The Motor and Social Communicative Skills in Young Children with Autism Spectrum Disorders

by
Ayesha Khader

A PROJECT

submitted to

Oregon State University

University Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Bioengineering
(Honors Scholar)

Presented May 15th, 2015
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Megan MacDonald

Interventions for young children with Autism Spectrum Disorder (ASD) focus on core impairments in social communication skills, yet studies have shown a relationship between social and motor skill deficits in children with ASD. The purpose of this study is to further examine individual levels of gross and fine motor skills in relation to social communication skills of young children with ASD. Using the Peabody Developmental Motor Scales – Second Edition (PDMS-2) and specific sections of modules 1 and 2 of the Autism Diagnostic Observation Schedule (ADOS), the relationship between motor skills and social communicative skills are explored. Pearson Correlation coefficients are used to describe the relationship between motor skills and social communicative skills for children with ASD and typically developing children. Results indicate strong negative correlations between fine, gross, and total motor skill scores and ADOS calibrated severity scores. Children with ASD are found to display strong motor skills in relation to strong social communicative skills. In an effort to improve the motor and social communicative skills of young children with ASD, further exploration is warranted.

Key Words: ASD, autism, children, motor skills, communication skills, characteristics, correlations, motor development, ADOS, PDMS-2, social skills, Pearson Correlation coefficients

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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Introduction

Children with autism spectrum disorder (ASD) are subject to deficits in motor skills and social or communicative skills (Todd, 2012). While social communication skills of children with ASD have been explored, motor skills have received less attention (Staples, MacDonald, & Zimmer, 2012). Interventions tend to focus on a child's communicative skills but neglect to acknowledge the possible connection between motor skills and social skill deficits. Research has suggested that children with stronger motor skills have better communication skills (MacDonald, Lord, & Ulrich, 2013b; Staples & Reid, 2010); however, how this relationship exists behaviorally warrants further exploration (MacDonald, 2011). As more information is gathered, research has indicated that interventions for children with ASD can be improved to accommodate for impairments in motor skills and social interaction (MacDonald, Lord, & Ulrich, 2013a; MacDonald, et al., 2013b).

Children with well-developed motor and social skills have an easier environment in which they can engage in play and activities with others. The ability to interact with their peers increases emotional and physical health, as well as self-confidence in social situations (Loprinzi, Cardinal, Loprinzi, & Lee, 2012). In a study that examined the relationship between motor skills (fine and gross) and calibrated severity of young children with ASD (N=110), pervasive developmental disorder – not otherwise specified (N=26), and non-ASD (N=23), found that motor skills significantly predicted calibrated autism severity (MacDonald, 2011). This suggests a clear relationship between the two developmental areas of interest. The purpose of this study was to further examine the

relationship between motor skills and social communicative skills in typically developing children and children with ASD, by targeting specific aspects of each skill.

Autism Spectrum Disorder (ASD)

ASD is an inclusive term for a group of neurodevelopmental disorders that share similar impairments in communication, reciprocal social interaction, and restricted repetitive behaviors (American Psychological Association [APA], 2013). ASD includes autism, Asperger's/High Functioning Autism, pervasive developmental disorder (PDD), and pervasive developmental disorder – not otherwise specified (PDD-NOS) (APA, 2013), that previously were diagnosed separately (Centers for Disease Control and Prevention [CDC], 2015). However, ASD is now understood as one unified term that exists across a continuum of severity (APA, 2013). The 4th Edition of the Diagnostic and Statistical Manual of Mental Disorders included a disorder called Asperger's Syndrome, however the 5th edition now places Asperger's under the umbrella diagnostic term ASD (National Institutes of Health [NIH], 2015). Asperger's and autism are different due to the less severe symptoms and absence of language delays in children with Asperger's (Autism Society, 2014). Asperger's is often referred to as a less severe form of autism, and now the characteristics of Asperger's are included within the broader category of ASD (NIH, 2015).

ASD is one of the more frequently observed childhood neurodevelopmental disorders (Downs & Downs, 2010). ASD generally affects 1 in 68 individuals (CDC, 2014), and approximately 1 in 50 school-aged children (Blumberg, et al., 2013). ASD can affect a child from birth and the symptoms may or may not improve over time. Children present symptoms within a few months of life or later around 2 years of age (CDC,

2015). Children with ASD may appear to be typically developing until they begin to show delays in skill development or lose skills that they once had. Over one third of parents of children with ASD will notice unusual behavior before the child's first birthday, and over 80% of parents noticed problems by the age of 2 (CDC, 2015). In a study examining the early detection and diagnosis of autism and ASDs as well as the broad phenotype of ASD in young children, the results show a focus on social interactions (Yirmiya & Ozonoff, 2007). The results showed that early phenotypes that would often precede ASD were impairments in social orientation, receptive communication, social affective engagement, and reactivity. These impairments were exemplified by such behaviors as waving their arms or covering their ears with their hands more frequently than a comparison group (Yirmiya & Ozonoff, 2007). This suggests that motor skills and movements may precede a diagnosis of ASD, yet are addressed in relation to social communicative skills.

Motor Skills

Motor skills consist of underlying capacities (motor abilities) that contribute to performing movements (such as throwing a ball). These include general abilities such as balance, hand-eye coordination, and strength (Staples & Reid, 2010). It is important to note that "motor" and "movement" are two separate constructs. The words motor and movement are used inconsistently throughout literature but is important to distinguish the difference in order appropriately use developmental assessments. Motor skills are not directly observable and are assessed through observation of movement skills. Motor skills build a movement, which is an observable act that is divided into two general types for measurements, process and product. The process refers to patterns, performance, and

accuracy (i.e. for a throw). The product refers to several variables that define the outcome, such as distance, time, energy, mass, frequency, etc. In the measurement of motor skills most assessments focus on product and coordination of these skills to see if the skill is impaired, and there is less importance placed on the process. However, the process is important for assessment of motor skills (Staples, et al., 2012), as it requires the movement itself (movement skill) and maintained lateral stability of the body (motor skill) (Longuet, et al., 2012).

Motor skills are vital for the performance of movement (Todd, 2012). Children with ASD have difficulty performing movements such as running, jumping, cycling, throwing, and catching (Staples & Reid, 2010). This difficulty affects the ability to participate in games or sports that include those skills (Todd, 2012). Fundamental movements are building blocks for more advanced skills. For children to have well-developed skills, they need instruction, practice and reinforcement. The 2012 Todd study builds a connection between motor deficits and ASD before moving to how children learn through imitation, how individuals with ASD have reduced postural control, and how physical activity is beneficial. Individuals with ASD have poor motor skills, and the study addresses how poor motor skills via intervention construction can benefit young children with ASD (Todd, 2012). In contrast to the Todd 2012 study, this study addresses deficits in motor skills in relation to specific social communicative skills, which can be translated to programs adapted to improve motor skill development in young children with ASD.

The motor skills of young children with ASD could use further exploration (MacDonald, 2011). Understanding motor development deficits in young children with

ASD is important because motor deficits affect other aspects of a child's life (Robinson, 2013). Specifically, without the early development of motor skills, the resulting movement skills are impaired, which can translate to decreased physical activity (Robinson, 2013). Movement is a cumulative and sequential process that develops and changes over time. Even typically developing preschool-age children do not always receive appropriate guidance or development, and this can cause developmental delays in their motor skills (Robinson, 2013). With early well-developed motor skills, children are more competent, and they gain confidence to engage in social activities and play with others (Robinson, 2013).

ASD and Motor Skills

When "autism" is searched on the current American Psychological Association website, it is defined as a severe developmental disability involving deficits in social interactions and communication. However, the APA does not mention motor development or motor skills (American Psychological Association, 2012). However, young children with ASD do in fact show delays or deficits in their motor skills, and these have even been suggested as preliminary diagnostic characteristics of ASD (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; MacDonald, et al., 2013a; MacDonald, et al., 2013b).

A developmental *delay* is when a child does not reach developmental milestones at the expected times. For example, young children with ASD often have delays in walking when compared to typically developing children (Ozonoff, et al., 2008). However, if a child is temporarily behind in development then this is not considered a delay. The sooner a young child with a developmental delay receives attention and early

intervention, the greater the progress can be in early development (Boyse, 2010). In contrast, Merriam-Webster defines a *deficit* as a lack or impairment in a functional capacity. This suggests that a deficit is long term and permanent, whereas a delay may be long term but can be treated. The culmination of developmental delays can result in deficits in the performance of motor skills (Staples, et al., 2012). Individuals with ASD often show developmental delays before they reach 2 years of age, and if these are not addressed than those delays can turn into life-long deficits in vital areas of development (CDC, 2015).

There are several factors that may influence the understanding of motor and movement impairments in young children with ASD. A study that focused on the motor coordination in young children with ASD examined motor coordination deficits as an underlying feature of ASD (Fournier, et al., 2010). Eighty-three ASD studies that focus on motor coordination, arm movement, gait, or postural stability deficits were found (Fournier, et al., 2010). Results indicated that impairments in gait and balance, arm motor functions, and movement planning were observed and suggested to be due to underlying neurobiological changes in regional and functional brain anatomy. This meta-analysis of the existing literature concluded that ASD is associated with significant and widespread alterations in motor performance, and that motor coordination delays and deficits are existent across diagnoses and therefore are a characteristic of ASD (Fournier, et al., 2010). A 2015 comprehensive review of evidence-based practices for individuals with ASD listed several reviews that have previously been done, none of which addressed motor skills or motor development. The study looked through 456 intervention articles for children with ASD and found that outcomes were associated with social,

communication, and challenging behaviors, but motor skills were excluded (Wong, et al., 2015), even though motor skill deficits are a key characteristic of ASD (Fournier, et al., 2010).

Motor skill developmental delay has been indicated in young children with ASD (MacDonald, Lord, & Ulrich, 2014; Lloyd, MacDonald, & Lord, 2011), who perform movement skills at a level equivalent to children half their chronological age (Staples & Reid, 2010), suggesting that young children with ASD have decreased motor skill development. A study by Lloyd and colleagues in 2011, found that fine motor skills are delayed in young children (12 – 36 months of age) with ASD and would fall further behind as they got older. Differences became significantly greater with each 6-month period of chronological age, which constitutes that a delay in motor skill development may exist. Over a time period of one year, the developmental gap in the fine and gross motor skills significantly widened (Lloyd, et al., 2011), suggesting that children with worse motor skills also have higher severity scores, which indicate the level of deficits in social skills, displaying an initial relationship between core deficits and motor skills (MacDonald, 2011).

Motor skill impairments often appear early in life for young children with ASD (MacDonald, Lord, & Ulrich, 2013a) described in literature as uncoordinated, relatively slow, and inaccurate (Todd, 2012). The consensus indicates that young children with ASD have a difficult time performing skills such as running, jumping, cycling, throwing, and catching. These children's scores generally fall below the 15th percentile. Delays in motor skills can affect the children's ability to participate in games or sports that include those skills (Todd, 2012). A 2010 study by Staples and Reid, investigated the

fundamental motor skills in 9 to 12 year old children with ASD. These children were compared to three typically developing groups, matched based on chronological age, movement skill equivalence, and mental age equivalence. The study found that the children with ASD performed movement skills similar to typically developing children half their chronological age indicating that the movement skills of children with ASD were more impaired than expected based on their cognitive level (Staples & Reid, 2010). Essentially the fundamental movement skills of young children with ASD suggest considerable deficits and delays by late childhood (Staples & Reid, 2010).

One avenue used to examine the planning of a motor movement is determining how a child with ASD plans to reach a goal. A study focusing on goal directed locomotion and balance control of children with ASD found that the main components affected during locomotion are the goal of the action and the orientation towards this goal, as well as the trajectory due to an impairment of movement planning (Vernazza-Martin, et al., 2005). Typically developing children (N =6) and children with ASD (N = 9) were instructed to walk 5 meters. Close to 80% of the children with ASD were not able to achieve the goal of the tasks, even with verbal reinforcement, and many of the children stopped before reaching the destination of five meters. The study concluded that children with ASD have disturbance of pattern maintenance and impairments in movement planning, which affect goal-directed locomotion (Vernazza-Martin, et al., 2005; Longuet, et al., 2012).

ASD and Motor Skills, Physical Activity, Health and Interventions

It is often a challenge for people with ASD to participate in physical activity (PA) because of poor motor function, low motivation, and difficulty in planning and self-

monitoring. Therefore, the promotion of physical activity that includes complex motor skills can be an obstacle (Todd & Reid, 2006). A study by Tyler, MacDonald, and Menear (2014) indicated that children with ASD (ages 9 to 17 years) are less physically active when compared to typically developing peers. The study suggests adapted PA programs can be used to increase the physical activity and fitness of children with ASD (Tyler, MacDonald, & Menear, 2014). People with ASD also face challenges in participating in team activities because of difficulty in performing fundamental physical skills (Staples, et al., 2012). Physical activities that are not team oriented and are less skill-based, are more appealing and accessible to those with ASD (Todd & Reid, 2006). It is important to note that physical educators also use fitness and PA assessments, however, children with disabilities are typically excluded from physical fitness assessment data collection (Egan, Dreyer, Odar, Beckwith, & Garrison, 2013). Few studies have focused on the fitness and physical activity of children with severe ASD, however individuals with ASD are typically less active (Tyler, et al., 2014). Therefore, programs that can promote physical movement involving simple motor activities and sustained participation should be further explored (Todd & Reid, 2006).

Health benefits are strongly associated with PA in typically developing children and adolescents (Loprinzi, et al., 2012). A 4-week after-school program focused on motor skills and fitness in kindergarten and 1st grade when assessed shortly after the program ended and 4 months later, indicating that regular participation in PA during childhood has great benefits (Matvienko & Ahrabi-Fard, 2010). The benefits of early PA include positive changes in adiposity, skeletal health, psychological health (self-esteem), and cardiorespiratory fitness (Loprinzi, et al., 2012). Motor skill development in early

childhood can have immediate health benefits and long-term benefits (Loprinzi, et al., 2012). Key environmental settings and determinants may influence activity-related behavior in children and adolescents, suggesting that strategies or interventions to influence PA should be developed (Loprinzi, et al., 2012).

Although several studies have found motor skill delays to be a significant characteristic of young children with ASD, motor skill development has not typically been involved in discussions of early interventions (MacDonald, et al., 2014). For example, strength is lacking in young children with ASD and this could be a possible starting point for physical fitness-based interventions (Tyler, et al., 2014). Additionally, learning individual students' limitations and designing programs to address them will increase student success. For example, in one study motor skills were assessed and motor planning was used to try to understand why children with ASDs have difficulty performing motor skills (Todd, 2012). Todd (2012) found that individuals with ASD had a significantly more difficult time executing simple goal-directed tasks compared to typically developing children. It appeared that additional time to organize movements for response would be beneficial for these young children. While individuals with ASD had a difficult time performing motor skills, physical activity would still be beneficial for them given the right environment and support (Todd, 2012).

Early intervention is the most highly recommended treatment for young children with ASD (Kasari, et al., 2005), and the majority of interventions focus on the improvement of social communicative skills. However, young children with ASD also have motor skill deficits, and motor skills may influence the characteristics and severity of ASD in young children (MacDonald, 2011). Motor skill deficits may hinder the

success of early interventions that focus solely on social communicative skills (MacDonald, et al., 2014). Therefore, interventions should be developed to focus on motor skills and movement performance. The study by Todd and Reid (2006) focused on the outcomes of an intervention including two physical activities, snowshoeing and walking/jogging. Three males (15-20 years of age) with ASD participated in the six-month program. They found that the distance covered through snowshoeing, walking, or jogging (in each 30 minute section) increased as the edible and verbal reinforcement decreased. The pace at which each participant moved was determined individually, but the program increased sustained participation, suggesting that instructional strategy supported sustained physical activity participation (Todd & Reid, 2006).

Motor control may lie at the center of the science of mental life and behavior. An article published in *The American Psychologist Journal* (2005) focuses on the paucity of research concerning motor control. It states that changes in the nervous systems prior to the performance of a movement may reflect on the "history of the act's beginning." So, through learning, the motor actions are performed more quickly, automatically, and consistently. Studies have investigated the relationship between perception and performance, because perception may influence plans for motor activity, suggesting support for the feedback processing perspective. Even psychologists have taken an interest in motor control (Rosenbaum, 2005). Now is a great time for that interest to be translated to an early intervention approach for motor skill improvement for young children with ASD.

ASD and Social Communicative Skills

An individual with ASD experiences deficits in social skills that are often displayed, by playing alone not relating with peers. Typically developing toddlers are interested in the surroundings and people, they will copy words or actions and show interest in social games such as peek-a-boo. A toddler with ASD is more likely to have difficulties interacting with other people (CDC, 2015). Additionally, young children with ASD are characterized by marked delays in social reciprocity and expressive and receptive language, as well as repetitive and stereotypical behaviors (Todd, 2012). Forty percent of children with ASD are non-verbal, while approximately 25%-30% of children use a few words between 12 and 18 months of age and then lose them (CDC, 2015).

ASD, Loneliness, and Relationships

Loneliness is the undesirable feeling associated with negative affects. This can result from the lack of friends or gaps between actual and wishful social status, as well as a lack of bonding affectively (Bauminger & Kasari, 2000). Essentially, a major part of loneliness is dependent on peer interactions and influences. There are two suggested forms of loneliness, emotional and social-cognitive. Emotional loneliness refers to the subjective responses to the lack of bonding with others, which can result in sadness, fear, restlessness, and emptiness (Bauminger & Kasari 2000). Social-cognitive loneliness depends on cognitive processes such as self-evaluation (Bauminger & Kasari, 2000). Children with ASD lack social communicative skills which likely affect relationships with family and peers. The lack of motor skills affects the ability to participate in activities with other children as well. These two developmental deficits together place children with ASD to have a higher risk to being affected by loneliness. While the

majority of interventions focus on social communication and behaviors, it seems right that interventions are developed to target motor skills and play abilities so that children with ASD are better equipped at engaging with peers. With effective interventions concerned with both areas of development, the risk of feeling lonely would be decreased for children with ASD.

ASD, Motor Skills, and Social Communicative Skills

For young children with ASD it appears that motor skill delays appear early in life. In a study investigating the relationship of motor skills and adaptive behavior in young children with ASD (N=233), results indicated that fine and gross motor skills were directly related to adaptive behavior skills. For young children with ASD, fine motor skills significantly predicted adaptive behavior skills, gross motor skills significantly predicted daily living skills, and weaker motor skills were accompanied by greater deficits in adaptive behavior skills indicating a relationship between motor skills and adaptive behavior skills to be further investigated for future interventions (MacDonald, et al., 2013a). Motor skills must be considered and included in early intervention programs. The outcome measures were concerning the adaptive behavior skills, and the gross motor skills and calibrated severity were predictors of daily living skills. It is clear that early interventions for young children with ASD are needed, especially as this study shows that a relationship between motor skills and core characteristics of ASD (deficits in social and communicative domain) exists (MacDonald, et al., 2013a).

Additionally, another study measured functional motor skills of children 6-15 years of age with high-functioning ASD. High-functioning children with ASD were compared to children with specific motor skill disabilities. It was found that children with

ASD had weaker motor skills when compared to children with specific motor skill disabilities (Green, et al., 2002). This suggests that while there is not a specific motor skill disability for children with ASD, there is an overall deficit in motor skills, even when compared to a child with a specific motor disability (Green, et al., 2002). Additionally, young children with ASD or PDD-NOS perform over 6 months behind the norm-referenced gross motor skills and over 9 months behind the norm-referenced fine motor skills of typically developing children (MacDonald, et al., 2014). Object-control motor skills significantly predicted calibrated ASD severity, suggesting a relationship to social communicative deficits (Green, et al., 2002). The ADOS calibrated severity score is dependent on social and communicative development as well as language level (Gotham, Pickles, & Lord, 2009). This established direct relationship between the calibrated severity score and motor skills of children with ASD (Green, et al., 2002; MacDonald, et al., 2014) indirectly provides a relationship between motor skills and social skills.

From existing literature and studies it is clear that further exploration is warranted examining the relationship between the motor and social communicative skills of young children with ASD. Definitions of ASD focus on the deficit of language or communication skills and lack information regarding the motor skills of these children, yet young children may be hesitant to participate in activities out of fear of embarrassment or ridicule, because deficits in motor skills are fairly apparent to others (Todd, 2013). Interventions also tend to focus on interactive play and social behavior and inadvertently fail to mention motor skill deficits and delays that are present. It is important for activities to be adapted for successful inclusion of young children with

ASDs and to be aware of likely motor skill deficits. Motor skill developmental delays are present in young children with ASD and further studies are needed to determine the extent of these delays. The age group of 2 to 7 years is critical because fundamental motor skills (locomotor and object control skills) appear between the ages of one and 7 years of age (Todd, 2013). Therefore the purpose of this study is to examine the relationship between motor and social communicative skills in young children with ASD.

Methods

Participants

The participants (N = 18) were recruited for research projects within the Children and Youth with Disabilities Lab at Oregon State University. Participants were either typically developing (N=9) or had a previous diagnosis of ASD (N=9) based on parental report and confirmed theory of the Autism Diagnostic Observational Schedule (ADOS), and ranged from 2 to 7 years of age. The children with ASD ranged from mild severity to high severity on the autism spectrum. The Institutional Review Board (IRB) approved all methods and procedures for this study. All parents signed informed consent and participants assented before the beginning of the study. Table 1 displays participant descriptive information.

Procedures

The legal guardian of each participant was given a supplemental survey that included demographic information such as age of the participant, maternal education, income, ethnicity, and previous diagnosis of an ASD. The data collection occurred in a lab-based setting at Oregon State University, and the participants completed the majority of assessments in 2-4 hours over one or two days. The Autism Diagnostic Observational

Schedule was typically completed before the Peabody Developmental Motor Scales – Second Edition, unless there was a specific request or need. Each assessment session considered the scheduling needs and individual comforts of each participant. The assessments are described below.

Measurements

The Autism Diagnostic Observation Schedule (ADOS). The ADOS is a semi-structured standardized assessment focused on communication, social interaction, play, and restricted and repetitive behaviors for individuals who may have ASD or some other pervasive developmental disorder (Autism Genetic Research Exchange [AGRE], 2001). This assessment has four modules, all of which are appropriate for children and adults of all developmental and language levels, from nonverbal to verbally fluent (AGRE, 2001).

The assessment contains various activities that elicit behaviors directly related to core deficits associated with ASD. The observation and coding of these behaviors allows the examiner to collect information that furthers a diagnosis, treatment planning, and education (Hogrefe, 2015). The ADOS is a 30-45 minute observation period during which the examiner provides the individual opportunities to exhibit specific behaviors using a series of 'social presses,' or activities that involve interactive stimulus materials, across the majority of developmental levels and chronological ages. Social presses are compiled, pre-planned social occasions where certain behaviors of communication, social interaction, and play, are likely to occur (AGRE, 2001). For example, module 1 has activities such as a 'birthday party,' or a 'snack,' which are meant to elicit a response from the child. Module 2 has the individual do construction and demonstration tasks, while module 3 includes activities like telling a story from a picture book or talking about

a conversation or event. Module 4 is advanced and includes conversations about daily life, telling a story, and discussing emotions and dreams (Hogrefe, 2015).

For each individual, one of the three modules is chosen based on the individual's expressive language level and cognitive age (Gotham, et al., 2009). For this study module 1 and module 2 were used. This assessment is to be supplemented by information such as a detailed history from the parents of the individual, and is not meant to measure response to treatments or interventions but to simply confirm previous diagnosis of ASD (AGRE, 2001). The ADOS is developed such that a higher score indicates greater severity (Gotham, et al., 2009).

The Peabody Developmental Motor Skills – Second Edition (PDMS-2). The PDMS-2 is a 60-minute assessment of the fine and gross motor skills in children from birth through the age of seven years. Six subtests quantify motor skills that generally develop early in life. The fine motor subtests are object manipulation, grasping, and visual-motor integration, and the gross motor subtests are reflexes, stationary, and locomotion. For children more than 12 months old, the gross motor quotient (GMQ) is based on stationary, locomotion, and object manipulation and the fine motor quotient (FMQ) is based on grasping and visual-motor integration ("PDMS-2 Peabody Developmental Motor Scales – Second Edition," 2000).

The reflex subtest examines automatic reactions to environmental events, but since reflexes typically develop before a year of age, this subtest is only administered to children eleven months or younger. The stationary subtest measures the ability to sustain control of the body with the center of gravity and maintained equilibrium. The locomotion subtest measures the ability to move from one place to another (i.e. crawling,

walking, running, hoping, and jumping forward). The object manipulation subtest is for children over 12 months old and measures the ability to manipulate balls (i.e. catching, throwing, and kicking). The grasping subtest measures the ability to use the hands, from holding an object up to the controlled use of fingers. The last subtest is visual-motor integration measure of the ability to use visual perceptual skills to perform complex eye-hand coordination tasks (i.e. reaching and grasping for objects, building with blocks, and copying designs) ("PDMS-2 Peabody Developmental Motor Scales – Second Edition", 2000).

The PDMS-2 has a Fine Motor Quotient and a Gross Motor Quotient. The Fine Motor Quotient is a combination of results from subtests that target the small muscle systems, whereas the Gross Motor Quotient is a combination of results from subtests that measure the use of the large muscle systems. The scale is developed such that a lower score indicates greater severity.

Data Analysis

All participants' motor skills and social communicative skills were assessed with the PDMS-2 and ADOS, respectively. The ADOS sections chosen for analysis are; the Calibrated Severity Score (CSS), Unusual Eye Contact (UEC), Shared Enjoyment in Interaction (SEI), Spontaneous Initiation of Joint Attention (SIJA), Response to Joint Attention (RJA), Amount of Social Overtures (ASO), Quality of Social Overtures (QSO), and Hand and Finger and Other Complex Mannerisms (HFM). The PDMS-2 sections chosen for analysis are; the Gross Motor Quality (PGMQ), Fine Motor Quality (PFMQ), and Motor Total Quality (PMTQ). The participants were assessed with modules 1 or 2 of the ADOS. The majority of sections chosen from the ADOS overlap in both modules 1

and 2 to maintain consistency when comparing participants' results, a couple of sections were chosen for interest although they do not overlap in both modules. It is important to note that the CSS is a standardized score that applies for all three modules of the ADOS and therefore appears as one score rather than a score for module 1 or 2.

The Pearson Correlation coefficient is a value commonly used as a measure of the degree of linear correlation (dependence) and strength of relationship between two variables. The value is between +1 and −1 inclusive, where 1 is a total positive correlation, zero is no correlation, and −1 is a total negative correlation ("Pearson's Correlation Coefficient," 2015).

Results

Participant information is presented in Table 1 and Pearson Correlation coefficients for motor skill scores and ADOS sections are presented in Table 2. Results indicate a negative linear relationship between motor skill scores and social communicative skills via the calibrated severity scores (CSS), indicating that as the severity of ASD increases, the development of motor skills (fine and gross) decrease. It is important to note that a low score on the ADOS indicates less severe ASD characteristics, whereas a low score for the PDMS-2 indicates greater deficits in motor skills. Therefore, a negative correlation value between an ADOS and a PDMS-2 variable, indicates that as motor skills decrease so do social skills. A positive correlation value between two ADOS sections or two PDMS-2 scores, indicates that as one social skill increases so does the other social skills or as one motor skills increases so does the other, respectively.

Table 1

Participant Descriptive Information (N=18).

	Group	
	TD	ASD
	n = 9	*n = 9*
Characteristics	(2 F, 7 M)	(1 F, 8 M)
Age *(SD)*	3.94 (±1.54)	4.73 (±1.41)
minimum	2.06	3.08
maximum	7.10	7.07
IQ	*n = 8*	*n = 8*
non-verbal ratio IQ score *(SD)*	110.26 (±19.9)	76.38 (±26.7)
verbal ratio IQ score *(SD)*	101.25 (±28.2)	69.24 (±34.4)
Race/Ethnicity (*frequency)*		
Caucasian	6	6
African American	1	-
Multiracial	-	2
Other	2	1

TD = Typically Developing; ASD = Autism Spectrum Disorder; F = Female; M = Male; ADOS = Autism Diagnostic Observation Schedule; SD = Standard Deviation.

Table 2

Pearson Correlation Coefficients for all variables chosen from the ADOS and PDMS-2.

Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. PGMQ	1	.713**	.885**	-.614**	-	-	-	-1.00**	-	-.270*	-.328*	-.502**	-.631	-.662**	-.649*
2. PFMQ	.713**	1	.932**	-.678**	-	-	-	-1.00**	-	-.106	-.317	-.198	.426	-.369	-.500
3. PTMQ	.885**	.932**	1	-.743**	-	-	-	-1.00**	-	-.215	-.381	-.391	-.596	-.584	-.657*
4. CSS	-.614**	-.678**	-.743**	1	-	-	-	1.00**	-	-.645*	.733*	-.867**	.237	.803**	-.789*
5. UEC1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
6. SEI1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
7. SIJA1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
8. RJA1	-1.00**	-1.00**	-1.00**	1.00**	-	-	-	1	-	-	-	-	-	-	-
9. ASO1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
10. UEC2	-.270*	-.106	-.215	-.645*	-	-	-	-	-	1	.745*	.714*	-.333	.816**	.408
11. SEI2	-.328*	-.317	-.381	.733*	-	-	-	-	-	.745*	1	.532	-	.609	-
12. SIJA2	-.502**	-.198	-.391	-.867**	-	-	-	-	-	.714*	.532	1	.048	.758*	.700*
13. RJA2	-.631	.426	-.596	.237	-	-	-	-	-	-.333	-	.048	1	.272	-
14. QSO2	-.662**	-.369	-.584	.803**	-	-	-	-	-	.816**	.609	.758*	.272	1	.667*
15. HFM2	-.649*	-.500	-.657*	-.789*	-	-	-	-	-	.408	-	.700*	-	.667*	1

* = significant to 0.05 level (2 – tailed)
** = significant to 0.01 level (2 – tailed)

The Unusual Eye Contact from module 2 (UEC2) showed linear relationships with gross motor quality score (correlation coefficient $= -0.270$, $p < 0.05$), as did Spontaneous Initiation of Joint Attention (correlation coefficient $= -0.502$, $p < 0.01$), Quality of Social Overtures (correlation coefficient $= -0.662$, $p < 0.01$), and Hand and Finger and Other Complex Mannerisms (HFM2) section (correlation coefficient $= -0.649$, < 0.05) from module 2.

The Response to Joint Attention section from module 1 (RJA1) had strong negative correlations (correlation coefficient $= -1.00$, $p < 0.01$) with the development of motor skills (gross, fine and total scores), whereas the same section from module 2 did not (correlation coefficients $= -0.631, 0.426, -0.596$). UEC2 and HFM2 show a negative correlation with CSS (correlation coefficients $= -0.645$, $p < 0.05$, -0.789, $p < 0.05$ *respectively*) suggesting that as these section scores increased (greater skill deficits) the calibrated severity scores would decrease. However, the positive Pearson Coefficient coefficients for CSS and module 2 sections of Shared Enjoyment in Interaction and Quality of Social Overtures (QSO) as well as RJA1 (correlation coefficients $= 0.733$, $p < 0.05$, 0.803, $p < 0.01$, 1.00, $p < 0.01$ *respectively*), suggest that for these sections higher scores did coincide with greater severity. Correlations within the ADOS assessments show that QSO has a strong positive correlation with UEC2 (correlation coefficient $= 0.816$, $p < 0.01$), Spontaneous Initiation of Joint Attention (correlation coefficient $= 0.758$, $p < 0.05$), and HFM2 (correlation coefficient $= 0.667$, $p < 0.01$).

Discussion

The early development of motor skills for a child affects nearly all other aspects of development (Staples, et al., 2012). From the Pearson Coefficient correlations in Table

2, the development of motor skills is directly related to specific aspects of social communicative skills. The social communicative skills are determined based on the calibrated severity score (CSS) of ASD. The strongest relationship was found was between the response to joint attention section and motor development scores (fine, gross, and total motor scores) for children assessed by ADOS module 1 as well as the CSS (correlation coefficient = *1.00*, $p < 0.01$). Children with less severe ASD assessed with ADOS module 2 do not show these strong relationships, suggesting that a difference other than language is apparent between modules.

A high score for Quality of Social Overtures (QSO) indicates that the child was unable to appropriately engage with the examiner or social overtures did not occur. Children who scored high (more severe) on the QSO section of module 2 had significantly weaker gross motor skills (correlation coefficient = *-0.662*, $p < 0.05$), however their fine motor skills were not as significantly affected. Subtleties such as this will enable programs to adapt to each individual child with ASD, specific to module assessment *and* fine or gross motor skills. This would also help identify an initial starting point for intervention for a child where it is most needed in either fine or gross motor skills.

QSO also showed a strong linear dependence with Unusual Eye Contact (UEC), Spontaneous Initiation of Joint Attention (SIJA), Hand and Finger and Other Complex Mannerisms (HFM), and gross motor skills. UEC, QSO, and SIJA fall under the Reciprocal Social Interaction section of the ADOS module, and HFM is a part of the Stereotyped Behaviors and Restricted Interests section. A child with a high score for UEC struggled to initiate, regulate, or terminate social interaction through eye contact,

and a high score for SIJA means the child rarely or did not attempt to draw the examiner's attention, and a high score for HFM indicates that the child displayed some repetitive and unusual movements. Therefore, children who struggle to modulate eye contact are less likely to initiate social interaction or draw attention, display unusual repetitive mannerisms, *and* seem to have greater deficits in gross motor skills. We expected to find that a child displaying better motor skills would have stronger social communicative skills, exhibiting a strong correlation between the two developmental variables.

Overall, the three PDMS-2 variables for motor skills (gross, fine, and total) scores showed significantly strong negative correlations (correlation coefficients = -0.614, $p < 0.01$, -0.678, $p < 0.01$, -0.743, $p < 0.01$, *respectively*) to the calibrated severity scores of the ADOS. Since the ADOS calibrated severity scores are a measure of communication and social interaction and relatively independent of individual characteristics such as age and verbal IQ (Gotham, et al., 2009), it follows that the development of social skills does have a high degree of linear dependence with the development of motor skills. This too agrees with a study by MacDonald and colleagues (2011) in which motor skills were found to significantly predict calibrated severity scores for ASD.

This study does not indicate whether children's lack of participation in physical activity is due to deficits in motor skills or because the social aspects are too complex or intimidating. However, to prevent increased decline in motor skills and possible separation from social interactions, fine motor and gross motor programs should be included in early interventions for children with ASD (Lloyd, et al., 2011). Children with ASD may have delays in development, but if these are not addressed they can result in

long-term deficits in both motor skills and social communicative skills. The correlations drawn from this study show that these developmental skills are related, so perhaps a focus on motor skill development can also benefit the social skills of these children.

This study isolated components of social skill development and examined how they relate to fine, gross and total motor skills, across modules. Language abilities determine which ADOS module is administered, from the correlations found, it appears that more than just language separates modules 1 and 2, specifically a response to joint attention and how a child responds to the examiner's use of pointing or gaze in module 1. Module 2 presented more linear dependency within the ADOS assessment and fine and gross motor skills; these relationships show that individual components of social communicative skills may influence the calibrated severity score (CSS) differently. These scores are meant to display associations between severity of core and clinical characteristics such as behavior issues, friendships, and education progress, however deficits and delays in motor skills are characteristic of ASD as well. A linear relationship is present between motor and social skills, indicating a relationship between motor skills and the CSS itself. Therefore, it would be beneficial if the CSS could give insight into the motor development of a child as well. Essentially, modules may be chosen based on language level, but how a child performs in each section within the modules may be dependent on other factors such as confidence to initiate, or namely motor skill development.

Limitations

A limitation of this study was the time period. The study was completed over several months. A study done over several years would give a better understanding of

children with ASD and the development of motor and social communicative skills over time. Another limitation is the ADOS and PDMS-2 assessments themselves. The information gained from these assessments are only as good as those tests, there may be information that is excluded unintentionally.

A major limitation of this study was the number of participants (N =18). It would have been very beneficial to have more participants for the study. A greater number of children would have allowed for better statistical analysis. Additionally, the range of severity was limited and constrained the study to children with fairly severe ASD, and did not reach to children who would have needed Module 3 of the ADOS.

Future Work

It would be beneficial to recruit a large number of participants with a greater range of ASD severity for a study similar to this one. If overlapping sections of the ADOS Modules 1, 2, and 3 are used for analysis this could provide greater insight into the relationship between the motor and social communicative skills of children with ASD (regardless of severity).

Additionally, if the children are assessed over a longer period of time (several years) then the developmental skills can be monitored over time to see if age is a factor when comparing motor and social communicative skills between age groups. Perhaps deficits decrease with the help of a studied intervention, or children with developed motor skills similar to their peers may have better relationships with family and friends.

Lastly, it would be beneficial to structure an intervention that targets motor skills and social communicative skills in a comprehensive and cohesive manner. If the intervention is controlled and monitored closely, the impact on each child's development

could be assessed over time and individual aspects of the intervention may prove to be affective and beneficial for the children with ASD. For example, motor skills have a strong negative relationship to Response to Joint Attention (Modules 1 and 2), indicating that the stronger the motor skills the better the social response. This relationship suggests that an intervention focused on motor skills in a play environment, such as the one used for the ADOS Module, could increase social response skills for a child with ASD.

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