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AUTISM SPECTRUM DISORDER

Fine and Gross Motor Competence in Children With Autism Spectrum Disorder

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Abstract

Autism spectrum disorder (ASD) is characterized by challenges with social communication and the display of restrictive and repetitive behaviors. Research has also shown that children with ASD are behind their typically developing peers in motor skill competence. However, limited studies have used the Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) to assess motor competence of children with ASD. The purpose of this study was to fill the gap and comprehensively examine the fine and gross motor competence of children with ASD. Fifty-three children with ASD between the ages of 7 to 14 participated in the study. This study used the BOT-2 to comprehensively assess the children's fine and gross motor competence. The children with ASD were significantly delayed in all fine and gross motor subtests (i.e., fine motor precision, fine motor integration, manual dexterity, upper-limb coordination, bilateral coordination, balance, running speed, and strength and agility) compared to their typically developing peers. The children with ASD were impaired on all fine and gross motor composites of the BOT-2, with all scoring in the well below average category of the BOT-2. Incorporating fine and gross motor skill practice into the

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therapy treatments and daily activities of children with ASD is recommended for improvement of their social interaction, communication, and reduction in repetitive behaviors in school and physical activity participation.

Autism spectrum disorder (ASD) is often diagnosed in early childhood and affects 1 in 68 children in the United States (Autism Speaks, n.d.; Centers for Disease Control and Prevention, n.d.). Children with ASD are reported to display difficulties in social interaction, communication, and restrictive and repetitive behaviors (American Psychiatric Association, n.d.; Myers & Plauché, 2007). In addition, research has suggested that children with ASD are impaired in motor competence, which refers to the ability of performing fine and gross motor skills according to chronological age (Ayers et al., 2016; Green et al., 2009; Leary & Hill, 1996; Macdonald et al., 2011; Pan & Frey, 2006). Delays in fine and gross motor skills for children with ASD may lead to poor motor coordination, impaired postural control, and balance deficits (Provost et al., 2007; Smith, 2004; Staples & Reid, 2010). Children with ASD are either excluded or not interested in participating in sports and physical activities that require developed fine and gross motor skills, because of their motor delays. For example, Liu and Breslin (2013) used the Movement Assessment Battery for Children-2 (Henderson et al., 2007) to examine the fine and gross motor performance between children with ASD and typically developing children. They found that out of 30 children with ASD, 77% demonstrated significant motor delays and 3% were at risk for motor delays, whereas 100% of typically developing peers showed no movement difficulties. Similarly, Green et al. (2009) concluded that 79% of 101 children with ASD demonstrated definite movement problems, while about 10% demonstrated borderline problems when assessed with the Movement Assessment Battery for Children (Henderson & Sugden, 1992). Researchers have also reported that children with ASD have greater impairments in object manipulation skills such as throwing, catching, and balance in Movement Assessment Battery for Children-2 because of the lack of visual feedback (Ament et al., 2015; Green et al., 2002; Whyatt & Craig, 2012). Similarly, Whyatt and Craig (2012, 2013) also reported that motor deficits in children with ASD were likely due to difficulty with visual, spatial, and temporal characteristics of an action.

Fine motor skill competence can affect children's academic success, communication, and complex motor skill development. Macdonald et al. (2014) concluded that children with ASD's fine motor skill development was about 9.5 months behind their chronological age, suggesting that children with ASD were more delayed on fine motor proficiency compared to their typically developing peers. Delays in fine motor skills are crucial for children with ASD because it most notably affects their handwriting, which can lead to difficulties in academic performance at school (Liu et al., 2016). The immature pencil grasp also makes a child with ASD often feel uncomfortable and show noticeable difficulties in handwriting. Alaniz et al. (2015) found that grip strength correlates with handwriting legibility and children with ASD showed weaker grip strength than typically developing children. Broun (2009) explained that having to engage in handwriting is the most serious impediment to academic achievement for students with ASD, as they typically experience hypotonia, which is the impairment in the ability to execute skilled movements. Difficulties in handwriting can also affect classroom behavior because of the stress from the expectation of written output and from the frustration encountered when children with ASD cannot communicate effectively through their handwriting. Johnson et al. (2015) suggested that difficulties in handwriting for children with ASD are due to fine motor, attention, memory, and linguistic demands that are required during writing. MacDonald et al. (2013) suggested that teaching fundamental motor skills to children with ASD may help in creating an environment for practicing social skills during play, which may lead to positive social interaction with peers and adults. Being proficient in performing motor skills is important because it affects some of the aspects that are typical characteristics of children with ASD, including communication, academic achievement, and social interaction.

In addition to fine motor development, gross motor competence is important for children with ASD because children who have a high proficiency in gross motor skill performance are more likely to be physically active and participate in sports and physical activity. Delays in gross motor skill performance may have a negative impact on balance, social interaction, and motivation to participate in physical activities for children with ASD (Baranek,

2002; Bhat et al., 2011; Liu & Breslin, 2013). Ozonoff et al. (2008) suggested that motor deficits are crucial characteristics in children with ASD, besides social interaction and communication delays. Ming et al. (2007) concluded that hypotonia and apraxia were the main deficits that caused children with ASD to show impairment in gross motor performance. Staples and Reid (2010) used the Test of Gross Motor Development-2 (Ulrich, 2000) to assess the gross motor performance of children with ASD and their typically developing peers. The children with ASD performed gross motor skills at a level equivalent to the typically developing peers half their age. Mache and Todd (2016) found that children with ASD scored an average of 28.6 points lower than their typically developing peers on the Test of Gross Motor Development-3 (Ulrich, 2013). Macdonald et al. (2014) similarly reported that children with ASD were 6.4 months behind their chronological age on gross motor skill development, based on the Mullen Scales of Early Learning (Mullen, 1995). In addition, Van Damme et al. (2015) used the Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2; Bruininks & Bruininks, 2005) to examine the detailed motor profiles of children with different psychiatric disorders. They identified ASD as the most significant predictor for low BOT-2 composite scores. Pan (2014) studied 31 adolescents with ASD and 31 adolescents without ASD aged 10 to 17 years old, using the BOT-2. The children with ASD scored lower on all motor subtests compared to the adolescents without ASD. Pan also reported significant positive correlation between total motor composite and all physical fitness components in adolescents with ASD. These findings suggest that besides fine motor delays, children with ASD are delayed in gross motor proficiency.

Both fine and gross motor competence are important for the motor competence of children with ASD. However, limited research has comprehensively examined both fine motor skill competence and gross motor skill competence in children with ASD. The BOT-2 has been identified as a comprehensive tool in motor competence assessment. Therefore, the purpose of this study was to fill this gap in research and examine the fine and gross motor competence of children with ASD, using the BOT-2. The BOT-2 is a comprehensive measurement of fine and gross motor proficiency and examines four fine and gross motor composites: fine manual control, manual

coordination, body coordination, and strength and agility. Other instruments such as the Movement Assessment Battery for Children-2, which is considered a screening tool for motor competence that assesses limited fine and gross motor tasks, and the Test of Gross Motor Development-2, which only assesses gross motor skill performance for a small age range of children 3 to 10 years old, made it clear that the BOT-2 was the best fit as it allows for a detailed examination of the child's motor competence. The Movement Assessment Battery for Children-2 also tends to make it more difficult to identify the impairments in motor development, listing only one to two motor tasks under each motor subtest, which may not provide enough information for a true representation of the child's fine or gross motor skill competence (Staples, 2013). This study hypothesized that children with ASD would show significant delays in fine and gross motor competence on the BOT-2 compared to their typically developing peers.

Method

Participants

Fifty-three children with ASD participated in the study. They were between the ages of 7 and 14 years old (48 male, 5 female). ASD is 4.5 times more likely to occur in males than in females (Autism Speaks, n.d.; Centers for Disease Control and Prevention, n.d.); therefore, this study has an unbalanced number of male and female participants. Children were included in the study if they had (1) an ASD diagnosis, (2) the capability to understand directions given by the test administrator, and (3) the ability to perform the fine and gross motor tasks as instructed. Children who could not follow instructions and complete all motor tasks were excluded from the study. Consent forms were obtained from parents before their child's participation in the study. This study was approved by the Institutional Review Board.

Instrument

The BOT-2 (Bruininks & Bruininks, 2005) is a comprehensive assessment tool that measures both fine motor competence and gross motor competence for children between the ages of 4 and 21 years. This study used the BOT-2 Short Form measures to represent

four motor composites: *fine manual control*, which had the subtests of fine motor precision and fine motor integration; *manual coordination*, which had the subtests of manual dexterity and upper-limb coordination; *body coordination*, which had the subtests of bilateral coordination and balance; and *strength and agility*, which had the subtests of running speed and agility and strength. The BOT-2 standard scores were determined based on the participant's level of proficiency on each subtest. A child may be classified as *well-above average* if the standard score range is 70 or greater, *above average* if the standard score range is between 60 and 69, *average* if the standard score range is between 41 and 59, *below average* if the standard score range is between 31 and 40, or *well-below average* if the standard score range is 30 or less.

Procedures

The BOT-2 was administered in a quiet classroom with minimum distractions at a local elementary school by Jaclyn Capistran and Sayed ElGarhy. Prior to the test administration, Capistran and ElGarhy received extensive training on administering the BOT-2 tests. General administration directions were taught in a half-day workshop by Ting Liu. Capistran and ElGarhy took a training workshop to familiarize themselves with the BOT-2 testing kit. Each then practiced by going over possible administration scenarios, such as how to verbally instruct children with difficult behavior or how to take scores of a noncompliant child. They then tested two children while being observed by Liu. Feedback was given when administration deviated from standardization. Capistran and ElGarhy were considered proficient on assessing the BOT-2 once they reached 90% agreement with Liu. They proceeded to test for data collection under the supervision of Liu. The interrater reliability was high (98%) between Liu and Capistran and ElGarhy. All participants received verbal instructions and a visual demonstration of each task prior to their motor performance. The participants were given a practice

trial, and if they did not perform the skill correctly, additional instruction and demonstration was provided. All children completed the four subtests in the BOT-2 assessment.

Data Analysis

Descriptive statistical analysis was used to examine children's fine and gross motor competence on the BOT-2 test. Raw scores were converted to the standard scores and a total score using the norm tables in the BOT-2 manual. Standard scores were used to describe each child's level of competence on each subtest. A single sample *t* test was used to compare the mean of children with ASD's performance scores to the mean of the BOT-2 norms. Results were considered significant if the alpha level was less than .05.

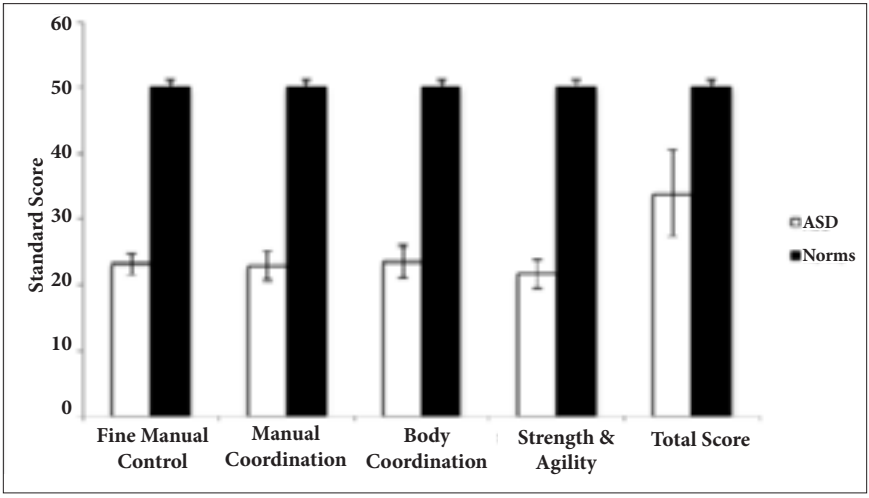
Results

The descriptive analysis showed that 24.5% of the children with ASD scored *well below average* on BOT-2, 66% scored *below average*, and only about 9.5% of the children were classified as *average*. Specifically, 90.5% children with ASD scored in the *well below average* and *below average* classification of the BOT-2.

A single-sample *t* test analyzed children with ASD's BOT-2 standard scores in comparison to their age-matched normative mean. A significant difference was found between children with ASD and the norms, $t(52) = -17.944$, $p < .01$. Children with ASD's standard score mean of 33.85 ($SD = 6.553$) was significantly lower than the normative mean of 50. Single-sample *t* tests were also used in the analysis of children's motor competence on each of the motor composites. Significant delays were found on fine manual control, $t(52) = -120.451$, $p < .01$; manual coordination, $t(52) = -90.996$, $p < .01$; body coordination, $t(52) = -75.616$, $p < .01$; and strength and agility, $t(52) = -96.463$, $p < .01$. These results, compared to the normative data (Figure 1), suggest that children with ASD perform much lower on fine and gross motor skills.

Figure 1

Children With ASD Scored Significantly Lower Than Their Typically Developing Peers on All Four Motor Composites of the Bruininks-Oseretsky Test of Motor Proficiency-2



Discussion

The purpose of this study was to comprehensively evaluate the fine and gross motor skill competence of children with ASD, using the BOT-2. The hypothesis that children with ASD would score significantly lower on fine and gross motor skill competence in comparison to the BOT-2 norms was supported in this study. About 90.5% of children with ASD were classified as either in the *below average* or *well below average* categories, indicating that children with ASD were delayed in fine and gross motor competence. These findings were in line with research stating that motor impairments were common in children with ASD (Dewey et al., 2007). The participants were delayed in all four subtests of fine manual control, manual coordination, body coordination, and strength and agility (Figure 1), with the total score mean being 13.85 points below the norm and standard deviation being 3.45 points below the norm (Table 1). This was consistent with the results of Hilton et al. (2014), who found that children with ASD showed motor impairment in BOT-2 on all four subtests. In addition, the finding that the strength and agility of children with ASD was scored the lowest of all four subtests was similar to Mattard-Labrecque et al.'s (2013) study results that children

with ASD and attention deficit hyperactivity disorder showed poorer strength and agility in the BOT-2 than children with attention deficit hyperactivity disorder alone.

Table 1
Mean and Standard Deviation of the Standard Scores in Each Subtest and Total Score of Children With ASD (N = 53)

Subtest	*M*	*SD*
Fine manual control	23.11	1.63
Manual coordination	22.98	2.16
Body coordination	23.47	2.55
Strength and agility	21.64	2.14
Total Score	91.17	6.48

The findings of this study are important because delays in fine and gross motor skill competence could affect children's academic success, communication, complex motor skill development, physical activity participation, sports performance, and social interaction. Delays in fine motor competence may affect the handwriting legibility, pencil control, and communication of children with ASD (Broun, 2009). Delays in gross motor competence affect physical activity and sports performance because children with ASD are less proficient in balance, body coordination, and strength and agility, which then leads to a lack of motivation to participate and has a negative impact on social interaction (Baranek, 2002; Bhat et al., 2011; Liu & Breslin, 2013).

This study adds new and valuable findings to the literature because it includes detailed results on the fine and gross motor performance in fine manual control, manual coordination, body coordination, and strength and agility of children with ASD. The BOT-2 was useful in providing a comprehensive understanding and specific details on both fine motor competence and gross motor competence in children with ASD. For example, handwriting legibility and finger and pencil control were observed with the drawing of lines through crooked paths in the fine motor precision subtest and with the copying of shapes in the fine motor integration subtest, which are essential aspects of academic success. Specific gross motor

skills such as the ability to balance by walking forward on a straight line and the ability to dribble a ball with alternating hands could be a determining factor of the reason children with ASD do not participate in physical activity or sports. The findings of this study were also in line with Pan's (2014) results, suggesting that children with ASD generally show a great delay in the motor composite of strength and agility.

Future studies may consider implementing fine and gross motor interventions on children with ASD. Many researchers have reported that utilization of interventions may improve the fine and gross motor competence of children with ASD. Wuang et al. (2010) found that after a 40-week horseback riding program, the children with ASD showed significant improvement on bilateral coordination, based on the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978). In addition, Srinivasan et al. (2015) implemented a rhythmic and robotic intervention to assess the motor competence of children with ASD, using the BOT-2. They found that after an 8-week training, the rhythm and robot groups who engaged in whole-body gross and fine motor games to the beat of music improved on body coordination, while the comparison groups who were engaged in sedentary fine motor imitation activities improved on the fine manual control composite of the BOT-2. These results suggest that interventions have positive impacts on the motor competence of children with ASD. Furthermore, the children's physical activity participation and the characteristics of academic performance were not collected in this study, which may help better explain the connections of motor competence to school success. Future research may collect this information to have a better understanding of the relationship between motor delays and academic performance.

In summary, this study indicates that children with ASD have definite movement impairments in fine and gross motor skill competence on the BOT-2 compared to their typically developing peers. It is recommended that researchers and educators incorporate fine and gross motor skills in their training programs, interventions, or curriculum to enhance the motor competence of children with ASD. Adding fine and gross motor skills to the daily activities of children with ASD may improve their academic success, communication, physical activity participation, and social interaction.

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