Adding Motor Assessment to the Disability Determination Process in School-Aged Children with ASD: Implications for Participation

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Abstract.

Objective. This project examines the prevalence of motor impairments in children with autism spectrum disorder (ASD) to determine the association of motor skill proficiency and participation in a variety of activities. ***Background.*** Although ASD is not considered a syndrome with obvious motor deficits, emerging evidence suggests the presence of motor impairments and that coordination and motor planning deficits are regularly recognized clinically in children with ASD. In addition to impaired social skills for the child with ASD, motor deficits may be an important contributor to poor motivation for activities involving peer interaction, decreased participation, and increased inactivity. ***Method.*** We conducted a cross-sectional study with school-aged children diagnosed with ASD recruited from Upstate NY. The Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form was used to objectively assess motor skill proficiency; the Children's Assessment of Participation and Enjoyment was completed together by children and parents to measure overall participation in a variety of activities. We analyzed the associations of motor proficiency and participation through multiple linear regression models to adjust for demographic variables. ***Results.*** Sixty-eight children with an average age of 9.4 years and IQ score of 98 participated in the study. Motor proficiency scores were in the below average range, one standard deviation below the mean. The association between motor proficiency and participation was statistically significant. ***Policy Implications.*** This study supports the position that an effective and relevant clinical evaluation of a child with ASD should include the measurement of motor performance. ***Potential Usefulness for DDP.*** Findings of motor skill deficiencies provide a fuller picture of the functional status of the child with ASD and therefore add necessary information to the disability determination process.

Background.

Autism spectrum disorders (ASDs) are a complex, lifelong group of developmental disabilities that can cause significant impairment in social, communication, cognitive and behavioral development(Centers for Disease Control and Prevention, 2012; Francis, 2005; Hsu, Lin, Chen, Wang, & Wong, 2009; Jasmin et al., 2009). Since the release of the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders, ASD has been recently reclassified into one broad category that includes autistic disorder, Asperger's disorder (AS) and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS). While there is no single etiology for ASD (Whiteley, Rodgers, Savery, & Shattock, 1999), the Centers for Disease Control (CDC) estimates that 1 in 68 children in the U.S. have an ASD (Centers for Disease Control and Prevention, March 27, 2014). In 2012, there were 604,500 children ages 6-12 that received SSI services, 67,704 of those children had a diagnosis of ASD (Social Security Administration, 2013;

Social Security Administration).

Currently, children under age 18 are considered disabled if they have a medically determinable physical or mental impairment (or a combination) that causes marked and severe functional limitations and that can be expected to cause death, or that have lasted or can be expected to last for a continuous period of not less than 12 months (Social Security Administration). For the impairment of a child with ASD to meet listing 112.10 (Autistic Disorder and Other Pervasive Developmental Disorders), both the medical findings (qualitative deficits in the development of reciprocal social interaction, qualitative deficits in verbal and non-verbal communication and in imaginary activity, and markedly restricted repertoire of activities and interests) *and* impairment-related functional limitations must be present (Social Security Administration).

Section 112.00 of the Listing of Impairments further states that functional limitations must be the result of the mental disorder that gave rise to the medical findings (Social Security Administration)**.** Functional areas used to measure severity in children ages 3-18 years include age appropriate cognitive/communication function, social function, and personal function; and difficulties maintaining concentration, persistence, and pace (Social Security Administration). After 36 months, gross and fine motor function is no longer assessed as it is not felt to be a primary determinant of mental function, although, of course, any motor abnormalities should be documented and evaluated (Social Security Administration,). Yet, the measures used to document medical findings between the age of 6 and 18 only include cognitive and adaptive assessments. Motor skills are not included in these assessments for children 6-12 years of age.

While impaired cognitive, communicative, and social behaviors are hallmark traits and primary concerns of ASD; the accompanying motor impairments are classified as secondary, or associated, symptoms (Provost, Lopez, & Heimerl, 2007) and are often overlooked (Jasmin et al., 2009). The most recent American Academy of Pediatrics Guidelines for ASD screening do not include a thorough motor assessment (Johnson, Myers, & and the Council on Children With Disabilities, 2007). Additionally, the absence of a routine assessment of motor development may be a function of the *Diagnostic and Statistical Manual* of Mental Disorders (DSM) current classification for which does not characterize motor involvement. The omission of motor examination results in an incomplete appreciation for the impact of ASD on the life of a child.

Motor assessment plays an even larger role in the daily life of school-aged children with ASD. Fundamental motor and active play skills are practiced through peer interaction. Gross motor skills become progressively more complex and skilled team games are an important part of play during elementary school, requiring progressively higher levels of coordination, planning, and body awareness (Provost et al., 2007). Performance of these more sophisticated skills is promoted by the ability to follow and understand instructions, imitate, and participate in social reciprocity (Green et al., 2009; Jasmin et al., 2009)—key impairments in ASD.

Although motor deficits are not considered core features of ASD, emerging evidence suggests the presence of motor impairments (Downey & Rapport, 2012); coordination and motor planning deficits are regularly recognized clinically in children with ASD (Ming, Brimacombe, & Wagner, 2007; Provost et al., 2007; Staples & Reid, 2010). In an attempt to describe motor ability in children with ASD, numerous studies have been conducted comparing typically developing children (Ming et al., 2007; Pan, Tsai, & Chu, 2009; Provost et al., 2007; Staples & Reid, 2010; Whyatt & Craig, 2012) . In these studies, overall motor performance was lower for the children in the ASD group as compared to the typical groups. Children with ASD demonstrated significant impairments in galloping, hopping, batting, ball skills, manual dexterity, and balance.

These motor deficits play a role in participation for school age children. Additionally, social impairments in ASD profoundly affect an individual's ability to relate and reciprocally interact with peers within their environment; therefore children with ASD are at considerable risk for limited participation in everyday activities. Participation is defined by the World Health Organization as involvement in life situations resulting from interactions within an individual's social and physical environments (World Health Organization, 2001). For children, participation is an essential component of development that influences long term mental and physical health (Kolehmainen et al., 2011; Law & King, 2000; Law et al., 2004). It is a vital aspect of human development and the lived experience (Law, 2002). Children grow and develop through their participation in a variety of activities (Law & King, 2000). Partaking in activities provides the infrastructure in which children learn to form friendships, develop and advance skills, express creativity, find satisfaction, and determine meaning and purpose in life (Law & King, 2000; Law, 2002).

This research sought to describe the variation in motor skill proficiency in elementary school aged children with ASD. Additionally, it assessed the relationship between motor skill ability and level of participation in a variety of activities. The specific aims of this study were to:

1. Describe the motor characteristics in a study population of children ages 6-12 with autism spectrum disorder, as measured by the Bruininks-Oseretsky Test of Motor Performance-2 (BOT-2) Short Form; and
2. Examine whether motor proficiency, as measured by the Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form, is associated with overall participation, as measured by the Children's Assessment of Participation and Enjoyment (CAPE) assessment.

Methods.

Study Design.

This study employed a cross-sectional assessment of independent and dependent variables. Children and their parents were seen for one study visit lasting approximately 60 minutes. The cross-sectional study design allowed for the prevalence of motor deficiency in children with ASD to be determined in a sample of school age children. This prevalence was compared to a normed typical developing age-matched U.S. sample and a clinical sample of children with high functioning autism and Asperger's syndrome.

Participants.

Elementary school-aged children ages 6-12 were recruited from Monroe County and surrounding areas. Participants were primarily recruited through participation in previous research studies at the University of Rochester who had consented to be contacted for future studies. Parents of potential participants were contacted to screen for eligibility and to discuss the study's requirements. Inclusion criteria included: clinical diagnosis of ASD supported by the DSM -V, age 6-12 years, IQ of at least 70 (through a school or clinic administered IQ test) or typical learning ability (participation in a regular school setting functioning at an age appropriate grade level), free from medical conditions that would impact capacity for physical activity, and free of other musculoskeletal or neurologic conditions that may limit motor ability (e.g., cerebral palsy). The IQ requirement was necessary so that the child participants comprehended directions and assessment items of the BOT-2 and were able to complete the required questionnaires with his or her parent or study personnel.

Outcome Measures.

Independent Variable: Motor Proficiency

The Bruinkinks-Oseretsky Test of Motor Proficiency-Second Edition assesses motor skill proficiency through the use of 53 goal-directed activities in children 4-21 years of age (Wuang & Su, 2012). It is an individually administered instrument developed to assess fine and gross motor skills. The current study used the BOT-2 Short Form that is comprised of 14 items selected from the full scale to equitably represent all motor areas (Deitz, Kartin, & Kopp, 2007). See Table 1 below for tasks and skills assessed. Each item was scored using specific criteria to obtain a point score. Point scores were summed for a total point score which was converted into a standard score using age and sex specific norms to compare children within the study. BOT-2 standard scores have a mean of 50 and a standard deviation of 10. Motor proficiency is also expressed as a categorical variable using the descriptive categories provided by the BOT-2: Well-Above Average, Above Average, Average, Below Average, and Well Below Average. The categories directly relate to the prescribed standard scores and therefore describe the relationship to the mean score. The average category corresponds to the range +/-1 one standard deviation from the mean; Above/Below Average categories correspond to the range +/- 2 standard deviation from the mean respectively. While both fine and gross motor skills were assessed, the composite score derived from the short form does not allow for distinguishing between the two.

Table 1. Skills Assessed on the BOT-2 Short Form

Skill Task	Assessment
Drawing Lines Through Paths	# of Errors
Folding Paper	# of Errors
Copying a Square	# of Errors
Copying a Star	# of Errors
Transferring Pennies	# of Pennies in 15 seconds
Jumping in Place -- Same Sides Synchronized	Repetitions
Tapping Feet and Fingers -- Same Sides Synchronized	Repetitions
walking Forward on a Line	Steps
Standing on One Leg on a Balance Beam -- Eyes Open	Time
One-Legged Stationary Hop	# of Hops in 15 seconds
Dropping and Catching a Ball -- Both Hands	Catches
Dribbling a Ball -- Alternating Hands	Dribbles
Push-Ups	# Performed in 30 seconds
Sit-Ups	# Performed in 30 seconds

Dependent Variable: Participation

Participation was measured through the use of the Children's Assessment of Participation and Enjoyment (CAPE) questionnaire. The CAPE is a 55-item instrument that assesses five dimensions of everyday activity participation: diversity, intensity, with whom, where, and enjoyment in children 6-21 years of age over the past 4 months (Engel-Yeger, Jarus, Anaby, & Law, 2009; King et al., 2007; Law et al., 2004). It is a child-report measure of recreational participation outside of school (Imms, 2008; Morris, 2009). The CAPE is completed by the child independently, with or without caregiver assistance, or by interview (Imms, 2008). Two of the CAPE dimensions were assessed capture child participation: diversity and intensity (both overall intensity and personal intensity). Diversity is the total number of activities in which the child engages in out of 55 possibilities within the assessment. Intensity is the frequency of performance of the CAPE's activities and is asked "in the past 4 months, how often have you done this activity." Responses are measured on a 7 point scale: 1 time in the past 4 months; 2 times in the past 4 months; 1 time a month; 2-3 times a month; 1 time a week; 2-3 times a week; and 1 time a day or more. *Overall* intensity is calculated by adding all responses and dividing by

the full 55 activities included on the assessment. *Personal* intensity is a second way to examine frequency of participation. It takes into account only those activities that the child has actually participated in (as compared to the full 55) and it is calculated by summing the individual intensity scores and dividing by only items the child endorses (as the child may not participate in all activities associated with the questionnaire).

Data Collection.

Children deemed eligible were scheduled for a 90-minute onsite study visit. Participants were assessed individually by study personnel in a quiet room located in the autism research suite at the University of Rochester Medical Center. With assistance from their parent, the child completed the CAPE for participation and physical activity assessment. Next, the child completed the BOT-2 fine and gross motor assessment activities with assistance from study personnel. The BOT-2 Short Form motor tasks were demonstrated by research assistants to ensure understanding and standardization. Child subjects were videotaped during the administration of the BOT-2 to assist in scoring each task. Simultaneously during the child's activities, parents verified the demographic data collected during the telephone screen, and completed the Social Responsiveness Scale Second Edition (SRS) questionnaire. The SRS is a tool that is used in varied populations of children including typically developing children and those diagnosed with psychiatric and pervasive disorders (Volkmar, Lord, Bailey, Schultz, & Klin, 2004). It is a 65-item screening questionnaire that provides quantitative data on the core deficits of ASD measuring social behaviors, language deficits, and stereotypic interests in children 4-18 years of age (Constantino et al., 2003). The SRS was included as a covariate to examine whether severity of ASD symptoms was correlated with motor proficiency and determine whether it confounds the relationship between motor proficiency and participation. Study visits lasted on average between 60-75 minutes. Parents were provided a parking pass and sent a summary report of their child's motor skills. Child participants were mailed $20 with full completion of all questionnaires and activities during the study visit.

All study questions were answered to participant satisfaction and written consent was obtained prior to initiating the assessment activities. The study protocol was approved by the University of Rochester Research Subjects Review Board.

Statistical Analysis.

All analyses were conducted using SAS Version 9.3. Univariate analysis for all variables was performed to examine the frequency and distribution of data. Measures of central tendency and frequency distributions are reported for continuous variables. Frequencies and proportions are reported for all binary and ordinal variables.

Means and medians were calculated for BOT-2 standard scores. Means and frequencies are reported for the demographic characteristics by motor proficiency category and t-tests were computed to determine whether statistically significant differences existed between the groups. Independent t-tests were also used to compare mean motor standard scores with the normative sample and the clinical sample test means provided by the BOT-2 assessment publisher.

Central tendencies are presented for each participation variable (diversity, intensity, and personal intensity). Both unadjusted and adjusted associations between motor proficiency and overall participation, defined as diversity, intensity, and personal intensity, were separately examined using linear regression.

Results.

Study Population.

Sixty-eight school-aged children ages 6-12 with ASD participated in the study. Characteristics of the study sample are presented in Tables 2 and 3. The average age of the child participants was 113 months (9.4 years), mean parental age was 42.6 years (85% mothers; 9% fathers; 6% other guardian), mean age of ASD diagnosis 4.7 years, and mean IQ score 98 (standardized average = 100). Out of the 68 child participants, 59 (86.8%) were male. The majority of participants were white (77.9%) and taking medication related to ASD symptomology (58.8%). Eighty-one percent of participants were from a two parent household and most parents possessed a 4-year college degree or higher (63.2%).

All children had a clinical diagnosis of ASD and a mean SRS score of 75. The cutoff score for screening positive for autism on the SRS is 60. Children with scores under 60 are typically not suspected for the diagnosis; scores between 60 and 75 indicate mild to moderate symptoms which often are false positives. Five children (7%) in the study sample had a score less than 60. Furthermore, forty percent of the children in this study demonstrated a score between 60 and 75 indicating mild to moderate symptomology. The nature of these lower SRS scores (less ASD severity) is most likely due to the eligibility requirements of an IQ score of at least 70.

Table 2. Continuous Characteristics of Participants in Motor Study, Overall and by Motor Skill Category

	Overall			Motor Skills by BOT-2 Category				
				Average Skills[a]		Below Average Skills[b]		
Total N		68		24		44		
	Mean (SD)	**Median (IQR)**	**Range**	**Mean (SD)**	**Median (IQR)**	**Mean (SD)**	**Median (IQR)**	**p-value**
Child Age (yr)	9.4 (1.7)	9.5 (7.6-11.3)	6-13	9.3 (1.9)	9.5 (7.5-11.3)	9.5 (2.0)	9.4 (8.0-11.3)	0.65
Age at Diagnosis (yr)	4.7 (2.3)	4 (4.0-7.0)	1-10	5.0 (2.2)	4 (4.0-7.0)	4.6 (2.4)	4 (2.5-6.0)	0.50
IQ	98.3 (17.4)	99 (92.0-110.0)	63-136	101.2 (12.6)	100 (92.0-110.0)	96.7 (19.5)	95.5 (80.0-109.0)	0.27
SRS-2 T-Score	75.3 (10.6)	79 (67.0-84.0)	49-90	74.7 (11.5)	77.5 (67.0-84.0)	75.7 (10.2)	79 (67.5-83.0)	0.73
# of Siblings	2.2 (1.3)	2 (2.0-3.0)	1-9	2.7 (1.6)	2 (2.0-3.0)	1.9 (1.0)	2 (1.0-2.0)	**0.03**
Parental Age, Study Visit	42.6 (7.5)	42.5 (37.0-46.5)	27-66	41.8 (6.2)	41.5 (37.0-46.5)	43.1 (8.1)	43. (37.5-48.0)	0.52
Parental Age, Child Birth	33.7 (7.2)	33 (29.0-38.0)	20-55	33 (5.5)	34 (28.5-37.5)	34 (8.0)	32 (37.5-48.0)	0.59

Note: [a] Above average (n=1) and average (n=23); [b] Well below average (n=3) and below average (n=41)

Table 3 Categorical Characteristics of Participants in Motor Study, Overall and by Motor Category

	Overall	Average Motor Skills[a]	Below Average Motor Skills[b]	
Total N	68	24	44	
	N (%)	**N (%)**	**N (%)**	**p-value**
Child Gender				1.00
Male	59 (86.8)	21 (87.5)	38 (86.4)	
Female	9 (13.2)	3 (12.5)	6 (13.6)	
Race/Ethnicity				0.36
White	53 (77.9)	21 (87.5)	32 (72.7)	
Black	2 (2.9)	1 (4.2)	1 (2.3)	
Latino	10 14.7)	2 (8.3)	8 (18.2)	
Other	3 (4.4)	--	3 (6.8)	
Diagnosis[c]				0.35
AS	16 (23.5)	8 (33.3)	8 (18.2)	
ASD	34 (50.0)	11 (45.8)	23 (52.3)	
PDD	18 (26.5)	5 (20.8)	13 (29.5)	
Medication				0.44
Yes	40 (58.8)	16 (66.7)	24 (54.5)	
Grade				0.42
Kindergarten	4 (5.9)	2 (8.3)	2 (4.5)	
1st	8 (11.7)	3 (12.5)	5 (11.4)	
2nd	11 (16.2)	5 (20.8)	6 (13.6)	
3rd	10 (14.7)	1 (4.2)	9 (20.5)	
4th	14 (20.6)	5 (20.8)	9 (20.5)	
5th	6 (8.8)	4 (16.7)	2 (4.5)	
6th	12 (17.7)	3 (12.5)	9 (20.5)	
7th	7 (10.2)	1 (4.2)	2 (4.5)	
Parent Education				1.00
4 year college degree	43 (63.2)	15 (62.5)	28 (63.6)	
Less than 4 yr degree	25 (36.8)	9 (37.5)	16 (36.4)	
Marital Status				1.00
Single	3 (4.5)	1 (4.3)	2 (4.5)	
Married	54 (80.6)	19 (82.6)	35 (79.5)	
Divorced	7 (10.5)	2 (8.7)	5 (11.4)	
Widowed	3 (4.5)	1 (4.3)	2 (4.5)	

Note: [a] Above average (n=1) and average (n=23); [b] Well below average (n=3) and below average (n=41); [c] ASD diagnosis includes: autism, AS (Asperger's disorder) and PDD (Pervasive Developmental Disorder) shown here to demonstrate the level of symptoms in the study population

Motor Proficiency in Children with Autism Spectrum Disorder

Specific Aim 1: Describe the motor characteristics in a study population of children ages 6-12 with autism spectrum disorder, as measured by the Bruininks-Oseretsky Test of Motor Performance-2 (BOT2) Short Form and compare to the BOT2 normative and High Functioning Autism/Asperger's Syndrome clinical samples.

The distribution of motor proficiency scores measured by the BOT-2 Short Form is presented in Figure 1. Because there were only 4 observations that fell outside of the below average and average categories, all motor scores were collapsed into these categories for further examination (65% below average; 35% average).

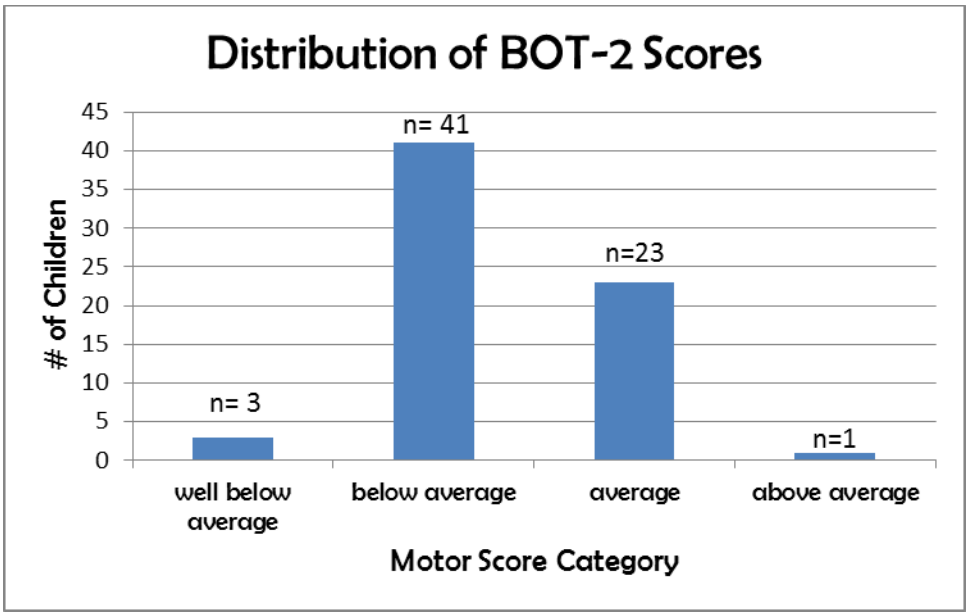

Figure 1. Distribution of Mean Motor Proficiency Scores by Study Participants
Note: well below average 4.4%; below average 60.3%; 3=average 33.8% 4=above average 1.5%

The BOT-2 Short Form was a quick and simple assessment for this study population. All children were able to follow the directions and attempt each task. The average motor score for child participants was 39.6 (SD =6.7) (Table 4). Sixty-five percent of the children demonstrated motor proficiency skills in the below average range, or one standard deviation below the test mean. As compared to the scores obtained by the assessment publishers, the independent t-test indicates that the children in this study performed significantly different from the normative sample (mean = 51.4), p-value <0.0001 (Table 4). However, compared to the publisher's clinical sample (children with HFA/Asperger's Disorder ages 6-12, N=32), the children in the current study performed similarly (mean = 36.7, p = 0.07). Although mean motor standard scores are not normally distributed, a parametric t-test was used for comparison to BOT-2 data as individual level was not provided.

Table 4 Comparison of Mean & Median BOT-2 Standard Scores of Study Participants, Normative Sample from BOT-2, & Clinical Sample of Children with High Functioning Autism from BOT-2

	Study Participants (N=68)	**BOT2 Normative Sample (N=687)**	**BOT2 Clinical Sample (N=32)**
Mean (SD)	39.6 (6.7)	51.4 (8.1)	36.7 (8.2)
Median (IQR)	38.0 (35.0-43.5)	51.0 (46.0-57.0)	37.5 (32.0-42.0)
p-value	--	<0.0001	0.07

Note: p-value indicates the independent t-test between study sample and normative sample means and study sample and clinical sample mean

As demonstrated in Tables 2 and 3, there was little difference in demographic characteristics for children with below average skills as compared to children with average skills except for number of siblings (p=0.03). Higher motor score was associated with an increased number of siblings; child participants' with average motor skills had three siblings whereas children with below average motor skills had two siblings. Correlations between motor proficiency and other continuous variables indicated that child age was not associated (r=0.01) with motor proficiency most likely due to the fact that BOT-2 scores are standardized on age;

older age at diagnosis demonstrated increased motor proficiency (r=0.16) as did children with more siblings (r=0.24); parental age was inversely associated (r=-0.05); and IQ was directly associated with motor skill (r=0.27). Interestingly, while it was expected that both IQ and SRS scores would indicate severity of ASD symptoms, SRS demonstrated no association to motor proficiency (r=0.01). Additionally, parent education and medication were also not associated to motor proficiency.

Association between Motor Proficiency and Participation

Specific Aim 2: Determine whether motor proficiency, as measured by the Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form, is associated with overall participation, as measured by the Children's Assessment of Participation and Enjoyment (CAPE) assessment.

The distribution of overall participation as measured by diversity, intensity and personal intensity is shown in Figure 2. Central tendencies of participation variables are shown in Table 5. Child participants endorsed 29 items on average and had a participation rate of 53% for assessed activities. Personal intensity, or personal frequency, is greater as compared to overall intensity, or overall frequency (approximately 2 times per month as compared to twice in the past 4 months). Again, overall intensity includes all CAPE activities (55) where as personal intensity includes only the items endorsed by the child. Considering only the activities a child participates in improves frequency of participation.

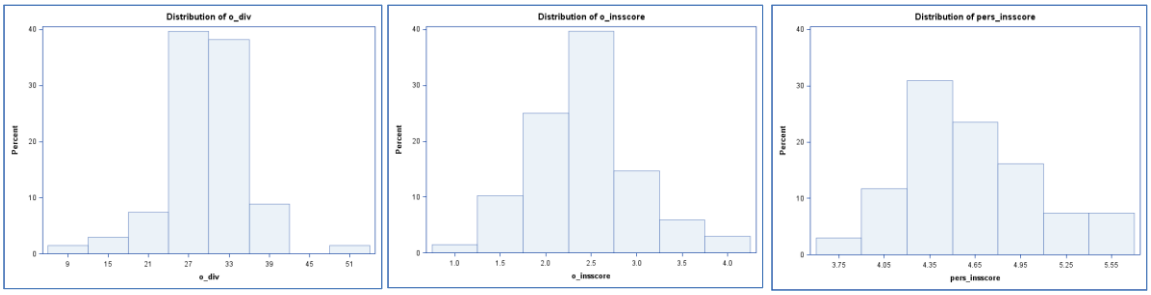

Figure 2. Distribution of Participation Variables: Diversity, Intensity, and Personal Intensity
Note: Diversity (variety of activities), Intensity (frequency of performance of the CAPE's 55 activities, and Personal Intensity (frequency of performance of the items endorsed on the CAPE)

Table 5. Mean and Median CAPE Participation Dimensions

Participation	Mean	SD	Median	IQR
Diversity	29.1	6.2	29.0	26.0-32.0
Intensity	2.4	0.6	2.4	2.1-2.7
Personal Intensity	4.6	0.5	4.5	4.3-4.9

Note: Diversity=number of activities performed out of 55; Intensity and Personal Intensity responses: 1=1 time in the past 4 months; 2=2 times in the past 4 months; 3=1 time a month; 4=2-3 times a month; 5=1 time a week; 6=2-3 times a week; and 7=1 time a day or more.

Table 6 presents the correlations between the independent variable, motor proficiency, and the dependent variables, participation diversity, intensity, and personal intensity. A positive although minimal relationship exists between motor skill proficiency and each of the participation variables.

Table 6. Bivariate Analysis between Motor Performance and Participation Variables, Spearman Correlation

	Motor Score	Diversity	Intensity	Personal Intensity
Motor Score	1	0.15 (0.21)	0.15 (0.21)	0.12 (0.35)
Diversity		1	0.91 (<.0001)	0.05 (0.70)
Intensity			1	0.41 (0.0006)
Personal Intensity				1

Separate models were analyzed for each participation outcome as the variables are correlated. The crude associations between motor proficiency and participation diversity, intensity, and personal intensity are shown in Table 7. For every one unit increase in motor standard score, diversity of participation increases by 0.13 (0.13 activities); overall intensity increases by 0.02; and personal intensity increases 0.01. The full model demonstrates the effect adjustment for IQ, age, number of siblings, medication, and parent education. When IQ was included in the model, it significantly changed the magnitude of motor proficiency, particularly participation diversity (Table 7). Motor proficiency is significantly associated with all dimensions of participation. For every one unit increase in motor standard score, the number of activities participated in, diversity, increases by 0.27. Overall, the result of these associations is unexpected. The direction of association is as anticipated: as participation increases motor proficiency also increases. However, unlike number of activities (diversity of participation) frequency of activity participation is only slightly related to motor skill performance.

Discussion.

It has been suggested that motor skill evaluation should be standard care for children with ASD as motor impairments influence participation in a variety of leisure time activities (Jarus, Lourie-Gelberg, Engel-Yeger, & Bart, 2011). With increased participation children have additional opportunities to practice and improve skills, interact with peers, and enrich development, health, and wellbeing. This research examined the patterns of motor proficiency and participation in a variety of leisure activities in children with ASD. The associations between these variables were also assessed. This study contributes to the current literature on children with autism spectrum disorder and activity participation by describing the role of motor skill proficiency and effect of quality of life in this population.

Study Population.

Participants in this study were representative of children with ASD in western New York. Kirch Developmental Services is the largest developmental clinic in western New York diagnosing 90% of the study participants. The study sample is representative of the overall pediatric population seen at the Kirch Clinic of which 49% of children have a diagnosis of ASD. While demographic data of study participants is comparable to those who had participated in previous research studies at the University of Rochester, families represented in this study generally do not match the population of the United States. The majority of child participants have parents who are married (81%) (U.S. Census Bureau, 2012) and possess a 4-year college degree or more (63%) (U.S. Census Bureau, September 09, 2014). This is 30% higher for both marriage and education status as compared to U.S. census data. It is likely that these families have more knowledge about the importance of participation, know how to access support, and have the financial resources to provide a variety of leisure time opportunities (Klaas, Kelly, Gorzkowski, Homko, & Vogel, 2010). A positive consequence of more opportunities for participation is the increased likelihood that a child's physical and social skills will be enhanced.

Table 7. Linear Regression Analyses: Association between Motor Proficiency and Participation Variables Diversity, Intensity and Personal Intensity β (CI)

	Participation Diversity		*Participation Intensity*		*Participation Personal Intensity*	
	Unadjusted	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
N	68	68	68	68	68	68
Motor Score	**0.13** (0.01, 0.35)	**0.27** (0, 0.53)	.02 (-0.01, 0.04)	0.03 (0.01, 0.06)	.01 (-0.01, 0.02)	0.02 (0, 0.04)
IQ	--	-0.07 (-0.17, 0.02)	--	-0.01 (-0.02, 0)	--	-0.01 (-0.01, 0)
Age	--	0.03 (-0.03, 0.10)	--	0 (0, 0.01)	--	0 (0, 0.01)
# of siblings	--	-0.65 (-1.95, 0.66)	--	-0.09 (-0.2, 0.03)	--	-0.06 (-0.16, 0.04)
Medication Yes	--	0.81 (-2.25, 3.88)	--	0.11 (-0.17, 0.38)	--	0.04 (-0.19, 0.28)
Parent Edu <4 yrs	--	-4.47 (-7.62, -1.32)	--	-0.37 (-0.65, -0.09)	--	0 (-0.24, 0.24)

Note: Diversity=number of activities performed out of 55; Intensity and Personal Intensity responses: 1=1 time in the past 4 months; 2=2 times in the past 4 months; 3=1 time a month; 4=2-3 times a month; 5=1 time a week; 6=2-3 times a week; and 7=1 time a day or more.

Second, this study took place in western New York in an area with robust services and opportunities for children with ASD. Activity participation and interventions are most likely different for study participants as compared to families with children diagnosed with ASD in other regions of the state and nationally. The western New York locale also may affect generalization of leisure activity participation patterns and opportunities due to seasons and climate. Interestingly, a study by Potvin, Snider, Prelock et al (2013) in Vermont demonstrated comparable participation patterns.

Motor Proficiency.

Our findings indicate that motor skill proficiency in children with ASD is lower than that of typically developing peers. Deficits were demonstrated in relatively high functioning children and in an area with robust ASD services. It is likely that motor proficiency would be more limited in other populations.

Sixty-five percent of the children scored one standard deviation below the mean or more as compared to BOT-2 normative data. These deficient motor findings are consistent with several other studies (Abu-Dahab, Skidmore, Holm, Rogers, & Minshew, 2013; Berkeley, Zittel, Pitney, & Nichols, 2001; Dewey, Cantell, & Crawford, 2007; Hilton, Zhang, Whilte, Klohr, & Constantino, 2012; Mattard-Labrecque, Ben Amor, & Couture, 2013; Noterdaeme, Wriedt, & Hohne, 2010; Pan et al., 2009; Pan, 2012). Four studies (Dewey et al., 2007; Hilton et al., 2012; Mattard-Labrecque et al., 2013; Pan, 2012) demonstrated similar findings using the BOT-2; all studies except the one by Dewey, Cantell and Crawford (2007) used the full scale. Mean standard scores for these studies ranged from 34.3-38.6, indicating motor performance one standard deviation below the mean. Three of these studies assessed children within the same average age (9.7-10.2 years) (Dewey et al., 2007; Hilton et al., 2012; Mattard-Labrecque et al., 2013). The fourth study assessed adolescents between the ages of 10-17 years (mean=14.5 years) demonstrating a mean standard score of 37.9 (Pan, 2012). This suggests that motor deficiencies persist through adolescence.

Motor skill deficits are less noticeable at an earlier age. With age, skill demands of activity increase which may increase the gap between children with disabilities and their peers creating frustration and activity avoidance (Jarus et al., 2011). Early identification of motor impairments will help target interventions to promote active play and foster physical activity throughout adolescence and beyond (Kantomaa et al., 2011). Motor skill competence as a child may lead to improved self-esteem, more enjoyment of physical activities, and increased participation (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009). Ensuring that children have the necessary skills and capabilities to participate with their peers in these healthy behaviors will cultivate and encourage these behaviors.

Other variables' relationships to motor proficiency were also assessed. While child age was not associated, number of siblings was significantly related: the more siblings in a family, the better the motor skills of the child. This could be possible for three reasons. First, having a child with autism may deter parents from having more children; an instance of reverse causality. Second, more siblings may provide role models available for motor skill development. Third, parents with more children have more experience with the overall motor development process. Age at diagnosis also had a positive correlation. The older the child was at diagnosis, the more proficient their motor skills were. Diagnosis at an older age may suggest less severe symptoms (Mazurek et al., 2014; Wiggins, Baio, & Rice, 2006). Lastly, parental age was inversely associated with motor skills. Older parents were associated with more deficient motor skills. This relationship is somewhat puzzling. In one way, older parents may be less agile to play with their

children. It may be difficult for the older parent to actively engage in and demonstrate motor skills. On the contrary, older parents may have more knowledge regarding the importance of providing a variety of movement experiences to facilitate motor development. Older parents may see greater value in diverse experiences that facilitates overall development. Additionally, older parents may have more resources to afford numerous opportunities.

Association Between Motor Proficiency and Participation

We found a direct relationship between motor proficiency and diversity of participation: children with better motor scores participated in a wider variety of activities. Furthermore, the parameter estimate for motor proficiency doubled in size after controlling for IQ, child age, number of siblings, medication, and parent education. Motor proficiency was associated with participation independent of cognitive status, age, ASD related symptoms, and family factors.

It may be that children with more proficient motor skills have more motivation for participation, particularly in more complex skills (i.e. physical activity vs sedentary activity) (Srinivasan, Pescatello, & Bhat, 2014). Additionally, children with better motor skills may have more positive experiences with these types of activities which conditions them to participate again (M. King, Shields, Imms, Black, & Ardern, 2013). Success with activity increases participation (Cairney et al., 2005; Heah, Case, McGuire, & Law, 2007). Wider range of participation could also be related to higher self-efficacy and feeling that more opportunities are available to them (Cairney et al., 2005; Fong et al., 2011). Poorer motor skills in children with ASD may be due to impaired social skills, deficient physical skills, motivation, or some combination as these variables are all important for the practice and refinement of motor skills (Pan, 2012). But, the opposite may also occur. Lack of participation may lead a decrease in skill development and refinement, fitness, acceptance by peers and friendships (Imms, Reilly, Carlin, & Dodd, 2008; Schreuer, Sachs, & Rosenblum, 2014). For these reasons, it is important to foster self-confidence and challenge skills in a non-threatening manner.

Participation is vital for a child's overall development (Liberman, Ratzon, & Bart, 2013). Active engagement in meaningful activities is key for promoting health, autonomy, skill development, social integration, and life satisfaction (Majnemer et al., 2008). Therefore it is important to consider the child's goals and preferences (Bult, Verschuren, Lindeman, Jongmans, & Ketelaar, 2014; Imms et al., 2008; Majnemer et al., 2008) and use individualized strategies to improve participation (Beutum, Cordier, & Bundy, 2013; Bult et al., 2014; Imms et al., 2008). Informal activities in a non-competitive environment may facilitate participation in children with impaired motor proficiency (Beutum et al., 2013). Moreover, taking into account the child's preferences will increase motivation for participation overall (Majnemer et al., 2008).

Limitations.

Limitations are inherent in all studies. First, this study examined only a segment of the pediatric population with ASD, namely children 6-12 years of age with IQs greater than 70. School age children were the focus of this study. Data from a younger age on how and when motor milestones were initially achieved would offer further knowledge about motor development in ASD. Children with lower IQs may demonstrate more motor impairment and less activity participation than the study population, thus further research is necessary to assess motor proficiency, patterns of leisure activity, and quality of life in these children. While children with lower cognitive function may demonstrate lower motor proficiency, it is unknown whether an improvement in skill would increase participation. Cognitive function in addition to motor performance likely plays a role in participation outcomes. Additionally, selection bias is

likely present as the majority of families were recruited through an ASD research database. Child participants and their parents had previously participated in research studies and therefore may be different from the general population.

Second, the BOT-2 short form is unable to distinguish between fine and gross motor impairments. While the BOT-2 assesses a wide range of motor skills including fine motor integration and precision, manual dexterity, upper extremity coordination, bilateral coordination, balance, strength, and agility, the 14-item short form examines only 1-2 items from each subscale on the full assessment. Only a composite score is provided with use of the short form and therefore it is difficult to tease out where the motor impairment exists. Further assessment is necessary to determine whether the impairment is related to stability, upper extremity coordination, strength, or some combination. Praxis, the planning of movement, also needs to be included in motor assessment (Green et al., 2009). Testing only few items in each motor area does not allow for an in depth focus on coordination, motor planning, and balance that are implicated in the disorder. Associations made with motor proficiency are likely biased towards the null.

Additionally, although the BOT-2 assesses a wider range of skills as compared to the Test of Gross Motor Development (TGMD-2) and the Movement Battery Assessment for Children (M-ABC), it does not assess quality of movement as well (Pan et al., 2009). Qualitative movement attributes are important because refinement of skill is a principal concern in motor skill development in ASD (Staples & Reid, 2010). Results using the short form make it difficult to determine whether atypical movement patterns exist. The short form was selected to keep the participants focused and the study visit length to a minimum. However, the use of the full scale would have provided more detailed information. As all the children were able to follow the directions and complete the standardized assessment, it is likely that all children would have been able to complete the full scale.

Future Research.

This research examining the association between motor skill proficiency and participation is still in its elementary stage. Future research should include motor assessment with a focus on fine motor control, coordination, and motor planning. While these aspects were touched upon in this current study, it was not possible to determine their separate effects. More in depth assessment is needed to determine how these specific motor characteristics affect participation. Subscales of the BOT-2 full scale could be used or additional scales and activities could be added with the possibility of developing an ASD specific motor skill outcome assessment.

In addition to skill attainment, the examination of skill quality, i.e. *how* skills are performed, is also important. Currently, motor skill assessment is not a priority in the overall evaluation of a child with ASD. This is most likely due to the fact that children do achieve milestones (i.e. sitting, grasping, walking). Refinement of these and other more complex skills is required for children with ASD to keep up with their peers. By elevating motor skill assessment to a necessity or requirement, future research will also need to shift to evidence-based interventions.

This study investigated whether motor skill proficiency is associated with activity participation. A prospective design where children are recruited and followed from a young age would allow for the determination of causality. A repeated measures design and larger sample size would allow for evaluation of the direction of the associations—invaluable information. Future research could address the nature of the relationships and whether they change over time (Westendorp, Houwen, Hartman, & Visscher, 2011). Increased participation at a young age may

foster motor development. Motor competence in the older child may encourage engagement in a variety of activities. Measuring motor skills longitudinally would also provide knowledge on whether the motor skill gap widens or narrows as children age.

Policy Implications.

One in every 68 children is diagnosed with ASD in the United States (Centers for Disease Control and Prevention, 2014). This study supports the position that an effective and relevant clinical evaluation of a child with ASD should include the measurement of motor performance. This research adds to the field by describing the motor skills of school age children with ASD, a necessary component for a complete picture of a child when determining disability status. Typical motor skills are particularly important for social acceptance and inclusion in this group, as several activities essential for play and social relationships through school age are dependent upon how well a child learns and practices fundamental motor skills with peers (Nervik, Martin, Rundquist, & Cleland, 2011; Provost et al., 2007). Regularly examining motor skills and addressing deficiencies in this population may have several benefits including: increasing participation in educational, social, and sports related activities; increasing and improving peer and parental interactions; refining delayed motor skills; fostering greater independence; and promoting social connections and friendships through successful participation in leisure activities. Furthermore, this study advances our understanding of the degree to which impairments in motor proficiency play a role in participation and overall activity level. The empirical data on motor skills is useful in supporting the development of improved clinical assessments and promotion of interventions that allow for participation and functional independence in everyday activities.

Potential Usefulness for DDP.

Participation is a multi-faceted phenomenon, and the role of motor proficiency is often overlooked in ASD. Including assessment of motor skill abilities of children with ASD will provide a clearer picture to providers, educators, and families of their functional abilities. While some studies examining motor skills in school aged children with ASD have presented mixed results, several studies to date indicate these children have impaired motor proficiency in both fine and gross motor skills. Motor skills and participation in life activities are equally important building blocks for the growth and development of children. Knowledge of the proposed analysis may prioritize motor assessment in this population, provide insight into appropriate interventions, and improve the long-term health outcomes for children with ASD. So although motor skill deficiencies may not be primary in this population, it is important to evaluate whether children with ASD have motor impairments. Balance, coordination, strength, and motor planning are key ingredients to successful play, the occupation of childhood (Pollock et al., 1999). Lastly, because motor skills and participation are connected to improved socialization it is a likely consequence that when these are present there will be a positive transition to adulthood with maximum independence.

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