

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

OBJECT CONTROL SKILLS OF CHILDREN AND YOUTH  
WITH AUTISM SPECTRUM DISORDER

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the  
Degree of Master of Science in Exercise and Sport Science-Physical Education Teaching  
Adapted Physical Education Concentration

Megan Valley

College of Science and Health  
Adapted Physical Education

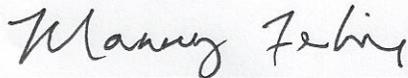
August, 2013

OBJECT CONTROL SKILLS OF CHILDREN AND YOUTH  
WITH AUTISM SPECTRUM DISORDER

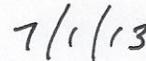
By Megan Valley

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Exercise and Sport Science: Physical Education Teaching – Adapted Physical Education Concentration

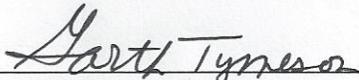
The candidate has completed the oral defense of the thesis.



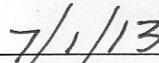
\_\_\_\_\_  
Manny Felix, Ph.D.  
Thesis Committee Chairperson



\_\_\_\_\_  
Date



\_\_\_\_\_  
Garth Tymeson, Ph.D.  
Thesis Committee Member



\_\_\_\_\_  
Date



\_\_\_\_\_  
Richard Mikat, Ph.D.  
Thesis Committee Member

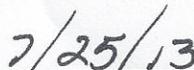


\_\_\_\_\_  
Date

Thesis accepted



\_\_\_\_\_  
Steven Simpson, Ph.D.  
Graduate Studies Director



\_\_\_\_\_  
Date

## ABSTRACT

Valley, M. Object control skills of children and youth with autism spectrum disorder. MS in Exercise and Sport Science-Physical Education Teaching, Adapted Physical Education Concentration, August 2013, 65pp. (M. Felix)

Autism spectrum disorder (ASD) is the fastest growing classification of disability in the U.S., with 1 in every 50 births resulting in a person diagnosed with ASD (Centers for Disease Control and Prevention, 2013). Several studies have identified a delay in the gross motor skills of children with ASD (Breslin & Rudisill, 2011). This is a significant concern for the field of adapted physical education since there will be more students with ASD who may be in need of specially designed physical education services.

Understanding these delays is important for those who provide services to students with ASD. The purpose of this study was to compare the object control skill functioning of children and youth with ASD to their typically developing peers. Participants were (N = 27) 4-18 year olds with ASD who were tested on the object control skill subtest in the Test of Gross Motor Development-2 (Ulrich, 2000). Results indicated that those with ASD are delayed an average of 57 months behind their typically developing peers.

Descriptive analysis suggests that the greatest delay occurs in participants with autistic disorder, delay increases with age, and dribbling and rolling skills were the most delayed compared to other object control skills.

## ACKNOWLEDGEMENTS

I would first like to thank my thesis committee chair, Dr. Manny Felix, for his guidance and support throughout this entire process. I would also like to thank my committee members, Dr. Garth Tymeson and Dr. Richard Mikat, for their professional assistance as I have completed this study and written this manuscript.

I would also like to offer my thanks to Leah Ketcheson, doctoral student at the University of Michigan, who assisted in the early stages of planning for this project and Dr. Marquell Johnson, assistant professor at the University of Wisconsin-Eau Claire, who connected us with participants from the Eau Claire area.

This process would have been much more difficult without the support of Cathy Jambois and the other graduate students in the Adapted Physical Education program. I especially want to thank Stephanie Sciarrino who worked with me to recruit, test, and score all the participants in this study.

I would like to sincerely thank all the children and youth and their parents who participated in this study from the La Crosse and Eau Claire areas. I appreciate the extra time you took out of your schedules for testing and giving us the information we needed to complete the study. I would also like to give an extra thanks to those who participated in the creation of the picture task cards and in the pilot study. The parental insights and experience with the children and youth were instrumental in developing the methods for this study.

Finally, I would like to thank my family, specifically my mother, father, and grandmother for all their love and support that they have given me throughout my experiences while completing my masters. I dedicate this manuscript to you three.

## TABLE OF CONTENTS

|  | PAGE |
|--|------|
| ABSTRACT .....   | iii  |
| ACKNOWLEDGEMENTS .....   | iv   |
| TABLE OF CONTENTS .....  | v    |
| LIST OF TABLES .....   | vi   |
| LIST OF APPENDICES .....   | vii  |
| INTRODUCTION .....   | 1    |
| METHOD .....   | 6    |
| Participants .....   | 6    |
| Data Collection .....  | 6    |
| Procedures .....   | 7    |
| Pilot Study .....  | 9    |
| RESULTS .....  | 11   |
| Figure 1. Mean Differences Between Chronological Age and<br>Age Equivalent by Diagnosis .....  | 16   |
| Figure 2. Mean Differences Between Chronological Age and<br>Age Equivalent by Age Groups ..... | 17   |
| DISCUSSION .....   | 18   |
| REFERENCES .....   | 23   |
| APPENDICES .....   | 25   |

## LIST OF TABLES

| TABLE   | PAGE |
|---|------|
| 1. Gender, Age, and Diagnoses of Participants .....                                     | 11   |
| 2. Object Control Scores .....  | 13   |
| 3. Individual Skill Scores by Diagnosis .....   | 14   |
| 4. Mean Differences Between Chronological Age and Age Equivalent<br>by Diagnosis .....  | 15   |
| 5. Mean Differences Between Chronological Age and Age Equivalent<br>by Age Groups ..... | 17   |

LIST OF APPENDICES

| APPENDIX   | PAGE |
|--|------|
| A. Participant Recruitment Flyer .....             | 25   |
| B. Participant Demographic Information Sheet ..... | 27   |
| C. Informed Consent Form .....                     | 29   |
| D. TGMD-2 Object Control Subtest Score Sheet ..... | 33   |
| E. Picture Task Cards .....                        | 35   |
| F. Review of Literature .....                      | 39   |

## **INTRODUCTION**

Autism spectrum disorder (ASD) is the fastest growing classification of disabilities in the U.S. today with 1 in 50 births resulting in a person who is later diagnosed with ASD (Centers for Disease Control & Prevention, 2013). The Individuals with Disabilities Education Act (IDEA) (2004) states that ASD comprises a range of developmental disorders that impact the brain and can affect communication, social interaction, and stereotyped behaviors within an individual. IDEA recognizes ASD as a disability and therefore schools must provide a free and appropriate public education for students with ASD in the least restrictive environment. Individual education plans (IEPs) must be developed in order to meet the needs of these students if they qualify for special education. One component of that is meeting the physical education needs of these students. Due to the high rate of ASD, it is very likely that physical education and adapted physical education (APE) teachers will work with students with ASD in their classes.

Several studies have identified a delay in the gross motor skills of children with ASD (Berkeley, Zittel, Pitney, & Nichols, 2001; Breslin & Rudisill, 2011; Staples & Reid, 2010; Whyatt & Craig, 2012). Children with ASD may experience difficulty in learning fundamental motor skills (Breslin & Rudisill, 2011), which can impact not only gross motor development, but also successful social interactions with their peers (Berkeley et al., 2001).

It is important for teachers working with children with ASD to evaluate their gross motor development to determine if they are performing at the same level as their typically developing peers. If children with ASD are delayed, then specially designed or APE services may be necessary for them to become successful motor learners. In order to make appropriate comparisons, the use of a nationally standardized, normative test is necessary (Whyatt & Craig, 2012). Assessing and examining the fundamental motor skills of children with ASD is an important part of identifying whether or not there is a motor development delay and if APE services are needed. Standardized testing is often used and is the first type of test considered to assist in identifying delays, and help to identify the gross motor performance of an individual with ASD (Whyatt & Craig, 2012). The use of standardized testing is also important to continue to track the overall development of individuals with ASD (Lord et al., 2012).

Standardized assessments of motor control and coordination, like the Test of Gross Motor Development-2 (TGMD-2), are often used in educational settings to test a wide range of movements (Whyatt & Craig, 2012). The TGMD-2 is a test widely used to evaluate the object control and locomotor fundamental movement skills of children ages 3-10 years (Ulrich, 2000). It has been noted as one of most frequently used instruments to assess fundamental movement skills of children with disabilities (Kim, Park, & Kang, 2012). The TGMD-2 is a standardized, norm- and criterion-referenced test to measure fundamental motor skill functioning and compare results to a nationally normed population. It is also used in APE programs to determine eligibility, placement, and instructional programming for students with a wide range of disabilities.

There are conflicting results in the literature on object control skill functioning of children with ASD compared to their typically developing peers. Whyatt and Craig (2012) found that the two areas where children with ASD had the most difficulty were manual dexterity and ball skills (as measured by the Movement Assessment Battery for Children-2; Henderson et al., 2007). Berkeley et al. (2001) found that there is less of a deficit in object control skills than locomotor skills (as classified by the TGMD-2). Staples and Reid (2010) found no significant difference between object control and locomotor skills, but did note that object control skills may be more impacted by extraneous variables such as practice and personal life experiences. An additional finding by Staples and Reid (2010) is that tasks that involved coordination of arms and legs were most difficult for the children with ASD, which is an additional concern in motor skill development for these individuals.

These studies agree that there is a delay in the gross motor skills of children and youth with ASD, but results differ in which specific skills were most delayed. Whyatt and Craig (2012) found object control skills to be more delayed than locomotor skills, while Berkeley et al. (2001) found object control skills to be less delayed than locomotor skills. Staples and Reid (2010) found no significant difference between object control and locomotor skills. Due to the lack of consensus in relative skill delays of gross motor skills, a study that focused specifically on object control skills would be insightful to see whether there are specific delays in those skills in children and youth with ASD, and determine if more research would be beneficial to determine whether or not specific object control skills are frequently delayed in children and youth with ASD. Results could assist with development of much needed instructional programs for the students.

In the studies discussed, the researchers compared two groups to each other in order to draw conclusions. This study aims to compare the object control skills of children and youth with ASD to the normative standards provided in the TGMD-2. Results of this study could have meaningful implications for APE teachers because it could contribute to the body of literature of how much object control skill delay is typical for students with ASD. Further, this could help support having normative information for children with specific disabilities, such as ASD, in the next edition of the TGMD. This would allow practitioners to compare the test results of students with ASD to the typically developing normative data and also to other students with ASD across the country thus allowing the teacher to have a clearer understanding of the levels at which their students with ASD are performing.

Several studies have found differences in delays among different diagnoses of ASD (Behere et al., 2012; Berkeley et al., 2001; Green et al., 2009; Staples & Reid, 2010). Some research suggests that children with Asperger's disorder may have less of a delay while those with autistic disorder may have the greatest delay. Examining the amount of delay by ASD diagnoses is important to see if there are differences that could help APE teachers with their program planning.

The purpose of this study was to compare the object control skill functioning of children and youth with ASD to their typically developing peers. The research questions in this study were: (1) Are children with ASD developmentally delayed compared to their typically developing peers in object control skills?; (2) Are there specific object control skills in which children with ASD are more delayed?; and (3) Does object control skill functioning differ among ASD diagnoses? The results and implications of this study may

help in further understanding object control skill functioning among individuals with ASD. Special education teachers, including APE teachers, and parents will then be able to justify, create, and/or implement motor programs that best suit the psychomotor needs of children and youth with ASD.

## **METHOD**

### **Participants**

There were 27 children and youth, ages 4-18 years, from the La Crosse and Eau Claire, WI areas that participated in this study. Each participant had a diagnosis of ASD as defined by the American Psychiatric Association (APA, 2000). Participants were recruited using phone calls, emails, and flyers (see Appendix A) with the assistance of various community and university-based physical activity programs for children and youth with disabilities. The parents or legal guardians of the participants completed an information sheet (see Appendix B) that included demographic information about the participant in addition to the informed consent form (see Appendix C). Full IRB approval was obtained to ensure the procedures protected the rights of the participants.

### **Data Collection**

The participants were tested on the object control subtest of the TGMD-2. The TGMD-2 is a standardized test of gross motor skills that is norm- and criterion-referenced. Each of the two subtests (locomotor skills and object control skills) are comprised of six skill items. Each skill item has three to five behavioral or performance components. For the two data collection trials of each skill, each of the behavioral skill components were scored either a “0” (absence of skill component exhibited) or a “1” (presence of skill component exhibited) (see Appendix D). All skill component scores were added to determine a raw score for that test item (Ulrich, 2000).

In this study, only the object control subtest was utilized. The participants were shown a picture task card as a visual cue (see Appendix E) in order to help convey directions and obtain more accurate test results (Breslin & Rudisill, 2011; Staples & Reid, 2010). In this study, picture task cards were a pictorial representation of the motor skills being assessed (Breslin & Rudisill, 2011). More specifically, they were pictures of a child correctly modeling each of the six object control skills. The pictures were displayed to the students on an iPad after the required live demonstration and before the practice trial of the specific object control skill. If the participant did not demonstrate understanding during the practice trial, the picture task card was shown again before doing the two standard trials.

The TGMD-2 has established reliability and validity for its standardized uses. This test has established content sampling (object control  $r = .88$ ), time sampling (object control  $r = .93$ ), and interscorer differences (object control  $r = .98$ ) to demonstrate reliability. Validity was established using three methods- content description validity, criterion prediction validity, and construct identification validity. Overall the TGMD-2 demonstrates moderately high reliability and validity (Ulrich, 2000).

### **Procedures**

The TGMD-2 was administered to participants between January and April, 2013. All participants were tested individually in a dance studio or empty classroom to minimize distractions. All standardized test directions were followed precisely with the exception of the picture task cards. Staples and Reid (2010) suggested that visual aids should be added as part of the TGMD-2 standardized administration if it helps the student to understand the task, and they stated that they did not believe that deviated from

standardized intent of the assessment. Breslin and Rudisill (2011) completed a study that showed that minimizing verbal cues and maximizing visual cues elicited higher test scores when using the TGMD-2. Based on these studies, and the support for use of visual aids for students with ASD in educational settings (Breslin & Rudisill, 2011), a logical decision would be to attempt to gain the most accurate test result possible by using visual cues to aid in the administration of the assessment.

Two researchers tested participants in evenings and on weekends based on participant/parent's schedules. Parents completed the informed consent form and participant information sheet prior to testing. During the session, the participants were given a 2-5 minute acclimatization period with the researchers where they spoke with the participant and showed them the equipment to make them feel comfortable in the test setting. The object control skill tests were then administered by the two researchers, and video of the entire session was recorded for later scoring. Two trials of each skill were implemented, as per the standardized procedures including the use of picture task cards for instruction. Each object control subtest took approximately 5-10 minutes. Following the testing session, the parents of the participants received a score sheet along with an explanation of the scores and information about physical activity and motor development programs in the surrounding area. After testing, the two researchers reviewed the video together and scored the performance independently. Any discrepancies in scores were discussed, reviewed again on the video, and a final score was determined based on consensus.

## **Pilot Study**

A pilot study was conducted on two different days using six volunteer participants. The purposes of the pilot study were to modify the methods for testing for the study including space concerns, have the researchers practice the proper methods of the study, and to receive parent feedback to refine the participant information sheets. Three of the participants had ASD and three were siblings of those participants who did not have ASD. The participants completed the testing on an individual basis and the parents and siblings (if applicable) of the participants were in a far corner of the room completing the participant information sheet or playing games on iPads. Two parents of children with ASD completed the informed consent and participant information sheets and gave feedback on the quality and clarity of the forms. A few questions were changed to make it easier for the parents to understand and more space was given to write answers.

The object control subtest took 5-10 minutes for each participant. The order of instruction was finalized during the pilot study which resulted in the picture task card being shown after the live demonstration for each skill. The researchers scored the participants based on the videos from the pilot study. Changes that were made during and after the pilot study included relocating taped lines for the skill tests in order to avoid certain areas of the testing environment, changing the camera angle, and using tape marks to aid in giving participant direction and ensuring the proper angles for the video camera.

Interrater reliability was established between the two researchers by comparing their scores. A value of .99 for the object control subtest was found indicating that the researchers had very high interrater reliability. Individual object control skill reliability

was also calculated for each item. Interrater reliability coefficients of .90 or greater were found, indicating high interrater reliability among all test items.

## RESULTS

Table 1 presents demographic information about the participants.

Table 1. Gender, Age, and Diagnoses of Participants

| Participant<br>Number | Gender | Age<br>(mo) | Age<br>(yrs) | *ASD<br>Diagnosis | Additional<br>Diagnosis |
|-----------------------|--------|-------------|--------------|-------------------|-------------------------|
| 1                     | M      | 76          | 6.3          | AD                | Yes                     |
| 2                     | M      | 136         | 11.3         | AD                | Yes                     |
| 3                     | M      | 122         | 10.2         | Asp               | No                      |
| 4                     | M      | 157         | 13.1         | PDD               | Yes                     |
| 5                     | M      | 91          | 7.6          | AD                | Yes                     |
| 6                     | M      | 124         | 10.3         | AD                | Yes                     |
| 7                     | M      | 145         | 12.1         | Asp               | Yes                     |
| 8                     | M      | 104         | 8.7          | AD                | No                      |
| 9                     | M      | 174         | 14.5         | AD                | No                      |
| 10                    | M      | 73          | 6.1          | PDD               | Yes                     |
| 11                    | M      | 114         | 9.5          | AD                | No                      |
| 12                    | M      | 208         | 17.3         | AD                | No                      |
| 13                    | M      | 115         | 9.6          | PDD               | Yes                     |
| 14                    | M      | 116         | 9.7          | PDD               | No                      |
| 15                    | M      | 142         | 11.8         | PDD               | No                      |
| 16                    | M      | 195         | 16.3         | AD                | No                      |
| 17                    | M      | 216         | 18.0         | AD                | No                      |
| 18                    | M      | 104         | 8.7          | AD                | Yes                     |
| 19                    | M      | 76          | 6.3          | AD                | Yes                     |
| 20                    | M      | 53          | 4.4          | PDD               | No                      |
| 21                    | M      | 182         | 15.2         | PDD               | No                      |
| 22                    | M      | 146         | 12.2         | AD                | Yes                     |
| 23                    | F      | 174         | 14.5         | Asp               | Yes                     |
| 24                    | M      | 150         | 12.5         | AD                | Yes                     |
| 25                    | M      | 108         | 9.0          | AD                | No                      |
| 26                    | M      | 182         | 15.2         | AD                | Yes                     |
| 27                    | M      | 182         | 15.2         | AD                | Yes                     |
|                       | x      | 135.7       | 11.3         |                   |                         |
|                       | SD     | 43.7        | 3.7          |                   |                         |

\*AD=Autistic disorder; Asp=Asperger's disorder; PDD=PDD-NOS

The 27 of participants ranged in age from 53 months (over 4 years) to 216 months (over 18 years). They had ASD diagnoses of autistic disorder (n = 17), Asperger's disorder (n = 3), and PDD-NOS (n = 7). All participants except number 23 were males (n = 26). More than half (n = 15) of the participants had additional diagnoses such as emotional and behavior disorder, intellectual disability, and speech impairment.

The participants were scored based on the protocols of the TGMD-2. Participants over the age of 11 (n=14) were compared to the 10 year old age group in the TGMD-2 conversion tables. Table 2 displays the raw scores, standard scores, percentiles, and the age equivalents (in months) based on the object control subtest of the TGMD-2. The chronological age (in months) of each participant as well as the difference between that and their object control age equivalent were also added to the table for comparison purposes.

Table 2. Object Control Scores

| Participant Number | Raw Score | Standard Score | Percentile | Age Equivalent (mo) | Age (mo) | Difference (mo) |
|--------------------|-----------|----------------|------------|---------------------|----------|-----------------|
| 1                  | 38        | 10             | 50         | 78                  | 76       | 2               |
| 2                  | 13        | 1              | <1         | <36                 | 136      | >-100*          |
| 3                  | 44        | 10             | 50         | 111                 | 122      | -11             |
| 4                  | 36        | 5              | 5          | 75                  | 157      | -82             |
| 5                  | 34        | 6              | 9          | 69                  | 91       | -22             |
| 6                  | 35        | 5              | 5          | 72                  | 124      | -52             |
| 7                  | 39        | 6              | 9          | 81                  | 145      | -64             |
| 8                  | 38        | 7              | 16         | 78                  | 104      | -26             |
| 9                  | 33        | 4              | 2          | 69                  | 174      | -105            |
| 10                 | 14        | 2              | <1         | <36                 | 73       | >-37*           |
| 11                 | 39        | 6              | 9          | 81                  | 114      | -33             |
| 12                 | 11        | 1              | <1         | <36                 | 208      | >-172*          |
| 13                 | 39        | 6              | 9          | 81                  | 115      | -34             |
| 14                 | 42        | 8              | 25         | 93                  | 116      | -23             |
| 15                 | 41        | 7              | 16         | 87                  | 142      | -55             |
| 16                 | 39        | 6              | 9          | 81                  | 195      | -114            |
| 17                 | 41        | 7              | 16         | 87                  | 216      | -129            |
| 18                 | 25        | 2              | <1         | 51                  | 104      | -53             |
| 19                 | 42        | 12             | 75         | 93                  | 76       | 17              |
| 20                 | 25        | 10             | 50         | 51                  | 53       | -2              |
| 21                 | 46        | 11             | 63         | >129                | 182      | >53*            |
| 22                 | 36        | 5              | 5          | 75                  | 146      | -71             |
| 23                 | 36        | 7              | 16         | 72                  | 174      | -102            |
| 24                 | 19        | 1              | <1         | 36                  | 150      | -114            |
| 25                 | 43        | 9              | 37         | 99                  | 108      | -9              |
| 26                 | 35        | 5              | 5          | 72                  | 182      | -110            |
| 27                 | 31        | 3              | 1          | 63                  | 182      | -119            |
| x                  | 33.9      | 6.0            | 21.9       | 76.3                | 135.7    | -57             |
| SD                 | 9.7       | 3.1            | 21.5       | 31.4                | 43.7     | 46.2            |

\* = Not used for statistical procedures

A one-tailed paired samples t-test was performed to compare the chronological age of the participants in months to their object control subtest age equivalent in months. Participants 2, 10, 12, and 21 were excluded from this procedure since the values did not fall within the range of the equivalents that the TGMD-2 provided. The mean  $\pm$  standard deviation for chronological age was  $133.3 \pm 41.7$  months and the mean for age equivalent was  $76.3 \pm 16.3$  months. The p-value was  $<.001$  showing a significant difference between the two variables.

Percent mastery for individual object control skills was calculated. Table 3 shows the average score and maximum scores as well as the percent mastery for each skill by type of ASD.

Table 3. Individual Skill Scores by Diagnosis

| ASD Diagnosis                      | Strike | Dribble | Catch | Kick | Throw | Roll |
|------------------------------------|--------|---------|-------|------|-------|------|
| <b>Autistic Disorder (n = 17)</b>  |        |         |       |      |       |      |
| Average Score                      | 7.94   | 4.12    | 5.24  | 6.35 | 4.59  | 4.24 |
| Max Score                          | 10     | 8       | 6     | 8    | 8     | 8    |
| % Mastery                          | 0.79   | 0.51    | 0.87  | 0.79 | 0.57  | 0.53 |
| <b>Asperger's Disorder (n = 3)</b> |        |         |       |      |       |      |
| Average Score                      | 9.33   | 6.67    | 5.67  | 6.67 | 7.33  | 4.00 |
| Max Score                          | 10     | 8       | 6     | 8    | 8     | 8    |
| % Mastery                          | 0.93   | 0.83    | 0.94  | 0.83 | 0.92  | 0.50 |
| <b>PDD-NOS (n = 7)</b>             |        |         |       |      |       |      |
| Average Score                      | 9.43   | 4.71    | 4.29  | 7.00 | 4.86  | 4.43 |
| Max Score                          | 10     | 8       | 6     | 8    | 8     | 8    |
| % Mastery                          | 0.94   | 0.59    | 0.71  | 0.88 | 0.61  | 0.55 |
| <b>All ASD (N = 27)</b>            |        |         |       |      |       |      |
| Average Score                      | 8.12   | 4.58    | 4.87  | 6.29 | 4.95  | 4.25 |
| Max Score                          | 10     | 8       | 6     | 8    | 8     | 8    |
| % Mastery                          | 0.81   | 0.57    | 0.81  | 0.79 | 0.62  | 0.53 |

The dribble and roll skills had the lowest percent mastery for all three ASD diagnosis categories. With all participants combined the average percent mastery was 57% for the dribble and 53% for the roll. The third lowest percent mastery was the throw with 62%, however this was not consistent for each ASD group (autistic disorder = 57%, Asperger’s disorder = 92%, and PDD-NOS = 61%). The remainder of the skills had at least 75% mastery on average for all participants (strike = 81%, catch = 81%, and kick = 79%).

Means and standard deviations were calculated for the chronological age and age equivalent for the three different types of ASD present in this study- autistic disorder, Asperger’s disorder, and PDD-NOS. These values are displayed in Table 4 and Figure 1.

Table 4. Mean Differences Between Chronological Age and Age Equivalent by Diagnosis

| Diagnosis           | Mean Difference (mo) | SD (mo) |
|---------------------|----------------------|---------|
| Autistic Disorder   | 62.5                 | 49.6    |
| Asperger's Disorder | 59.0                 | 45.7    |
| PDD-NOS             | 39.2                 | 30.6    |
| All ASD             | 57.0                 | 46.2    |

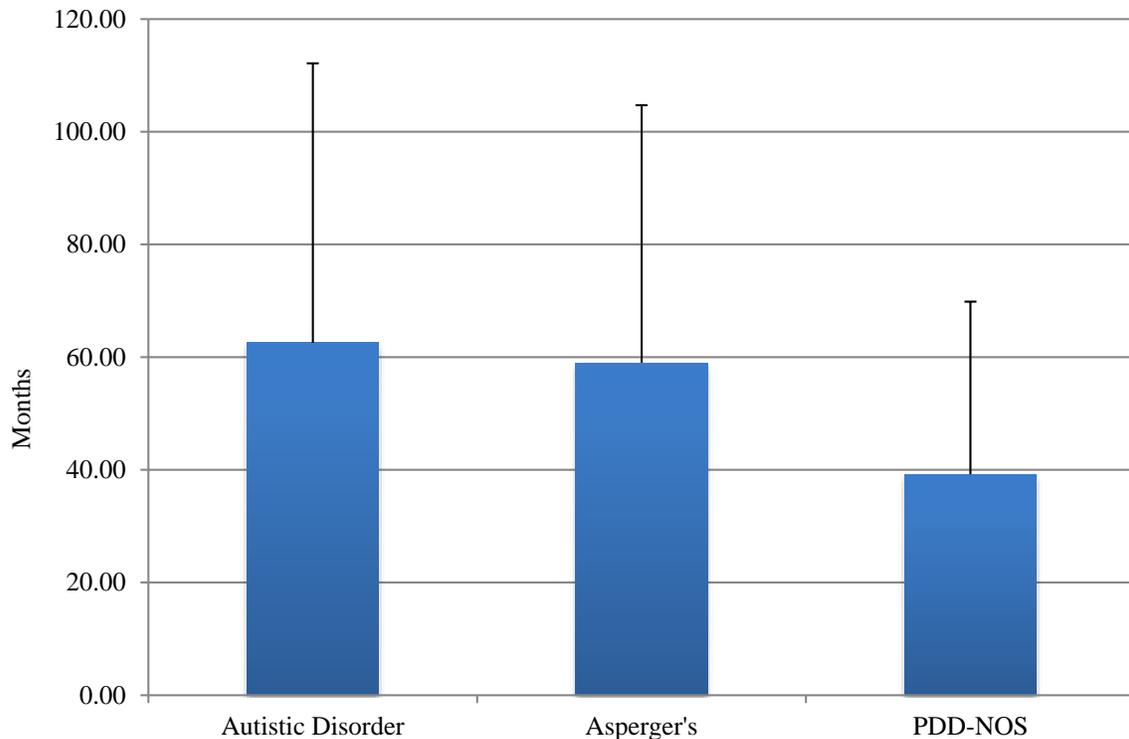


Figure 1. Mean Differences Between Chronological Age and Age Equivalent by Diagnosis

Table 4 and Figure 1 display the mean differences for the three ASD diagnoses, between chronological age and object control age equivalency. Autistic disorder showed the greatest difference ( $62.5 \pm 49.6$ ) followed by Asperger's disorder ( $59.0 \pm 45.7$ ) and finally PDD-NOS had the lowest difference ( $39.2 \pm 30.6$ ).

Mean differences between chronological age and object control age equivalency and standard deviations were also calculated for three age groups. One age group ( $n = 9$ ) consisted of participants between 53 and 114 months. A second age group ( $n = 9$ ) consisted of participants between 115 and 150 months. A third age group ( $n = 9$ ) consisted of participants between 151 and 216 months. These participants were equally grouped for comparative purposes. The values are displayed in Table 5 and Figure 2.

Table 5. Mean Differences Between Chronological Age and Age Equivalent by Age Group

| Age Group          | Mean Difference (mo) | SD (mo) |
|--------------------|----------------------|---------|
| One (53-114 mo)    | 15.8                 | 22.2    |
| Two (115-150 mo)   | 53.0                 | 32.1    |
| Three (151-216 mo) | 108.7                | 14.8    |

Figure 2. Mean Differences Between Chronological Age and Age Equivalent by Age Group

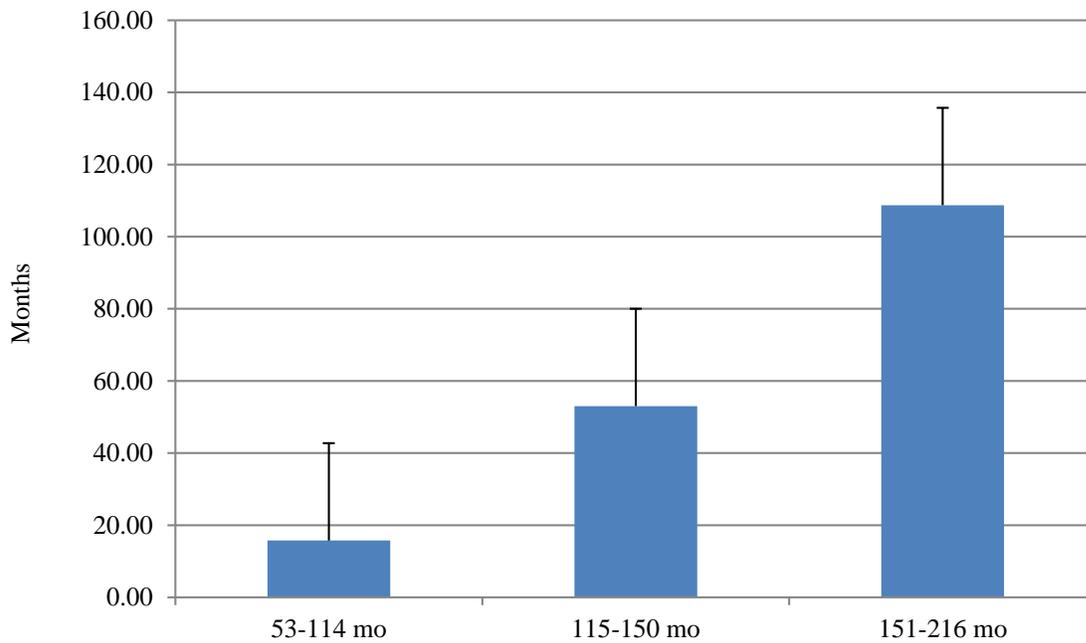


Figure 2. Mean Differences Between Chronological Age and Age Equivalent by Age Group

Table 5 and Figure 2 display the mean differences and standard deviations of the three age groups. These results show that the third or oldest group had the largest difference between the average chronological age and age equivalency score ( $108.7 \pm 14.8$ ).

## DISCUSSION

The purpose of this study was to compare the object control skill functioning of children and youth with ASD to their typically developing peers. The research questions were: (1) Are children with ASD developmentally delayed compared to their typically developing peers in object control skills?; (2) Are there any specific object control skills in which children with ASD are more delayed?; and (3) Does object control skill functioning differ among ASD diagnoses?

In order to assess if the participants were developmentally delayed compared to their typically developing peers, a one-tailed paired samples t-test was used to compare the chronological age ( $M = 133$  mo) of the participant with their age equivalent ( $M = 76$  mo) based on the object control subtest of the TGMD-2. The results showed a significant difference between these variables which suggests a developmental delay in children and youth with ASD of approximately 57 months or almost 5 years. This finding supports previous research with this population (Berkeley et al., 2001; Breslin & Rudisill, 2011; Staples & Reid, 2010; Whyatt & Craig, 2012).

Determining if certain skills are more delayed than others is important for APE teachers to be more aware while providing services to students with ASD. This second research question was addressed by looking at the averages of the raw scores for the six object control skill tests. Dribbling and rolling were the skills that participants had the lowest raw scores on. This could be partially due to the prevalence of youth baseball and soccer programs (which comprise the other four skills on the subtest) in the areas where

testing took place. A flaw in this logic though, is that there is also a large prevalence of youth basketball leagues in the areas as well. Another implication for this finding is that APE teachers could use the TGMD-2 to understand what strengths the students have and what skills need to be further addressed in their physical education setting. The descriptive nature and range of applicable skills in the test would be beneficial in designing IEP goals for students with ASD and has been used by teachers in the field.

The third research question for this study included evaluating whether or not different ASD diagnoses yielded different results in the object control subtest. The average delay for participants with each of the ASD diagnoses was determined. The participants with autistic disorder had an average delay of 63 months while those with Asperger's disorder had an average delay of 59 months. Those in the PDD-NOS group had an average delay of 39 months. These results indicate that delay may be dependent on the specific diagnoses of ASD. Behere et al. (2012) found that participants with autistic disorder had more delay than those with Asperger's disorder, but PDD-NOS was not included in the results of their study. Future studies that can analyze this hypothesis statistically should be conducted to better understand these potential differences.

The limitations of this study must be addressed. There was a wide age range (4-18 years) which led to a few limitations. First, since there were only 27 participants, it was more difficult to perform statistics with adequate power when breaking down the participant pool into three different diagnoses and age groups for comparison. Secondly, the TGMD-2 normative data only provides for children ages 3-10 years. Therefore, the 11-18 year olds in this study were being compared to the 10 year old age group. Despite this limitation, the study still found significant delays even in those older participants

whose scores indicated an object control skill level well under the age of 10 years. In terms of diagnoses, there were not equal numbers between the three diagnoses in the study (autistic disorder, Asperger's disorder, and PDD-NOS). Therefore, an ANOVA could not be used due to a failure to meet the assumptions. Another limitation is that the diagnosis and additional information used was provided by the parents through the participant information sheet instead of a psychologist providing this information for the study. Due to this, we were not able to obtain a level of severity category on the autism spectrum for the participants in the study.

A final limitation is that there were additional diagnoses of other disability conditions in 15 of 27 participants which were not controlled for this study. Some of those who had secondary diagnoses had conditions in which there is no evidence to support that they impact the gross motor performance of individuals with autism. Examples of these disability conditions are learning disabilities and speech impairments. Some participants did have additional disabilities that have been shown to impact gross motor performance such as intellectual disability (ID). Previous research has shown that individuals with ID have lower fitness and perceptual motor abilities than those without ID (Hezkiah, 2005). Because recruitment efforts focused on finding as many participants with different forms of ASD as possible, exclusion criteria to account for secondary diagnoses such as ID were not used. Using this exclusion would have resulted in very low participant numbers. Future research studies that can provide tighter control over this threat to validity while maintaining adequate participant numbers is recommended.

This study added to the body of literature that shows a significant developmental delay in the object control skills of children and youth with ASD. It also indicated the

possibility that children and youth with classic autism or autistic disorder have the greatest delays compared to other diagnoses on the autism spectrum. An important implication for future research would be to investigate more thoroughly whether or not different diagnoses of ASD results in varying degrees of developmental delay. A larger participant pool will be required to investigate this possibility. Also, recent changes in the Diagnostic and Statistical Manual-5 definitions of ASD may justify the importance of identifying motor skill performance at the different levels of severity among those with ASD in order to better help adapted physical educators better understand the motor skill abilities of students with ASD (American Psychiatric Association, 2013). The new definition includes a more merged definition of ASD that focuses more on the level of severity of ASD instead of specific diagnoses or types of ASD as in the past.

Lord et al. (2012) conclude that the TGMD-2 can be used to help monitor the gross motor skill progress of students with ASD. This is an important function of the TGMD-2 for APE teachers so that IEP goal progress can be measured over time. An implication of the research in the current study is that there may be a need for a standardized test that spans the school age range since the TGMD-2 is only standardized up to the age of 10. This could be useful for longitudinal research to further study how gross motor skills develop in persons with ASD. It would also be important to justify APE services based on objective testing.

Another suggestion for future research would be to examine the delay in relationship to age on all items of the TGMD-2. This would mean scoring the locomotor and object control subtests which would provide the gross motor quotient that indicates the overall level of gross motor functioning (Ulrich, 2000). A longitudinal study

following the gross motor skills of children and youth with ASD throughout their school years would be useful in order to determine if the delay remains consistent, or if there is a deficit in learning motor skills which could cause the individuals with ASD to fall farther and farther behind their typically developing peers in physical education, sport, and recreation. This could also be used to examine effective practices in APE programming. This suggestion also comes from the findings of Staples and Reid (2010) who found that individuals with ASD may have a different pattern of learning motor skills than persons without ASD.

Research that answers these important questions will contribute to the understanding of how children and youth with ASD develop their gross motor skills and how physical educators can be more effective in promoting the development of these skills in their students. This study lends support for required APE programming for students with ASD. Although not substantiated in this study, data appears to indicate a possible trend that as age increases, the amount of delay increases as well. Programming to aid students develop and become more physically active is an important consideration in their lives.

## REFERENCES

- American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5<sup>th</sup> ed.). Washington, DC: APA.
- Behere, A., Shahani, L., Noggle, C., & Dean, R. (2012). Motor functioning in autistic spectrum disorders: A preliminary analysis. *The Journal of Neuropsychiatry and Clinical Neurosciences*, 24(1), 87-94.
- Berkeley, S., Zittel, L., Pitney, L., & Nichols, S. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly*, 18(4), 405-416.
- Breslin, C., & Rudisill, M. (2011). The effect of visual supports on performance of the TGMD-2 for children with autism spectrum disorder. *Adapted Physical Activity Quarterly*, 28(4), 342-353.
- Centers for Disease Control and Prevention. (2013). Changes in prevalence of parent-reported autism spectrum disorder in school-aged U.S. children: 2007 to 2011-2012. *National Health Statistics Reports*, 65, 1-11.
- Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., et al. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine and Child Neurology*, 51, 311-316.
- Henderson, S., Sugden, D., & Barnett, A. L. (2007). *The movement assessment battery for children* (2nd ed.). London: The Psychological Corporation.
- Hezkiah, A. (2005). Adapted physical activities for the intellectually challenged adolescent: Psychomotor characteristics and implications for programming and motor intervention. *International Journal of Adolescent Medicine and Health*, 17(1), 33-47.
- Individuals with Disabilities Education Act Amendments of 2004 (IDEA) (PL 108-446), 20 U.S.C. 1400 (2004).
- Kim, Y., Park, I., & Kang, M. (2012). Examining rater effects of the TGMD-2 on children with intellectual disability. *Adapted Physical Activity Quarterly*, 29(4), 346-365.

- Lord, C., Luyster, R., Guthrie, W., & Pickles, A. (2012). Patterns of developmental trajectories in toddlers with autism spectrum disorder. *Journal of Consulting and Clinical Psychology, 80*(3), 477-489.
- Pan, C., Tsai, C., & Chu, C. (2009). Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. *Journal of Autism and Developmental Disorders, 39*(12), 1694-1705.
- Staples, K., & Reid, G. (2010). Fundamental movement skills and autism spectrum disorders. *Journal of Autism and Developmental Disorders, 40*(2), 209–217.
- Ulrich, D. (2000). *Test of Gross Motor Development (2<sup>nd</sup> ed.)*. Austin, TX: Pro-Ed.
- Whyatt, C., & Craig, C. (2012). Motor skills in children aged 7–10 years, diagnosed with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 42*(9), 1799–1809.

APPENDIX A  
PARTICIPANT RECRUITMENT FLYER

UNIVERSITY of WISCONSIN  
**LA CROSSE**

**Center on Disability Health and Adapted Physical Activity seeks contact  
with parents of children with autism, ages 3-18**

**What: Gross Motor Development Testing of Children with Autism**

Motor skill abilities of children with autism will be evaluated using the Test of Gross Motor Development (throwing, catching, rolling, etc.). This one-time session will take no longer than one hour. We will limit our testing to 50 children on a first come, first serve basis.

*Benefits:* Free gross motor development profile and suggestions for gross motor skill development; learn more about physical activity opportunities in the Coulee region for your child.

**Where: UW-La Crosse/Mitchell Hall**

**When: January-March 2013** (Set up a single one hour testing session at your convenience).

**How: Contact us to schedule testing or for information:**

- Stephanie Sciarrino and Megan Valley, 608.785.8695  
sciarrin.step@uwlax.edu, valley.mega@uwlax.edu

**Project under the direction of:**

- Dr. Garth Tymeson, 608.785.5415, gtymeson@uwlax.edu
- Dr. Manny Felix, 608.785.8691, efelix@uwlax.edu



University of Wisconsin-La Crosse

Living well with disability  
through an active  
and healthy lifestyle

**APPENDIX B**

**PARTICIPANT DEMOGRAPHIC INFORMATION SHEET**

**OBJECT CONTROL SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDERS**

Study Participation Information Sheet

Child's Name: \_\_\_\_\_ Child's Age: \_\_\_\_\_  
Child's Gender: (Circle One) Male Female Child's Date of Birth (MM/DD/YYYY): \_\_\_\_\_  
Child's School District: \_\_\_\_\_ Child's School: \_\_\_\_\_

Child's ASD Diagnosis: (Circle One)

Autistic disorder Asperger's disorder Rett's syndrome Childhood Disintegrative Disorder  
Pervasive Developmental Disorder- Not Otherwise Specified (PDDNOS)

Does your child have any additional diagnosed disabilities? (Please Circle) No Yes (Circle all that apply).

Deaf-blindness Deafness Developmental delay |  
Emotional disturbance Hearing impairment Intellectual disability  
Multiple disabilities Orthopedic impairment Other health impairment  
Specific learning disability Speech or language impairment Traumatic brain injury  
Visual impairment, including blindness

In which education setting(s) does your child receive their education?

General education (inclusive, no aide) General education (inclusive, with an aide)  
Self-contained class 1 on 1 with primary instructor

Other: \_\_\_\_\_

Please provide any additional information if necessary:

In which educational setting(s) does your child receive physical education services? (Circle One)

General PE (inclusive, no aide) General PE (inclusive, with an aide)  
Self-contained class 1 on 1 with primary instructor

Other: \_\_\_\_\_

Please provide any additional information if necessary:

On a scale of 0-10, how well does your child receive, process, and respond to verbal communication?

(0 = 0%, 5 = 50%, 10 = 100%)

0 1 2 3 4 5 6 7 8 9 10

On a scale of 0-10, does your child currently use picture icons or other forms of visual communication to assist with understanding language in the home and/or school environment?

(0 = never, 10 = all the time)

0 1 2 3 4 5 6 7 8 9 10

Signature of parent/guardian of Child: \_\_\_\_\_

Date: \_\_\_\_\_

APPENDIX C  
INFORMED CONSENT FORM

## **Informed Consent Form**

**Title of Study:** Object Control Skills of Children and Youth with Autism Spectrum Disorder

**Title of Study:** Effects of Visual Supports on the Gross Motor Performance of Children with Autism Spectrum Disorder

**Researchers:** Stephanie Sciarrino and Megan Valley, Graduate Students, Department of Exercise and Sport Science, University of Wisconsin-La Crosse

**PLEASE READ THE FOLLOWING INFORMATION TO BE SURE YOU ARE INFORMED ABOUT THIS RESEARCH STUDY. SIGN THE FORM IF YOU AGREE TO HAVE YOUR CHILD PARTICIPATE. YOUR SIGNATURE ON THE FORM CONFIRMS THAT WE HAVE INFORMED YOU OF THE PURPOSE OF THE STUDY, NATURE AND RISK OF PARTICIPATION, POTENTIAL BENEFITS, AND THAT YOU HAVE MADE YOUR DECISION VOLUNTARILY.**

### **Why is this research study being done?**

This study is being conducted in order to gather information about the object control skills of children and youth who have been identified with autism spectrum disorder (ASD). The results of this study will be used for two projects. One will compare the results with the information about object control skills of same-age peers who have not been identified with ASD. The other will compare which instructional support strategy (picture task card or video modeling) will be more effective in collecting accurate test results.

### **How many people will take part in the study?**

Approximately 40-50 participants, ages 3-18 years, with ASD will take part in this study. These participants will be from La Crosse and surrounding areas.

### **Why are you and your child being asked to take part in this research study?**

Your child has been invited to take part in this study because he/she has been identified as being on the autism spectrum and is between the ages of 3-18 years.

### **What will happen in the study?**

In this study, your child will be tested on six object control skills. These skills include striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll. A very common assessment, the Test of Gross Motor Development-2, will be used to assess these object control skills. This test will be performed twice, once for each instructional strategy (picture task card and video modeling)

Testing will take place in either Mitchell Hall or Wittich Hall on the UW- La Crosse campus. All testing will be conducted by the primary researchers (Stephanie Sciarrino and Megan Valley). All testing will be videotaped to verify scoring accuracy. Parents will be contacted to set up appointments for testing times. As part of the study, parents will complete a survey to collect demographic data such as the date of birth, gender, diagnosis of ASD, and behavioral characteristics (see attached form).

**How long will the research study last?**

It is anticipated that each participant will spend approximately 15-30 minutes in testing for this study. The parent will have the opportunity to fill out the survey to collect demographic data during that time.

**Are there reasons that my child and I might leave the study early?**

Your decision to have your child participate in this study is entirely voluntary. You or your child may decide to stop participation at any time without penalty. In addition, the researchers may stop your child's participation in this study at any time if it is determined to be in your child's best interest, if you or your child does not follow the study procedures, or if the study is stopped.

**What are the risks of the study?**

No risk is anticipated beyond that possibly experienced from light to moderate physical activity such as muscle soreness and fatigue. The object control skills included in this test are common and age-appropriate. The area used for testing will be clear of any obstructions.

**Are there benefits to taking part in this research study?**

We do not anticipate any direct benefits to the subjects as a result of participating in this study. The major focus is to gather descriptive data that can be used for possible intervention programs and for the development of instructional strategies to enhance the object control skills of children and youth with ASD. Results of the study will be shared with parents/guardians of the participants to provide information about their object control skills. This could help guide decisions about physical activity and motor development programming for the participant. The researcher will provide parents with information about available physical activity programs.

**Will there be any cost for participation in the study?**

There will be no cost to you for your child's participation. You will be responsible for transporting your child to the testing site.

**What happens if my child is injured in this research study?**

In the unlikely event that any injury or illness occurs as a result of this research, the Board of Regents of the University of Wisconsin System, and the University of Wisconsin-La Crosse, their officers, agents, and employees, do not automatically provide reimbursement for medical care or other compensation. I have been informed that payment for treatment of any injury or illness must be provided by me or my third-party payor, such as my health insurer or Medicare. If any injury or illness occurs in the course of research, or for more information, I will notify the investigator in charge. I have been informed that I am not waiving any rights that I may have for injury resulting from negligence of any person or the institution.

For information about policies, the conduct of the study, or the rights of research subjects, please contact the University of Wisconsin-La Crosse Institutional Review Board (IRB) for the Protection of Human Subjects (608-785-6892; [irb@uwlax.edu](mailto:irb@uwlax.edu)). The IRB is a group of people who review the research to protect the rights of research participants.

**What are my rights of my child if he/she takes part in this research study?**

Taking part in this research study does not take away any other rights or benefits that you or your child might have if they did not take part in this study. Taking part in this study does not give you or your child any special privileges. You and your child will not be penalized in any way if you decide to stop or withdraw your child after the start of the study. As the parent/guardian, you will be informed of any changes that may affect your willingness to continue to have your child in the study.

**What about confidentiality?**

Information from this study may be published or presented at professional meetings. Your child's name and other identifying information will not be used without your written permission. Any personal demographic information collected will be kept confidential.

**Who can answer my questions?**

You may speak with Stephanie Sciarrino or Megan Valley (608.785.8695) or Dr. Garth Tymeson (608.785.5415) at any time with questions you have regarding this study.

**I HAVE READ ALL THE ABOVE, ASKED QUESTIONS, RECEIVED ANSWERS CONCERNING MY QUESTIONS, AND I WILLINGLY GIVE MY CONSENT TO HAVE MY CHILD PARTICIPATE IN THIS STUDY. UPON SIGNING THIS FORM, I WILL RECEIVE A COPY.**

\_\_\_\_\_  
(Date)

\_\_\_\_\_  
(Signature of Parent/Guardian)

\_\_\_\_\_  
(Date)

\_\_\_\_\_  
(Signature of Individual Obtaining Consent)

APPENDIX D

TGMD-2 OBJECT CONTROL SUBTEST SCORE SHEET

**Object Control Subtest**

| Skill                         | Materials   | Directions   | Performance Criteria   | Trial 1 | Trial 2 | Score |
|-------------------------------|---|--|--|---------|---------|-------|
| 1. Striking a Stationary Ball | A 4-inch lightweight ball, a plastic bat, and a batting tee   | Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial.                                 | 1. Dominant hand grips bat above nondominant hand  |         |         |       |
|                               |   |  | 2. Nonpreferred side of body faces the imaginary tosser with feet parallel                               |         |         |       |
|                               |   |  | 3. Hip and shoulder rotation during swing  |         |         |       |
|                               |   |  | 4. Transfers body weight to front foot   |         |         |       |
|                               |   |  | 5. Bat contacts ball   |         |         |       |
| <b>Skill Score</b>            |   |  |  |         |         |       |
| 2. Stationary Dribble         | An 8- to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat, hard surface | Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial. | 1. Contacts ball with one hand at about belt level   |         |         |       |
|                               |   |  | 2. Pushes ball with fingertips (not a slap)  |         |         |       |
|                               |   |  | 3. Ball contacts surface in front of or to the outside of foot on the preferred side                     |         |         |       |
|                               |   |  | 4. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it |         |         |       |
| <b>Skill Score</b>            |   |  |  |         |         |       |

| Skill              | Materials   | Directions   | Performance Criteria  | Trial 1 | Trial 2 | Score |
|--------------------|---|--|---|---------|---------|-------|
| 3. Catch           | A 4-inch plastic ball, 15 feet of clear space, and tape   | Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial. | 1. Preparation phase where hands are in front of the body and elbows are flexed |         |         |       |
|                    |   |  | 2. Arms extend while reaching for the ball as it arrives                        |         |         |       |
|                    |   |  | 3. Ball is caught by hands only   |         |         |       |
| <b>Skill Score</b> |   |  |   |         |         |       |
| 4. Kick            | An 8- to 10-inch plastic, playground, or soccer ball; a beanbag; 30 feet of clear space; and tape | Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the beanbag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.   | 1. Rapid continuous approach to the ball  |         |         |       |
|                    |   |  | 2. An elongated stride or leap immediately prior to ball contact                |         |         |       |
|                    |   |  | 3. Nonkicking foot placed even with or slightly in back of the ball             |         |         |       |
|                    |   |  | 4. Kicks ball with instep of preferred foot (shoelaces) or toe                  |         |         |       |
| <b>Skill Score</b> |   |  |   |         |         |       |

|   |   |  |   |  |  |  |
|---|---|--|---|--|--|--|
| 5. Overhand Throw   | A tennis ball, a wall, tape, and 20 feet of clear space   | Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.                       | 1. Windup is initiated with downward movement of hand/arm                                     |  |  |  |
|   |   |  | 2. Rotates hip and shoulders to a point where the nonthrowing side faces the wall             |  |  |  |
|   |   |  | 3. Weight is transferred by stepping with the foot opposite the throwing hand                 |  |  |  |
|   |   |  | 4. Follow-through beyond ball release diagonally across the body toward the nonpreferred side |  |  |  |
| <b>Skill Score</b>  |   |  |   |  |  |  |
| 6. Underhand Roll   | A tennis ball for children ages 3 to 6; a softball for children ages 7 to 10; two cones; tape; and 25 feet of clear space | Place the two cones against a wall so they are 4 feet apart. Attach a piece of tape on the floor 20 feet from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat a second trial. | 1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones     |  |  |  |
|   |   |  | 2. Strides forward with foot opposite the preferred hand toward the cones                     |  |  |  |
|   |   |  | 3. Bends knees to lower body  |  |  |  |
|   |   |  | 4. Releases ball close to the floor so ball does not bounce more than 4 inches high           |  |  |  |
| <b>Skill Score</b>  |   |  |   |  |  |  |
| <b>Object Control Subtest Raw Score (sum of the 6 skill scores)</b> |   |  |   |  |  |  |

APPENDIX E  
PICTURE TASK CARDS

## Striking



## Dribbling



## Catching



## Kicking



## Throwing



## Rolling



APPENDIX F  
REVIEW OF LITERATURE

## **Review of Literature**

### **Introduction**

Autism spectrum disorder (ASD) is the fastest growing classification of disabilities in the U.S. today with 1 in 50 births resulting in someone who will be later diagnosed with ASD (Centers for Disease Control and Prevention, 2013). ASD comprises a range of developmental disorders that impact the brain and can affect communication, social interaction, and stereotyped behaviors within an individual. These affected areas lead to significant learning challenges and often times justify unique educational programming (IDEA, 2004).

Several studies have identified delay in the gross motor skills of children with ASD (Berkeley, Zittel, Pitney, & Nichols, 2001; Breslin & Rudisill, 2011; Staples & Reid, 2010; Whyatt & Craig, 2012) and further research is needed to identify the amount of delay. Children with ASD have a greater risk of not learning fundamental motor skill functioning (Breslin & Rudisill, 2011), which can impact not only their gross motor development, but also successful interactions with their peers (Berkeley et al., 2001).

It is important for those working with children with ASD to monitor their gross motor development to ensure they are on track with their peers. In order to make appropriate educational decisions, a standardized, normative test is necessary (Whyatt & Craig, 2012). The Test of Gross Motor Development-2 (Ulrich, 2000) is a widely used test to identify the object control and locomotor fundamental movement skill functioning of children (Ulrich, 2000). It is also considered one of most frequently used instruments to assess fundamental movement skills of children with disabilities (Kim, Park, & Kang, 2012).

The TGMD-2 is a standardized assessment that utilizes both norm- and criterion-referenced criteria to describe fundamental motor skill functioning in children 3-10 years of age. The TGMD-2 is often used in the clinical setting and in the adapted physical education (APE) setting to test a wide range of gross motor skills (Whyatt & Craig, 2012). It is used specifically in APE for assessment, placement, and instruction purposes. The TGMD (first edition, 1985) was praised by Berkeley et al. (2001) as a good choice for testing children with ASD due to its ease of use with students with ASD and for the decisions that the TGMD assists in making.

Studies that have tested children with ASD's fundamental motor skills have found mixed results in comparing these skills to children without ASD. Further research is necessary to clarify the extent of delays in motor development in children with ASD and specific skills that may be more delayed than others. Studies concerning the gross motor skills of children with ASD and studies that utilize the TGMD-2 in assessing the gross motor skills of children with ASD are outlined and discussed in this review.

### **Gross Motor Skills of Children with ASD**

Many studies that examine the gross motor abilities of children with ASD use a holistic approach to gross motor performance, in which the overall motor development is assessed on a wide scale. An alternative purpose would be to examine individual tasks such as those found in the Movement Assessment Battery for Children (M-ABC2) (Henderson & Sugden, 1992; Whyatt & Craig, 2012). Whyatt and Craig used this philosophy to guide their study which compared the gross motor skills of children with ASD to a language-matched group and a nonverbal IQ-matched group. Eighteen children, ages 7-10, in a school program for children with ASD were participants in this study.

They were classified according to their characteristics of ASD and the authors tested the children's gross motor skills using the M-ABC2, which included manual dexterity, ball skills, and balance items.

Results suggested that there may be some underlying difficulties that hinder the success of children with ASD in performance of gross motor skills. Examples of these include coupling speed and accuracy, visuo-motor integration, understanding of being timed, and perception-action coupling. The two areas where children with ASD had the most difficulty were the manual dexterity and ball skills components. These results differ from the Berkeley et al. (2001) study which showed less of a deficit in object control skills when compared to a typically developing group.

Implications from Berkeley et al. (2001) include the need for increased research in difficulties in specific motor concepts that could be unique to children with ASD, and further attempts to find the root of gross motor development problems in children with ASD. The results, in similar fashion to Staples and Reid (2010), indicated that children with ASD may not simply be delayed, but rather have gross motor deficits that must be addressed in an individual and specific manner. To clarify, a delay would mean developing on the same developmental trajectory as a typically developing child, but at a slower rate. A deficit would indicate differences in patterns of development from typically developing peers. This is an important implication for APE since if there is a deficit, and not simply a delay, that may impact the strategies teachers use for working with students with ASD. For example, if a different way of motor development was distinguished for students with ASD, an APE teacher could utilize that knowledge in developing individual education plan (IEP) goals for that student.

Several studies have contributed to the knowledge that there is a general delay in the gross motor skills of children with ASD (Berkeley et al., 2001; Breslin & Rudisill, 2011; Staples & Reid, 2010; Whyatt & Craig, 2012). Green et al. (2009) adds to that body of literature through their research with children with ASD. The authors of that study included a large participant pool and tested 101 children and youth with ASD and a wide range of IQ scores. Several tests for ASD were used along with the M-ABC to assess the gross motor skills of the participants.

The results of this study found that 79% of the children with ASD in the study had motor impairments as measured by the M-ABC. Children with ASD were found to have lower scores than those with other forms of ASD. This result could have specific implications for future research in assuring that specific diagnoses within the ASD spectrum are separated for analysis after gross motor skill testing is completed. The authors postulate that motor problems may be due to a neurological impairment that is found in severe autism and persons with low IQs. An implication of this would be to determine the levels of severity in autism prior to testing individuals' gross motor skills, in order to get a more diagnosis specific view of how persons with different ASD and different levels of ASD perform.

It is important to monitor changes in development when working with persons with developmental disorders such as ASD. Lord, Luyster, Guthrie, and Pickles (2012) used standardized measurements to monitor the development of toddlers from the ages of 18 to 36 months. The authors attempted to identify individual trajectories of development to help predict the paths that ASD would take in children later in life.

The Lord et al. (2012) study consisted of 78 individuals who were tested a total of 490 times using the Autism Diagnostic Interview-Revised (Le Couteur, Lord, & Rutter, 2003), the Autism Diagnostic Observation Schedule (Lord et al., 2000), and the Mullen Scales of Early Learning (Mullen, 1995). Many of the participants were at risk for ASD and not officially diagnosed; however, final results showed that 39 participants had an ASD diagnosis, 20 were labeled as typically developing, and 19 were diagnosed with nonspectrum diagnoses. Using the generalized linear latent and mixed models (Rabe-Hesketh, Skrondal, & Pickles, 2004), trajectories of development based on the results were created.

Growth trajectories for social-affective development, stereotyped behaviors, and repetitive interests were predictable in young toddlers. The implications of this study are that young children with ASD need periodic monitoring and continual assessment of educational and functional outcomes as they age in order to provide the most effective interventions. Similarly, the TGMD-2 can help monitor the gross motor skill progress of children with and without ASD.

Several studies have identified a delay in the gross motor skills of children with ASD (Berkeley et al., 2001; Breslin & Rudisill, 2011; Green et al., 2009; Staples & Reid, 2010; Whyatt & Craig, 2012). Although these studies contribute to the knowledge of gross motor developmental delays, another consideration when evaluating motor skills is to determine whether developmental delays remain stable over time. Van Waelvelde et al. (2010) investigated this by studying 49 children with or at risk of ASD, attention deficit hyperactivity disorder (ADHD), or developmental coordination disorder using the M-

ABC two separate times. This study aimed to see if a poor motor performance between the ages of 4 and 6 persisted for at least 2 years.

Participants in the study were measured using the M-ABC when they were between 4-6 years of age and again when they were between 6-9 years of age. The results showed that overall the mean M-ABC score significantly improved in the time period; however, children with ASD were shown to have both the lowest M-ABC scores and the lowest increase between the two time frames. This study demonstrates that not all motor performances are stable, but can be more stable in terms of the motor development of children with ASD.

There were some limitations in this study, a major one being a large number of participants who were not able to complete the follow-up portion of the study. The authors address this and suggest more longitudinal studies need to be completed. The implications of this study are that more early intervention services need to be provided to children with ASD, since their motor growth is delayed compared to their typically developing peers, peers with ADHD, and peers with developmental coordination disorder.

In order to assess the participation of individuals with ASD in after school physical activity, Obrušnikova and Miccinello (2012) used parental responses to determine barriers to participation through the multidimensional socioecological model. A total of 103 parents of 5-12 year old children in special education completed an online questionnaire with 11 of these parents participating in follow-up focus groups. Responses were coded in four different data sets and resulted in 225 advantages and 106 disadvantages to after school physical activity programs; the study also identified 225

facilitators that can help make after school physical activity a positive experience for individuals with ASD and 250 barriers to physical activity. It should be noted that this study was limited to the tri-state area of Delaware, Maryland, and Pennsylvania.

The results of this study will help after school physical activity programs limit sedentary behavior and increase physical activity for those with ASD. Future research in this area should expand the study to different regions or to even examine views on a national level to create meaningful guidelines for extracurricular physical activity involvement for individuals with ASD.

The researchers independently evaluated the questionnaire items using a 4-point scale. After initial evaluations, a pilot study was performed using five parents and the panel made their final assessments. Focus groups were used to clarify responses from the questionnaire and during data analysis both qualitative and quantitative factors were analyzed. Results indicated that exploring many physical activities and using sedentary interests to motivate individuals to be active are important guidelines for a positive physical activity experience. The authors noted that the way the student perceives the physical activity is essential in continued participation in that activity.

Other suggestions from this study included establishing a routine, empowering the individual, and finding activities that are intrinsically motivating. Additionally there is a need to prepare typically developing peers to increase their understanding of the needs of individuals with ASD and overall acceptance and inclusion during physical activity. An area of future research would be to further explore the object control skill levels of children with ASD and also examine their interest level in different types of physical activity. A relationship between these two variables may have implications for physical

activity recommendations for children and youth with ASD in the physical education and outside of school physical activity settings.

Despite ASD consisting of developmental disorders with broad but similar characteristics, there are still many unique differences that can be identified among the various ASD. Behere, Shahani, Noggle, and Dean (2012) studied differences in ASD (or autistic disorder) and Asperger disorder. The two major purposes were to examine the motor profiles of individuals with autism and Asperger disorder and to evaluate if motor characteristics can assist in diagnosing a specific ASD. Participants in this study included 16 individuals who were diagnosed with autism and 10 individuals who were diagnosed with Asperger's disorder. Participants were administered the standardized Dean-Woodcock Sensory-Motor Battery (DWSMB) to measure sensory and motor skills (Dean & Woodcock, 2003).

MANOVA analyses followed by a post-hoc discriminant function demonstrated a significant difference between the groups of participants with autism and with Asperger's disorder. The authors note that a limitation of the study was a small number of participants; however, the results were still found to be significant in showing that the participants with Asperger's disorder scored much higher than those with autism (Behere et al., 2012).

This study was one of the first to identify motor differences to differentiate between two different ASD. Sensory and motor functioning can lend knowledge to how the entire central nervous system is functioning in an individual (Behere et al., 2012). The authors state that neuroanatomical differences between the two disorders as indicated by motor differences can be used in the diagnostic process. Since this study demonstrates

how important motor functioning can be to accurate diagnosis within ASD, it can also support the use of standardized, gross motor skill testing in children with various diagnoses of ASD.

### **Uses of TGMD-2 with Children with ASD**

Several studies have been completed measuring the gross motor skills of children with ASD by utilizing the TGMD-2. In one research study, Breslin and Rudisill (2011) hypothesized that individuals with ASD would perform better on the TGMD-2 with the use of visual supports. The researchers tested 22 children ages 3-10 who were diagnosed with ASD. They tested three different protocols on three separate days, with individuals completing the protocols in a varied, randomized order. The traditional protocol was the standard use of the TGMD-2. The picture task card protocol included the use of a card with a picture of the task to be performed that was shown during the explanation of each task. The picture activity schedule protocol was similar to the picture task card protocol but also included the picture task cards on the wall during testing and they were taken down as each individual task was performed in order to use it for instruction.

Repeated-measures ANOVA found significantly different gross motor quotient (GMQ) results between protocols, and the participants were found to be developmentally delayed in their gross motor skill development. The picture task card protocol was found to elicit a significantly higher GMQ than the traditional protocol, but the picture activity schedule protocol did not. A 6 point difference in GMQ between protocols indicated a 10% change in performance. Thus, the use of increased visual cues to aid in testing may elicit a more accurate performance. To conclude, the use of minimal verbal

communication and picture cards was found to increase the GMQ score on the TGMD-2 for children with ASD in this study.

Certain limitations may have impacted the results in this study. The age and disability population was appropriate in conjunction with the TGMD-2; however, the same group of participants was tested using all three protocols. This could contribute to error since it is possible that varied levels of learning occurred between the days of the testings. The variable protocols (picture task card and picture activity schedule) involved both a minimizing of verbal cues and an increase in visual aids. These mixed variables made it difficult to distinguish which variable actually aided in improving results. Further studies that involve testing different children using the protocols, and creating more controlled variables would be insightful and useful.

The autism spectrum includes several different types of disorders all which exhibit various characteristics. Studies included in this review have examined different levels of the autism spectrum, with different types of assessments, to determine if motor delays are present. Berkeley et al. (2001) tested 15 children, ages 6-8, who were classified as having high functioning autism in order to assess their motor delay. Participants were chosen using three qualifications in addition to age: an official diagnosis of autism, demonstrated communication ability, and an acceptance for the test setting. The children were evaluated using the TGMD (Ulrich, 1985) on two separate occasions.

The results of the study indicated that the children with high functioning ASD had difficulty with the gross motor tasks in the TGMD-2. All girls in the study demonstrated delays in both their locomotor and object control skills. The boys' results were more

varied, with 70% of the boys showing a delay in locomotor skills and 30% in object control skills. The authors note that the significantly larger delay in locomotor skills could be due to the interpretation of the task rather than improvement in skill, since some children seemed to think the end result, rather than the movement form, was the goal for the locomotor test items. This indicates a lack of comprehension of the test could confound the evaluation of the gross motor skills.

Staples and Reid (2010) found no significant difference between locomotor and object control skills. They discuss that advanced object control skills could be the result of practice rather than natural ability, which could be an extraneous variable which impacts the understanding of motor skills in children and youth with ASD. This study identifies the TGMD-2 as an appropriate assessment tool to test the fundamental motor skills of children with ASD. The study did not distinguish between high functioning autism and Asperger's disorder which would be an important classification for further understanding of gross motor delays within the autism spectrum. An important implication for the improvement of gross motor skills in children with ASD is the possibility of increased involvement with peers which could lead to better social and communication skills.

Staples and Reid (2010) identified the need for research across a wider spectrum to fully examine ASD. The participants in their study included 25 children with ASD, ages 9-12, who covered the full range of ASD including sex, diagnosis (autistic disorder, Asperger's disorder, or PDD-NOS), and cognitive functioning. These participants were compared to three typically developing comparison groups using differing criteria which included sex and chronological age, movement skill performance, and sex and mental

age. The authors utilized several measures of ASD as well as the TGMD-2. The measures of ASD included the Autism Diagnostic Observation Schedule, Social Responsiveness Scale, and Leiter-R. It should be noted that the authors interpreted the TGMD-2 to allow for some individualization in the instructions given, and tried to suite each child's needs during the directions and demonstration.

Results revealed that the children with ASD completed the tasks but at a lower quality than their typically developing peers. Specific difficulties existed when children were asked to coordinate both arms and legs or either side of their body to complete a task. Momentum/force and timing/coordination were factors that influenced the greatest differences between typically developing groups and the children with ASD. A difference between a delay and a deficit was identified, and the researchers suggest individuals with ASD have a deficit in fundamental movement skills. A delay would mean developing on the same developmental trajectory as a typically developing child, but at a slower rate. A deficit would indicate differences in patterns of development from typically developing peers. This discrepancy may be important for future research and practical implications for working with persons with developmental disabilities as to help them better understand the development and how to intervene in order to improve the gross motor skills of children and youth with ASD.

A key implication based on these findings is that instruction for individuals with gross motor deficits may need individualized and specific instruction, rather than simply a curriculum designed for younger students. Utilizing visual cues, manually assisting students, and other specific accommodations were cited as potentially methods to help children with ASD to become more successful in their movement patterns. Specific

instructional aids written in the IEP could help the student have more effective instruction throughout their education.

There have been some gross motor similarities found with ASD and other disorders, such as ADHD. It is important to differentiate between the two disorders, which is what Pan, Tsai, and Chu (2009) chose to do in their study on fundamental movement skills. The authors measured gross motor skill functioning using the TGMD\_2 in 91 participants, aged 6-10 years old. Of the total participants, 34 were typically developing, 28 were diagnosed with ASD, and 29 were diagnosed with ADHD.

Results showed that the children with ASD and ADHD had lower scores in the TGMD-2 than their typically developing peers and their peers with ADHD. The authors emphasized that not all children with an ASD or ADHD diagnosis had difficulties with the gross motor skills found in the TGMD-2. They do mention the curriculum in Taiwan and its alignment with the skills tested in the TGMD-2 as a possible reason behind this finding. The authors of this study suggest that social interactions with peers may be impacted by the delay in gross motor skills of children with ASD. This is something that should be considered in the planning of a physical education curriculum, as well as an area of study that should be further studied in future research.

### **Summary, Conclusions, and Recommendations for Future Research**

The current research literature indicates a delay in the fundamental motor skills of children and adolescents with ASD (Berkeley et al., 2001; Breslin & Rudisill, 2011; Green et al., 2009; Pan et al., 2012; Staples & Reid, 2010; Whyatt & Craig, 2012). More research is needed to quantify how much of a delay is “typical” between children and adolescents with ASD and their typically developing peers. Further, future research

should consider effective intervention to overcome these delays. Specific areas of developmental delays have yet to be objectively established. Future research should address whether or not object control or locomotor skill functioning deficits occur and how they impact the delays in children and youth with ASD.

Assessing and examining the fundamental motor skills of children with ASD is an important part of identifying whether or not there is a developmental delay. Standardized tests, such as those used in the above studies, can help identify specific areas and can also help researchers to pinpoint certain underlying patterns that may cause a fundamental difference in the gross motor patterns of children with ASD. These tests can even help clarify a specific diagnosis for an individual on the spectrum. Practitioners should use standardized testing to continuously track the overall development of individuals with ASD as they implement intervention programs.

The TGMD-2 has specifically been used in several studies to examine the gross motor skills of children with ASD (Berkeley et al., 2001; Breslin & Rudisill, 2011; Pan et al., 2009; Staples & Reid, 2010). It is highly reliable and valid and the scores are based on the qualitative aspects of each skill. Since the TGMD-2 is standardized with national normative information, and has been used often in research design to compare populations, the general knowledge on object control skills in children and adolescents with ASD can be increased by testing this population using the TGMD-2 and comparing it with the test's established norms.

Due to the broad ranges of characteristics exhibited among individuals with ASD, future studies should consider well-controlled research designs and experimental procedures so that meaningful conclusions can be made. For example, a comparison

could be made using a traditional physical education model versus a specific, skill-based model in order to help students improve upon their gross motor skills.

The limitations of these studies are important for understanding the results, but they also provide implications for future research. Van Waelvelde et al. (2010) note their limitation of participation in their follow-up with participants which led to a smaller sample size, but conclude that a longitudinal study would be very beneficial to studying the stability of gross motor skills in individuals with ASD. A limit discussed by Berkeley et al. (2001) was obtaining an accurate ASD diagnosis by a psychologist which may impact interpretation of the test results by the researchers. This is supported by the more recent Behere et al. (2012) study which shows differences to the point of the ability to diagnose through the gross motor skills of children with autism (or autistic disorder) and children with Asperger's disorder. Green et al. (2009) found that children with autism scored lower on the M-ABC than children with other ASD. Implications from these studies would be to obtain a specific diagnosis from participants and to separate the results from different participants into groups based on diagnosis to look for significant differences between diagnoses and between persons with a specific diagnosis and typically developing peers.

Several studies report that the ability to participate in physical activity may help increase positive social interactions with peers among children with ASD (Berkeley et al., 2001; Obrusnikova & Miccinello, 2012; Pan et al., 2009). Poor gross motor skills can act as a barrier to participation in physical activity and decreased opportunities to interact with peers. It also can make participation more limited in a general physical education setting. In addition, Pan et al. (2009) discuss how a lack in gross motor skills may limit

an individual on successfully participating in physical activity and leading a lifelong healthy lifestyle. These findings could lead to many future studies examining the link between gross motor skills, participation in physical activity, choice of physical activity, and peer interactions. Future development of physical activity and gross motor skill recommendations for children with ASD may benefit the physical educators, physical therapists, doctors, parents, and others who work with children and youth with ASD in physical activity settings.

Breslin and Rudisill (2011) and Staples and Reid (2010) both examined more individualized and alternative approaches to administering the TGMD-2. Breslin and Rudisill utilized visual supports and Staples and Reid allowed for visual supports and multiple explanations in order to ensure the participant understands the task expected of them. Further research needs to be done in this area to determine if there are more effective ways of administering the TGMD-2 and to try to determine whether comprehension of the task or performance of the task is the larger contributor to the score received on the TGMD-2 (Breslin & Rudisill, 2011).

Another avenue of research that is lacking is comparing the motor delays of persons with different disabilities to see if there are distinct characteristics or a general delay in gross motor skills of persons with disabilities. Pan et al. (2009) explored the differences in motor delays in ASD and ADHD, and further work in this area would benefit the general field of research in motor development and disabilities.

Out of all the implications from these studies, one that is most clear is the need for future research on the gross motor skills of children and adolescents with ASD compared to their typically developing peers. The lack of consensus surrounding the object control

skills of individuals with ASD demonstrates a clear need for further testing. There is much evidence to support the use of standardized tests to assess the object control skill development of individuals. Due to its normative information and the range of practical skill sets it contains, the TGMD-2 is an appropriate choice for comparing children with ASD with their typically developing peers. A logical next step would be to perform a study that clarifies the uncertainties in this line of research. The results and implications of a study completed on children and youth with ASD through utilization of the object control skill subtest of the TGMD-2 would be very beneficial to help researchers further understand the relationship between gross motor skills and individuals with ASD.

After examining the related literature in this area of inquiry, a few specific research questions would benefit the study in discussion. Are children with ASD developmentally delayed compared to their typically developing peers in object control skills? Are there specific skills in which children with ASD have a more significant delay? Finally, several studies bring up the concern of different ASD diagnoses having different levels and specific areas of gross motor delay (Behere et al., 2012; Berkeley et al., 2001; Green et al., 2009; Staples & Reid, 2010). Further study is needed to address these important research questions and the study in discussion could strongly contribute to this on-going area of research.

## REFERENCES

- American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorder* (4<sup>th</sup> ed.). Washington, DC: APA.
- Behere, A., Shahani, L., Noggle, C., & Dean, R. (2012). Motor functioning in autistic spectrum disorders: A preliminary analysis. *The Journal of Neuropsychiatry and Clinical Neurosciences*, 24(1), 87-94.
- Berkeley, S., Zittel, L., Pitney, L., & Nichols, S. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly*, 18(4), 405-416.
- Breslin, C., & Rudisill, M. (2011). The effect of visual supports on performance of the TGMD-2 for children with autism spectrum disorder. *Adapted Physical Activity Quarterly*, 28(4), 342-353.
- Centers for Disease Control and Prevention. (2013). Changes in prevalence of parent-reported autism spectrum disorder in school-aged U.S. children: 2007 to 2011-2012. *National Health Statistics Reports*, 65, 1-11.
- Dean, R. & Woodcock, R. (2003). *Dean-Woodcock Neuropsychological Battery*. Itasca, IL: Riverside Publishing.
- Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., et al. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine and Child Neurology*, 51, 311–316.
- Henderson, S., & Sugden, D. (1992). *The movement assessment battery for children*. London: Psychological Corporation.
- Individuals with Disabilities Education Act Amendments of 2004 (IDEA) (PL 108-446), 20 U.S.C. 1400 (2004).
- Kim, Y., Park, I., & Kang, M. (2012). Examining rater effects of the TGMD-2 on children with intellectual disability. *Adapted Physical Activity Quarterly*, 29(4), 346-365.
- Le Couteur, A., Lord, C., & Rutter, M. (2003). *The Autism Diagnostic Interview–Revised (ADI-R)*. Los Angeles: Western Psychological Services.
- Lord, C., Luyster, R., Guthrie, W., & Pickles, A. (2012). Patterns of developmental trajectories in toddlers with autism spectrum disorder. *Journal of Consulting and Clinical Psychology*, 80(3), 477-489.

- Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P., Rutter, M. (2000). The Autism Diagnostic Observation Schedule—Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, 30, 205–223.
- Mullen, E. (1995). *Mullen Scales of Early Learning*. Circle Pines, MN: American Guidance Service.
- Obrusnikova, I. & Miccinello, D. (2012). Parent perceptions of factors influencing after-school physical activity of children with autism spectrum disorders. *Adapted Physical Activity Quarterly*, 29(1), 63-80.
- Pan, C., Tsai, C., & Chu, C. (2009). Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. *Journal of Autism and Developmental Disorders*, 39(12), 1694-1705.
- Rabe-Hesketh, S., Skrondal, A., & Pickles, A. (2004). Generalized multilevel structural equation modeling. *Psychometrika*, 69, 167–190.
- Staples, K., & Reid, G. (2010). Fundamental movement skills and autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 40(2), 209–217.
- Ulrich, D. (2000). *Test of Gross Motor Development (2<sup>nd</sup> ed.)*. Austin, TX: Pro-Ed.
- Van Waelvelde, H., Oostra, A., Dewitte, G., Van den Broeck, C., & Jongmans, M. (2010). Stability of motor problems in young children with or at risk of autism spectrum disorders, ADHD, and or developmental coordination disorder. *Developmental Medicine and Child Neurology*, 52(1), 174-178.
- Whyatt, C., & Craig, C. (2012). Motor skills in children aged 7–10 years, diagnosed with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 42(9), 1799–1809.