

The Relationship of Motor Skills and Social Communicative Skills in School-Aged Children With Autism Spectrum Disorder

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Motor skill deficits are present and persist in school-aged children with autism spectrum disorder (ASD; Staples & Reid, 2010). Yet the focus of intervention is on core impairments, which are part of the diagnostic criteria for ASD, deficits in social communication skills. The purpose of this study is to determine whether the functional motor skills, of 6- to 15-year-old children with high-functioning ASD, predict success in standardized social communicative skills. It is hypothesized that children with better motor skills will have better social communicative skills. A total of 35 children with ASD between the ages of 6–15 years participated in this study. The univariate GLM (general linear model) tested the relationship of motor skills on social communicative skills holding constant age, IQ, ethnicity, gender, and clinical ASD diagnosis. Object-control motor skills significantly predicted calibrated ASD severity ($p < .05$). Children with weaker motor skills have greater social communicative skill deficits. How this relationship exists behaviorally, needs to be explored further.

Keywords: autism spectrum disorder, social skills, calibrated autism severity, motor behavior

Autism spectrum disorder (ASD) is a pervasive developmental disorder characterized by deficits in social skills, communication and repetitive or restricted interests (American Psychological Association [APA], 1994, 2000). Prevalence statistics

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suggest that 1 in every 88 children are diagnosed with ASD (Centers for Disease Control & Prevention [CDC], 2012). For school-aged children with ASD programs and services are focused on core impairments, which are part of the diagnostic criteria, deficits in social communication skills, and often packaged as a “social skills” program. Social communicative deficits for children with autism range in nature, however more generally these children experience difficulties in reciprocal social communication, initiating social interactions and verbal (i.e., language) and nonverbal communication (i.e., eye contact and gestures). Many social skills programs have been successfully indicated in research and practice. However more recently program efficacy along with the application of learned social skills beyond the treatment setting have come into question (Bellini & Peters, 2008; Bellini, Peters, Benner, & Hopf, 2007; Chamberlain, Kasari, & Rotheram-Fuller, 2007; Kasari, Locke, Gulsrud, & Rotheram-Fuller, 2010; Williams White, Keonig, & Scahill, 2007).

One avenue that has been underexplored is the effect that motor skills play in the social development of children with ASD. Deficits in the social communicative domain are so prominent that “best practice” recommendations for programs and intervention have been created by leaders in the field of ASD. One recommendation indicates that skill practice is critical to apply learned skills beyond the treatment setting (Lord, 2000; Rao, Beidel, & Murray, 2008). For school-aged children social communicative practice might include school-based play or common schoolyard activities; these activities often require relatively proficient motor skills to participate with success (Berkeley, Zittel, Pitney, & Nichols, 2001; Ulrich, 2000). Motor skill deficits are common among school-aged children with ASD and may in turn be hindering opportunities for social communicative practice (Berkeley, et al., 2001; Green et al., 2002; Green et al., 2009; MacDonald, Jaszewski, Esposito, & Ulrich, 2011; Staples & Reid, 2010).

Motor skill deficits are present and persist in school-aged children with ASD (Berkeley, et al., 2001; Staples & Reid, 2010). In a large, well-defined sample of 10- to 14-year-old children with ASD ($N = 101$), 79% presented with motor skill deficits (Green, et al., 2009). It has been suggested the severity of motor skill deficit is driven by intellectual ability, in other words, children with lower overall developmental levels have weaker motor skills (Green, et al., 2009). Yet, research suggests that motor skill deficits cannot entirely be attributed to intellectual ability (Green, et al., 2002; Lloyd, MacDonald, & Lord, 2013). When a higher-functioning group of children with ASD were compared with children with a motor skill specific disability (developmental coordination disorder, commonly referred to as DCD), children with ASD had the weakest motor skills (Green, et al., 2002). This finding indicates the depth of motor skill deficits in children with ASD.

Children with ASD have deficits in locomotor and object-control skills based on the Test of Gross Motor Development-2 (TGMD-2), a valid and reliable measure of motor skills (Berkeley, et al., 2001; Staples & Reid, 2010; Ulrich, 2000). The TGMD-2 assesses the locomotor skills running, galloping, hopping, sliding, leaping, and jumping as well as the object-control skills overhand throwing, striking, kicking, underhand rolling, dribbling, and catching (Ulrich, 2000). The skills tested on the TGMD-2 are considered essential skills needed in physical education and active play (Ulrich, 2000). A more recent study, using the TGMD-2, corroborated previous findings and reemphasized that children with ASD could perform the fundamental motor skills on the assessment, but in a less mature form (Staples &

Reid, 2010). In this study Staples & Reid (2010) used two control groups, age-matched typically developed peers and children matched on the raw scores of the TGMD-2 (younger children). They concluded that children with ASD performed movement skills at a level equivalent to children half their chronological age (i.e., 10-year-old children with ASD performed motor skills equivalent to a 5-year-old).

Generally, findings from social skills-based research for school-aged children with ASD indicate some immediate social change, but longitudinal social change and generalizing learned skills over time was undoubtedly a limitation of interventions (Lopata, Thomeer, Volker, Nida, & Lee, 2008; Lopata et al., 2010). Nevertheless, it has been established that social skills interventions are a necessity in any educational program for children with ASD, based on the extensive social deficits experienced in this group (McConnell, 2002).

ASD symptomology is thought to be modifiable and peer relationships possible when a favorable environment has been provided (Bauminger & Kasari, 2000; Bauminger, Solomn, et al., 2008a; Bauminger, Solomon, et al., 2008b; Bauminger, Solomon, & Rogers, 2010; Pan, 2009). Teaching functional motor skills to children with ASD may help in creating such an optimal environment and in turn provide a context for practicing social skills during physical play leading to further social success. From the literature that has been reviewed, more work is needed in developing efficacious programs to teach both social skills and to facilitate learning motor skills (Lloyd, MacDonald, & Lord, 2013; McConnell, 2002; Staples & Reid, 2010). But, what is unknown is the relationship of these skills to each other.

Even though motor skill deficits are present in school-aged children with ASD, the major developmental area of concern and focus of intervention is on social communicative skills. The importance of providing efficacious social programming for school-aged children with ASD has clearly been established (Lord, 2000; McConnell, 2002). However, there is less agreement on the specific content of social skills programs (Bellini, et al., 2007; Gresham, Sugai, & Horner, 2001; Kasari & Rotheram-Fuller, 2005). Researchers are still working on methods of “best practice”, but, for the most part, literature supports programs that provide flexibility, naturalistic settings, and the opportunity for social communicative skill practice (Elliott, Malecki, & Demaray, 2001; Gresham, et al., 2001; Lim, Kattapuram, & Lian, 2007; Rao, et al., 2008). Based on these recommendations it seems reasonable to consider that proficient motor skills may help in establishing optimal opportunities to practice social skills.

The purpose of this study is to determine whether the functional motor skills, as measured by the TGMD-2, of children ages 6–15 with high-functioning ASD, predict success in standardized social communicative skills. It is hypothesized that children with better motor skills will have better social communicative skills.

Method

Participants

The participants for this study were recruited as a part of a school-based social skills research project. All participants had an educational classification of ASD and met the diagnostic criteria for ASD based on the Autism Diagnostic Observational Schedule (ADOS; Lord et al., 2000). The participants were between the ages of 6–15,

had an IQ score above 64, and were included in typical classrooms. Participants were selected based on the school districts participating in the social skills based research project. Eligibility criteria for the social skills research project included that all participants had an IQ of 64 or above to participate (the project was focused on high-functioning children with autism). None of the participants in this study had additional diagnoses of sensory or physical disabilities. The Institutional Review Board approved all methods and procedures for this study. The participants for this study were students in the public schools. Permission to work within the school was obtained from the superintendent, the head psychologist, principals of the schools, and teachers whose students were eligible to participate in this study. All parents signed informed consent and all participants assented before the start of the study.

Measurements

Motor skill measurement. The motor skills of each participant were measured using the TGMD-2 (Ulrich, 2000). The TGMD-2 is a valid and reliable assessment of motor skills for children (Ulrich, 2000). The TGMD-2 is divided into two subtests: locomotor skills and object-control skills. Although the TGMD-2 is a norm-referenced test for children aged 3- to 10-years-old, it has been used frequently in older children, especially older children with disabilities (Berkeley, et al., 2001; Morin & Reid, 1985; Staples & Reid, 2010). The maximum raw score for the locomotor is 48 and the maximum raw score for the object-control scale is 48 (Ulrich, 2000). Interrater reliability was established at 80% before the study began.

Child diagnostic measure. All participants had an educational classification of ASD and a confirmatory diagnosis of ASD or PDD-NOS was determined by administering the ADOS, a valid and reliable semistructured standardized assessment of communication, social interaction and play (Gotham, Risi, Pickles, & Lord, 2007; Lord, et al., 2000). Prestablished diagnostic algorithms and cut-points informed diagnosis (Gotham, et al., 2007; Lord, et al., 2000). Each member of the research team was research trained in the ADOS and established interrater reliability exceeding 80% exact agreement ($\kappa > 0.60$) for all ADOS items on three consecutive administrations before the study began. All ADOS administrators were research trained and reliable before administering the ADOS.

Intelligence quotient (IQ). The Stanford-Binet Intelligence Scales, fifth edition (SB-5) were used to measure each participant's IQ (Roid, 2003). This is a valid and reliable measure of IQ for individuals from ages 2–85 years (Roid, 2003). This assessment was used to ensure that the participants in this study had an IQ above 64. This test has been used previously for children in this age range to confirm IQ. All team members had experience and practice in administering this standardized assessment.

Measure of social skills. Teachers of the participants completed the Social Skills Improvement System (SSIS) Rating Scales (Gresham & Elliott, 2008). The SSIS is a valid and reliable measure of social skills for children (Gresham & Elliott, 2008). A standard social score is derived from this tool based on social skills, problem behaviors, and academic performance (Elliott, Gresham, Frank, & Beddow, 2008).

A calibrated ASD severity score (CSS) was derived as a measure of social communicative skills based on algorithms established through the ADOS (Gotham, Pickles, & Lord, 2009; Gotham, et al., 2007). The calibrated autism severity score range is 1–10 (Gotham, et al., 2009). The calibrated severity scores were mapped based on ADOS raw scores, which represent core deficits specific to the social communicative domain and the basis of ASD characteristics. These deficits of social skills, communication and repetitive behaviors, or restricted interests were based on the standardized semistructured interview, administered to the individuals through presses (a common term used in the ADOS, a press is based on the manualized protocol for ADOS administration) meant to obtain and give opportunity for social communication based on age and language level (Lord, et al., 2000). The calibrated severity scores were calculated independent of cognitive function (Gotham, et al., 2009). In other words, cognitive function is not indicative of ASD severity. Of interest to the study, the calibrated severity scores did not consider motor skills in the algorithm.

Procedures

For the most part, all of these assessments were conducted during one session. In rare instances some children would need a break and the assessment took part over a two-day period.

Data Reduction

All administrators strictly adhered to the standardized procedures outlined in each respective test manual. ASD cut-off was based on standardized revised algorithms (Gotham, et al., 2007). Calibrated ASD severity was calculated based on standardized algorithms (Gotham, et al., 2009). Raw scores from the TGMD-2 were used for analysis as some of the participants exceeded the age of the norm-referenced motor scores. Descriptive characteristics of the sample included age, gender, ethnicity, and IQ.

Data Analysis

Data analysis tested the effect of motor skills measured by the TGMD-2 on the standard social skills of children with ASD as indicated by the SSIS and the calibrated autism severity. The univariate GLM (Garson, 2012) was used to test the relationship of motor skills on social communicative skills holding constant age, IQ, ethnicity, gender, and clinical ASD diagnosis (ASD or PDD-NOS). The univariate GLM was chosen based on the ability to analyze fixed factors and covariates as predictors (Garson, 2012).

Results

A total of 35 participants with a confirmed diagnosis of ASD ($N = 23$) or PDD-NOS ($N = 12$) were included in this study (mean age 9.2 (± 2.5) years). Descriptive characteristics of the sample can be found in Table 1.

Table 1 Descriptive Characteristics of the Participants

Variable	Mean/Frequency <i>N</i> = 35
Age (years)	*9.2(2.5)
Gender	25M, 10F
Race/ethnicity	21 Caucasian, 2 African American, 8 Hispanic, 4 Asian American
Autism diagnostic classification	23 ASD, 12 PDD-NOS
Test of gross motor development–total	*61.1(12.7)
Test of gross motor development–locomotor	*30.9(8.0)
Test of gross motor development–object-control	*30.2(6.6)
IQ–Stanford Binet	*94.77(19.88)
Calibrated autism severity score	3–10 (range)

*Mean (standard deviation)

Motor Skills and Calibrated ASD Severity

The univariate GLM (general linear model) was performed fitting total raw motor skills indicated by the TGMD-2 (Ulrich, 2000), IQ, age, gender, ethnicity, and ASD diagnosis based on up-to-date algorithms (Gotham, et al., 2007). The univariate GLM is used to run regression and ANOVA models. The univariate GLM allows for fixed factors, random factors, and covariates as predictors (Garson, 2012). There were no significant interactions. Total raw motor skill scores were not a significant predictor of calibrated ASD severity holding all other variables in this model constant. The only significant predictor in this model was gender ($p < .05$). The univariate GLM was performed on each subscale of the TGMD-2, the locomotor subscale and the object-control subscale. The locomotor subscale did not predict calibrated ASD severity. The only predictor in this model, fitting locomotor raw scores, IQ, age, gender, ethnicity, and ASD diagnosis, was gender ($p \leq .05$). When the univariate GLM was performed on the subscale of object-control, motor skills were a significant predictor of calibrated ASD severity ($p < .05$; see Table 2). Holding all variables in this model, constant object-control skills significantly predicted calibrated ASD severity ($p < .05$). The other predictor in this model was gender ($p < .05$).

Motor Skills and Standardized Social Skills

The univariate GLM fitting total raw motor skills scores, IQ, age, gender, ethnicity, and ASD diagnosis was performed and the standardized social skills as indicated through the social skills skills improvement system (SSIS). There were no significant interactions. The univariate GLM was performed on subscales of the TGMD-2, the locomotor subscale and the object-control subscale. Neither the locomotor or object-control subscale predicted standardized social skills, as indicated through the SSIS.

Table 2 Univariate GLM for TGMD-2 Raw Scores on Calibrated Autism Severity Scores

Motor Skills	Mean (Standard. Deviation)	<i>p</i>	F	df	Effect Size
Total (raw score)	61.1(12.7)	.301	1.149	1	0.73
Locomotor (raw score)	30.9(8.0)	.877	0.067	1	0.16
Object-control (raw score)	30.2(6.6)	.044*	4.852	1	0.91

* Indicates statistical significance ($p < .05$)

Discussion

The object-control skills of school-aged children with ASD predict social communicative skills as indicated through calibrated autism severity scores (Gotham, et al., 2009). Although the motor skills of school-aged children with ASD did not map on to social communicative skills based on the SSIS, it is possible that the calibrated autism severity scale is more indicative of social communicative skills in this group of children. The calibrated autism severity scores have been validated in children with autism and come from algorithms with strong sensitivity and specificity (Gotham, et al., 2009; Gotham, et al., 2007). Deficits exist in both the social communicative and motor skills of children with ASD, but the relationship of these skill sets has been underexplored. School-aged children with ASD have consistently performed poorly on standardized tests of motor skills (Berkeley, et al., 2001; Green, et al., 2002; Green, et al., 2009; Staples & Reid, 2010). Although descriptive studies have clearly indicated motor skill deficits in children with ASD, the focus of intervention for school-aged children has been social skill development and very few motor skill interventions have been implemented (MacDonald et al., 2012; McConnell, 2002). Calibrated autism severity scores have been ideally indicated for the comparison of assessments across time (and age), and to identify trajectories of ASD severity independent of verbal IQ (Gotham, et al., 2009). The relationship of standardized object-control skills to calibrated ASD severity implies motor skills are impacting the social communicative skills of children with ASD. Children with weaker object-control skills, based on the TGMD-2 (Ulrich, 2000), had higher calibrated severity scores, indicative of more severe ASD symptomology and therefore poorer social communicative skills (Gotham et al., 2009).

Previous to calibrated severity scores, ASD “severity” was comprised of common stand-ins such as language delay, cognitive function, behavioral issues, and raw scores from the ADOS (Gotham, et al., 2009; Lovaas, 1987; Sutter, Pandey, Esser, & Rosenthal, 2007). However, none of these substitutes constitute valid and reliable methods of severity assessment. Calibrated severity scores were drawn from ADOS raw scores, which represent core deficits specific to the social communicative domain and the most common behaviors of ASD. Calibrated severity scores are independent of cognitive function (Gotham, et al., 2009). In other words, cognitive function is not symptomatic of ASD severity. The relationship of object-control skills to calibrated ASD severity may help to better understand ASD

as a whole, and further how motor skills influence social communicative skills and the core characteristics of ASD.

The social deficits of school-aged children with ASD are the hallmark characteristic of the disability and the primary focus of intervention (Machalicek et al., 2008; Williams White, et al., 2007). However, social skills driven interventions have only shown minimally effective social skill improvements (Bellini, et al., 2007). Generally, it appears that some immediate social improvement occurs, but longitudinal social improvement is weak and generalizing learned skills over time is undoubtedly a limitation of social communicative interventions. Regardless of the limitations to current social skills research, it has been established that social skills interventions are a necessity in any educational program for children with ASD (Lord, et al., 2000; Lord et al., 2005; McConnell, 2002).

Since object-control skills map on to the calibrated severity of ASD, and since calibrated severity captures the social communicative deficits of this group of children, it is possible that improved motor skills may impact social communicative success. Although total motor raw scores did not predict calibrated autism severity, gender appeared as a predictor in this model. In this study, boys with ASD had worse social communicative skills than girls with ASD; this finding needs to be further explored in future work. Behaviorally higher levels of social communicative success have been established when children participate in games on the playground. For example, children participating in sports like soccer, or games like four-square (a common ball-game on the playground), are ranked in the highest category of social communicative success (Kasari, et al., 2010). It is less clear whether children's lack of participation in movement games on the playground are due to deficits in motor skills, or whether the social aspect of the game is too complex or intimidating. Creating successful environments for children to practice social skills is important, and for school-aged children the playground is an important social context to explore. How improved motor skills may impact this avenue of social skill generalization is an area of future research.

Although motor skills did not predict standardized social skills, based on the SSIS, there is a need to further established assessments that capture changes based on intervention (Matson & Wilkins, 2009). Finding measures with strong sensitivity and specificity are a necessity (Gotham et al., 2009). The calibrated autism severity scores have been validated on children with autism, whereas the SSIS was standardized in typically developed children. Currently, the calibrated ASD severity scores are the closest measure to capture the core social communicative characteristics with the necessary specificity and sensitivity for children with ASD (Gotham et al., 2009).

Limitations

Standardized assessments are important in research and practice and standardized measures of social skills fall into this category. Yet, researchers often measure social skills differently across studies. A more standardized and sensitive measure of social change would be optimal for this study and it is a challenge to find a standardized measure as such. Calibrated severity is independent of IQ, however, children with ASD have a broad range of IQ and this particular study was limited to children with an IQ above 64. A more comprehensive study would include children with ASD, regardless of IQ scores.

Future Research

Future research needs to further explore how motor skills and social skills are related. Learning how motor skills map onto social change and whether improved motor skills correspond with positive social development is an area of future study. Social skills are a priority in ASD research. But, understanding other factors that may impact social success is important. Content of social skills intervention has been questioned, and motor skills have not been included in the discussion. This study shows that a relationship exists. Understanding the depth of this relationship needs to be explored further.

Conclusion

School-aged children with ASD have both motor skill and social communicative deficits. The hallmark characteristics of ASD are deficits in the social communicative domain. This study provides an initial relationship between motor skills and social communicative skills as indicated through the calibrated severity scores. Children with weaker motor skills have higher calibrated severity scores. How this relationship exists behaviorally, and from a social skills programming perspective, needs to be explored further. However, given the necessity of social skills programs for school-aged children with ASD and the broader need to explore specific social skills content, motor skills need to be included in the discussion.

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