets.

Keywords: Autism Spectrum Disorder, Intellectual Disability, Motor Skills, Balance

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Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that affects the cognitive and social emotional development of the developing child. Children with ASD experience challenges in communication and may show repetitive, restricted behaviors and interests (Neely et al., 2019).

According to Vlachos et al. (2013) achievements of motor milestones are significant for development and specially during preschool years as this is a critical period for the acquisition of motor skills. It is well known that during the preschool period motor capabilities and fundamental neuroanatomic structures show development, elaboration and myelination (Lakhani et al., 2016).

Even though difficulties in motor development is not the key symptom in the diagnosis of ASD, several studies confirm that motor difficulties are common in children with ASD (Kaur et al., 2018; Odeh et al., 2022; Williams et al., 2012; Wilson et al., 2018) and potentially lead to abnormalities in social communication. Such studies indicate that motor impairments may be one of the first signs of atypical development in children with ASD including basic motor impairments in balance, gait, coordination, fine and gross motor skills (Hirata et al., 2015; Siaperas et al., 2012; Stins & Emck, 2018; Vlachos et al., 2007; Whyatt & Craig, 2012).

However, the assessment of motor function in ASD has been less prioritized compared to other methods of behavioral phenotyping. Majiviona and Prior (1995) found that 67% of children with autism and 50% of children with Asperger syndrome showed an impairment in movement on the Henderson Test of Motor Impairment and Ghaziuddin and Butler (1998) showed that movement problems in Asperger's syndrome as well as in autism were common on the Bruininks- Oseretsky Test of Motor Proficiency. Green et al. (2008) found that 79% of children with autism exhibited definite movement problems on MABC, with an additional 10% showing borderline problems. Siaperas et al. (2012) as well as Whyatt and Craig (2012) found severe difficulties in children with autism compared to typically developing children. More specifically, Whyatt and Craig (2012) evaluated balance and ball skills in children with ASD in comparison with typically developing children and they found that autistic children’s performance was worse compared to the typically developing children in the measured motor skills. In a review published recently, Stins and Emck (2018) reported that children with ASD scored worse than typically developing peers on tests of balance and postural stability and that children with ASD had difficulties in socializing and interaction. In addition, Zhou et al. (2020) found that the severity in the gross motor impairments of toddlers with ASD had a high association with the score of ADOS-2 (Autism Diagnostic Observation Schedule -2nd edition) and the social composite score of CSBS-DP-ITC (Symbolic Behavior Scales-Developmental Profile -Infant Toddler Checklist). Last but not least, in a recent review of Gandotra et al., (2020) it was concluded that children with ASD had less developed fundamental movement skills compared to their typically developing peers, with these difficulties persisting from early years into adulthood.

Despite research evidence indicating common motor difficulties in children with ASD that emerge early in development, there is conflicting evidence regarding which domains of motor development are affected. The present study aimed to investigate the motor function of preschool children with ASD compared to two groups: age-matched intellectually disabled (ID) and typically developing (TD) children, focusing on three motor domains: fine motor skills, gross motor skills, and balance.
Methods

Participants

The sample consisted of 20 children ranged in age from 4 to 6 years ($M = 4.51$ years, $SD = 0.48$) with a diagnosis of ASD (19 boys and 1 girl), 20 children with a diagnosis of intellectual disability (19 boys and 1 girl) and 20 typically developing children (19 boys and 1 girl). The three groups were pair matched for age and gender. The group of children with ASD and ID were also matched on nonverbal IQ, using the Wechsler Non-Verbal (WNV) Scale of Ability (Jaquette et al., 2017; Wechsler & Naglieri, 2006). The WNV Scale of Ability is an individual assessment of general cognitive ability for ages 4 years and 0 months to 21 years and 11 months. The children of the two clinical groups had received a diagnosis of ASD or ID by experienced psychologists and psychiatrists according to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (APA, 2013).

Materials & Procedure

The Movement Assessment Battery for Children (M-ABC; Henderson & Sudgen, 1992) is a clinical assessment test used to determine the extent of impairment in fine and gross motor skills as well as balance (static and dynamic) and was used to assess the children’s motor skills. In more detail, the battery is comprised of 8 subtests which assess posting coins, bicycle trail, bead threading, throwing ball into goal, catching bean bag, jumping over cord, one leg balance and walking heels raised. In addition, 7 clinical tests of motor competency (Dow & Moruzzi, 1958), were used to assess the participants’ motor skills. These clinical tests assessed limb shake, hand declination, toe tapping, past pointing, balance time, weighting time and postural stability. Table 1 presents the three motor domains examined in this study and the corresponding 15 tests used per motor domain. The sum of the scores of the 15 tests per domain gave the total score for fine motor skills, gross motor skills, and balance respectively.

<table>
<thead>
<tr>
<th>MOTOR DOMAIN</th>
<th>TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINE MOTOR SKILLS</td>
<td>MABC TESTS</td>
</tr>
<tr>
<td></td>
<td>Posting coins</td>
</tr>
<tr>
<td></td>
<td>Bicycle trail</td>
</tr>
<tr>
<td></td>
<td>Bead threading</td>
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<tr>
<td>GROSS MOTOR SKILLS</td>
<td>Throwing ball into goal</td>
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<tr>
<td></td>
<td>Catching beanbag</td>
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<tr>
<td></td>
<td>Jumping over cord</td>
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<tr>
<td>BALANCE</td>
<td>One leg balance</td>
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<tr>
<td></td>
<td>Walking heels raised</td>
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<tr>
<td></td>
<td>CLINICAL TESTS</td>
</tr>
<tr>
<td></td>
<td>Limb shake</td>
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<tr>
<td></td>
<td>Hand declination</td>
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<tr>
<td></td>
<td>Toe tapping</td>
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<tr>
<td></td>
<td>Past pointing</td>
</tr>
<tr>
<td></td>
<td>Balance time</td>
</tr>
<tr>
<td></td>
<td>Weighting time</td>
</tr>
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<td></td>
<td>Postural stability</td>
</tr>
</tbody>
</table>

Table 1: Grouping of the motor tests used per motor domain

For each child, assessments took place individually in an empty school class; the duration of each assessment lasted between 30 and 40 minutes and the order of the administration of the tests was the same for all the children.
Results

One-way univariate analysis of variance (ANOVA) was conducted to ascertain whether mean scores on the above-mentioned motor domains (fine motor skills, gross motor skills, and balance) differed significantly across the three groups. Scheffe’s post–hoc test was undertaken in cases where a significant group difference was observed. Table 2 presents the mean and standard deviation on the fine motor skills, gross motor skills and balance scores for the 3 groups of participants, as well as the summary of the statistical analysis.

Statistical analysis revealed significant differences between the three groups in all the three domains (Table 2). Statistically significant differences were found between the three groups in fine motor skills ($F(2, 57) = 50.46; p < .01$). Post hoc comparisons indicated that fine motor skills score of the ASD group ($p < .01$) and the ID group ($p < .01$) differed from the TD group, but there were not significant differences between the ASD and the ID group.

<table>
<thead>
<tr>
<th>Domain</th>
<th>ASD</th>
<th>ID</th>
<th>TD</th>
<th>F (2,57)</th>
<th>Scheffe Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Motor</td>
<td>0.62</td>
<td>0.73</td>
<td>0.61</td>
<td>-0.85</td>
<td>50.46**</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Gross Motor</td>
<td>0.33</td>
<td>0.41</td>
<td>-0.01</td>
<td>0.76</td>
<td>67.80*</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td>-0.04</td>
<td>0.53</td>
<td>0.16</td>
<td>0.45</td>
<td>297.59**</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
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</tbody>
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* * $p < .05$  ** $p < .01$

Table 2: Mean, standard deviation and summary of the statistical analysis for the three groups in terms of performance by motor domain

However, the three groups differed significantly in the gross motor skills ($F(2, 57) = 67.8; p < .01$) and balance scores ($F(2, 57) = 297.59; p < .01$) (Table 2). Scheffe’s post–hoc test revealed that in these two domains children with ASD demonstrated statistically significant different performance compared to both the TD children and children with ID ($p < .01$). Additionally, post hoc comparisons showed the TD and ID groups differed significantly in the gross motor and balance domains ($p < .05$ and $p < .01$ respectively).

Discussion and Conclusion

The aim of the present study was to examine the motor function of young children with ASD, aged 4 to 6 years, in comparison to two groups of age- and gender-matched intellectually disabled (ID) and typically developing (TD) children. Our findings showed significant differences between the three groups in three motor domains (fine motor skills, gross motor skills, and balance). Children with ASD presented statistically significant different performance compared to both the TD children and children with ID in all domains, and children with ID performed better than those with ASD in the gross motor and balance domains.

The present findings are in line with the results of previous studies which demonstrated that children with ASD present severe difficulties in motor skills compared to typically
developing children (Kaur et al., 2018; Odeh et al., 2022; Siaperas et al., 2012; Williams et al., 2012; Wilson et al., 2018). Our results are consistent with previous studies in which children with ASD showed lower performance compared to children with ID in tests evaluating balance and gross motor skills and these findings support the specificity of motor impairments in children with ASD (Stins & Emck, 2018; Whyatt & Craig, 2012; Zhou et al., 2020). Furthermore, our outcomes support the conclusion of a recent study suggesting that impairments in gross motor skills may be an independent predictor of autism severity (Zhou et al., 2020).

Given that the cerebellum is the neuroanatomical structure which coordinates skilled voluntary movements, and controls motor tone, posture, and gait, the motor deficits observed in people with ASD could possibly attributed to cerebellar dysfunction (Cundari et al., 2023). Several studies have shown that deviations in cerebellar function have extensive overlap with ASD symptomatology and both cerebellar dysfunction and ASD could impact on motor competency, social communication, language development, reading, working memory, executive function skills and on affect and emotional behavior (Andreou et al., 2007; Bhat, 2021; Kasselimis et al., 2008; Lord, 2020; Vlachos et al., 2007).

In conclusion, although impaired motor activity is not included in the diagnostic criteria of ASD, motor skill difficulties are often observed. The existing research evidence and the findings of the present study could contribute to a deeper understanding of the specific and subtle motor impairments in children with ASD and observed motor skill difficulties can serve as a marker for early diagnosis, and provide further justification for the inclusion of motor skill development in programmes of early intervention for children with ASD.
References


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