THE EFFECTS OF A PHYSICAL EDUCATION PROGRAM ON THE MOTOR SKILL PERFORMANCE OF CHILDREN WITH AUTISM SPECTRUM DISORDER

HESTER HENDERSON
University of Utah

STACY NOREN
University of Utah

DANIEL WILLIAMS
University of LaVerne, CA

ARWEN FULLER
University of Utah

VANESSA MORTENSEN STOUT
University of Utah

Abstract

The purpose of this study was to evaluate the effects of a 40-minute physical education class provided twice a week for six months on the performance of motor skills in 37 children with autism spectrum disorder (ASD) aged 5 to 12 years. A repeated-measures design and the Test of Gross Motor Development (TGMD-2) (Ulrich, 2000) were used to examine six-month changes in six locomotor and six object control skills. The locomotor skills included the run, slide, gallop, hop, leap, and horizontal jump. The object control skills included the underhand roll, catch, overhand throw, stationary bounce, kick, and ball strike. Paired *t*-tests were used to determine whether there were physical education-related changes in motor skills. The 37 children with ASD demonstrated improvements in 10 of the 12 motor skills ($p \leq 0.020$) after six months of the twice weekly physical education class.

Keywords: *ASD, assessment/measurement of motor skills, autism, intervention/training studies, movement skill interventions, physical education*

Globally, the prevalence of autism has increased 20-30 fold since the late 1960s and early 1970s, when the earliest epidemiologic studies were conducted (Baio, 2014). In 2014 the Center for Disease Control and Prevention (CDC) estimated that 1 in every 68 American children was diagnosed with autism spectrum disorder (ASD) and an estimated 2 million individuals in the U.S. and tens of millions worldwide have ASD (CDC, 2014). This is a 30% increase over previous estimates reported in 2012, in which 1 in 88 children was estimated to be identified as having ASD. Males are nearly five times more likely to be diagnosed with ASD than females. In fact, 1 in every 42 males and 1 in every 189 females are diagnosed with ASD (CDC, 2014). While there is no known reason for this growth in prevalence, Schieve et al. (2012) suggested three possible underlying explanations, including "(1) a change in how prevalence is measured by surveys and surveillance systems; (2) changes in ASD awareness, screening tests, access to diagnostic services, diagnostic criteria, and special education placements that all lead to a greater identification of children with ASD in the community; and (3) changes in either ASD genetic susceptibility among persons having children within a population or non-genetic risk factors" (p. S152).

In the new *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5)(American Psychiatric Association, 2013) umbrella term, Autism Spectrum Disorder, has replaced the separate diagnostic labels of autistic disorder, Asperger's syndrome, childhood disintegrative disorder, and pervasive developmental disorder–not otherwise specified (PDD–NOS). Further, distinctions are made according to severity levels (Level 1, Level 2, and Level 3) based on the amount of support needed due to challenges with social communication, restricted interests, and repetitive behaviors. Individuals with ASD tend to have deficits in communication, such as responding inappropriately in conversations, misreading nonverbal interactions, or having difficulty building friendships appropriate to their age. They may be overly dependent on routines, highly sensitive to changes in their environment, or may focus intensely on inappropriate items. Symptoms are usually apparent by the age of 3 years.

Children with ASD also have problems with motor skill development (Sowa & Meulenbroek, 2012). Deficits in motor skill proficiency is concerning given that proficiency levels track into adolescence (Branta, Haubenstricker, & Seefeldt, 1984; McKenzie et al., 2002) and are related to health outcomes such as cardiorespiratory fitness (Okely, Booth, & Patterson, 2001) and obesity (Okely, Booth, & Chey, 2004) as well as the probability of being physically active (Okely, Booth, & Patterson, 2001; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006).

Researchers have found limited motor coordination and deficiencies in fine and gross motor functioning (Emck, Bosscher, van Wieringen, Doreleijers, & Beek, 2011; Pan, Tsai, & Chu, 2009) and problems maintaining balance and motion planning in children with ASD (Downey & Rapport, 2012; Vernazza-Martin et al., 2005). Breslin and Rudisill (2011) found that children with ASD are at risk for failing to learn and develop mature, fundamental motor skills. The social and sensory deficits that characterize children with ASD make it a challenge for physical educators to both teach and evaluate the motor skills of these students. Several studies (Ghaziuddin & Butler, 1998; Green et al., 2009; Manjiviona & Prior, 1995) that measured motor skill performance of children and adolescents with high functioning autism and Asperger's Disorder found that the motor skills of those with ASD were significantly below those of their peers without disabilities. An examination of the locomotor and object control skills of children with high functioning autism aged 6-8 years found that fundamental skill delays were demonstrated by 73% of all children, placing them in the "poor" to "very poor" performance categories on the Test of Gross Motor Development (TGMD-2) (Berkeley, Zittel, Pitney, & Nichols, 2001). Others have reported similar delays in motor skill development in children with ASD using the TGMD-2 (Pan, Tsai, & Chu, 2009; Staples & Reid, 2010). In fact, Staples and Reid (2010) found that children with ASD had difficulty with bilateral coordination and performed at a similar motor skill level as children approximately half their chronological age.

Several studies that used home videos to compare motor behavior of children later diagnosed with ASD with their typically developing peers found that within the first 2 years of age there were definite motor differences (Adrien et al., 1993; Baranek, 1999; Teitelbaum et al., 2004). To highlight the expanse of this issue, Pan, Tsai, and Chu (2009) found that poor motor skills were correlated with poor self-esteem, increased anxiety, and decreased social function. In addition, Kopp, Beckung, and Gillberg (2010) reported that poor motor scores in girls were related to poor performance in activities of daily living as well as a decrease in participation in physical education.

Fournier, Hass, Naik, Lodha, and Cauraugh (2010) conducted a systematic review and meta-analysis to determine the degree of motor deficits within individuals with ASD across fundamental behaviors of motor performance. Results of this analysis provide convincing empirical evidence to support the theory that individuals with ASD are less coordinated and show fewer motor capabilities than controls with typical neurological development. They also found impairments in gait and balance, arm motor functions, and movement planning. As a consequence of the widespread evidence of an identified motor coordination deficit, this is now considered by some researchers to be a core symptom of ASD (Ben-Sasson et al., 2009). Fournier et al. (2010) suggest that the treatment of ASD should consider including interventions focused on improving motor performances that are involved with motor coordination such as gait and balance, arm functions, and movement planning. Therefore, physical education should target these motor domains when teaching children with ASD.

In the study by Baio (2014), it was reported that 31% of those individuals with ASD had an intellectual disability as characterized by an IQ less than 70; 23% were in the borderline range with an IQ between 71-85, and 46% had an IQ above 85. Lower than average IQ coupled with deficits in communication may hinder the ability to understand and follow test administration instructions that are provided verbally (Breslin & Rudisill, 2011; Schlosser et al., 2013). Therefore, strict adherence to standardized test protocols like those in the TGMD-2 may decrease the validity of this test in children with ASD. The TGMD-2 instructs test administrators to use complete sentences to cue and prompt students. It has been suggested that for children with ASD the use of visual supports, such as picture task cards, may help direct the child's attention to the relevant stimuli within the task thus providing more of an opportunity for the child to process the information and follow instructions more accurately. Breslin and Rudisill (2011) compared the use of picture task cards to the traditional protocol and found a significantly higher (p = 0.008) gross motor quotient with the picture task card protocol. Despite this adaptation, the authors reported that students with autism aged 3 to 10 years were found to be developmentally delayed in motor skill acquisition and test performance. Even with the use of picture cards and schedules to assist students in recognizing and attending to the task at hand, the students performed below the normative reference values for their ages (Breslin & Rudisill, 2011). As such, research is warranted to determine the effects of a physical education program incorporating what was learned from the research findings into the motor skill assessment as well as the teaching intervention.

In a review of the literature on sensory and motor development/abnormalities in children with autism, Baranek (2002) found that there were no empirical studies on motor skills interventions with children with autism. A decade later, researchers continue to identify a persistent lack of empirical research related to interventions for motor activity impairments in children with ASD (Downey & Rapport, 2012; MacDonald et al., 2012)

The purpose of this study was to evaluate the effects of a physical education class designed to improve motor skill acquisition in children with ASD. Specifically, we assessed the effect of a 40-minute physical education (PE) class provided twice a week for 6 months on the performance of motor skills in children with ASD ages 5 to 12 years. We hypothesized that motor skill performance would improve following the PE class-based instructional intervention.

Method

Participants

Thirty-seven children with autism spectrum disorder, ages 5-12 years, participated in this study. Thirty five were male, two were female. For a distribution of ages of the participants see Table 1. The inclusion criteria for this study were a) be enrolled as a student at the center for children with autism, b) be 5 to 12 years of age, c) be classified by the school psychologist as having autism using the criteria outlined in the DSM-IV, and d) be capable of participating in the physical education program at the center. The Institutional Review Board approved all procedures for this study. Parental permission was obtained for all children prior to their participation in this study. Sixty children returned the completed Parental Permission Forms and were deemed eligible to participate in the study.

Table 1
Descriptive Data of the Participants

Ages	Number
5	3
6	4
7	5
8	11
9	1
10	7
11	2
12	4

Of the 60 potential participants whose parents signed consent forms, one child was excluded from this study because of a physical disability that precluded him from being able to accurately perform all 12 of the motor skills. Another child was excluded because of a severe cognitive disability that precluded his ability to follow the teacher's verbal directions and physical demonstration of the 12 motor skills. The other 21 potential participants were not included either because they were absent when the pre- or posttest assessments were administered (n = 3), they would not perform the test as directed (n = 2), or the videotape did not record the entire skill (n = 16).

Instrumentation

The TGMD-2 (Ulrich, 2000) is a standardized assessment tool used to qualitatively and quantitatively assess components of a movement skill sequence for six locomotor skills (run, horizontal jump, gallop, hop, slide, and leap) and six object control skills (underhand roll, catch, *overhand* throw, stationary dribble, kick, and striking an object). These are considered essential skills needed in physical education and active play (Ulrich, 2000). This assessment instrument was selected because the scoring is based on specific qualitative performance criteria that assesses the performance of the mature pattern of each skill rather than a simple quantitative assessment of a skill such as the distance a ball is thrown or the number of times a ball hits the target. Additionally, normative data for the TGMD-2 were established on a sample of 1208 children ages 3 to 10 years and the test-retest reliability was r = .93 (alpha = .88) for the object control and r = .88 (alpha = .85) for the locomotor subtests (Ulrich, 2000). Because our participants were 5 to 12 years of age, standard scores, age equivalents, and gross motor quotient values were not available for our 11- and 12-year-old children. However, this did not inhibit our primary aim, which was to prospectively evaluate the effect of the physical education program on the performance of each of the 12 motor skills over six months.

The TGMD-2 defines three to five performance criteria in the evaluation of an individual's performance of a mature skill. The scoring procedure defined in the TGMD-2 was used in this study. Briefly, a score of 1 was assigned to each correctly performed criterion. If the individual did not perform the criterion correctly, a score of a 0 was assigned. Each individual performed two trials for each skill. A sum of the scores for each criterion during both trials was assigned as the individual's score for a given skill. Thus the total possible score for a skill with 3 criteria was 6; for a skill with 4 criteria was 8; and for a skill with 5 criteria was 10. Change in the raw scores from pretest to posttest was used to evaluate the effects of the physical education class on motor skill performance.

Description of the Physical Education Program

The physical education program for this study took place in the gymnasium at a center for children with autism spectrum disorders. There were approximately 10 students in each class and all had moderate to severe autism. The physical education teachers were graduate students in their second year of a Master's program in adapted physical ed-

ucation. All of the physical education teachers had taught physical education at this center the previous year and had administered the TGMD-2 to children with ASD on at least two previous occasions. There were at least three aides in each class who accompanied the students. These aides were primarily responsible for managing the behavior of individual students but often helped the physical education teacher by encouraging the students to perform the skills being taught. The didactic teaching style was augmented with many demonstrations, repetition of cues, and verbal, manual, and physical prompting to elicit performance.

All of the participants were pretested using the TGMD-two for two weeks (four class periods) prior to participating in physical education classes. Then they participated in the physical education program. This program consisted of 20 weeks of 40-minute classes taught twice a week for a total of 40 classes. The first week of the program the run and the horizontal jump were taught on Day 1, and then both of these locomotor skills were practiced on Day 2. Then on Day 1 of the second week, the gallop and the leap were taught then practiced on Day 2. In week 3 the slide and the hop were taught Day 1 then practiced Da,y 2. In weeks 4 through 9, an object control skill was taught Day 1 and practiced Day 2. Then on Day 1 of Week 10, all of the locomotor skills were practiced, and on Day 2, all of the object control skills were practiced. It should be noted that although only six lessons were dedicated to teaching the locomotor skills, these skills were practiced in the warm ups and the different activities for all of the lessons taught thereafter so the participants practiced these skills every lesson. The first 10 weeks of the second semester was the exact same procedure using the same lesson plans. The only difference might be that the teacher could choose different activities listed on the lesson plans to practice the skills. The participants were then posttested for two weeks on each of the motor skills using the TGMD-2 and the same protocol as the pretesting.

The curriculum for this program consisted of nine lesson plans targeting the six locomotor and six object control skills of the TGMD-2. For the locomotor skills, two skills were included in each lesson plan; that is, the run and the jump were taught in one lesson plan, the gallop and the leap in another; and the slide and the hop in another. For the object control skills, there was one lesson plan for each individual skill. Each lesson plan had instructions for the teaching of the skill (for Day 1) and instructions and suggestions of activities for the re-teaching and practicing of the skill (for Day 2).

The beginning of each lesson included a warm up, which consisted of stretching, a strength exercise, and the running of laps around the gym starting with the run and switching to other locomotor skills that had been taught, such as sliding, jumping, or galloping. The first lesson of the week focused on skill acquisition and controlled practice. After the teacher presented the skill and its corresponding teaching cues and picture task cards, the participants rehearsed the skill while the teacher provided specific feedback for the duration of the class period. On the second class of the week, the teacher taught the skill again then had the participants do activities or play games with modified sport activities that increased the number of practice trials for that skill. These included multiple goals in soccer, skill stations with different targets for throwing or different objects for throwing and catching, as well as obstacle courses and tag games that required participants to practice their locomotor skills. Figure 1 is an example of a lesson plan used in this study for teaching the overhand throw.

Teachers and aides provided the participants with specific teaching cues as defined by the skill's task analysis in the TGMD-2 to help them perform the mature skill. Cues were shortened to allow the participants to focus on the key words and not get lost in the instructions. They were asked to repeat the teaching cues back to the teacher to further increase familiarity with the skill and its cues. The cues were designed to closely match the test administration dialogue in the TGMD-2 and were concise to decrease language interference during the pre- and posttesting.

Procedures

The first week all of the participants were assessed on the locomotor skills; the second week all participants were assessed on the object control skills. The test administrator led each participant through two trials of each test item on the TGMD-2 individually until all six locomotor skills were completed. Then the next participant was assessed. The test administrator used a demonstration of the skill as outlined in the *TGMD-2 Test Manual* (Ulrich, 2000) and a set script of verbal cues augmented by visual task cards. The visual task cards were simply the illustrations provided in the TGMD-2 manual of each skill. Each of the 12 illustrations were attached to 8X10 inch cards with colored backgrounds and then laminated. Figure 2 is an example of the visual task card used in this study for the overhand throw. All participants were videotaped for the duration of their assessment session. Each class had 10 students. A total of five participants were assessed during the first 40-minute class period, then the other five participants were assessed during the second 40-minute class period. The participants that were not being assessed played games with their teacher on the playground. The same procedure was used to assess object control skills during the second week.

Two trained research assistants viewed the DVD recordings of the pre- and posttests and qualitatively analyzed the skills using the criteria outlined in the TGMD-2. One research assistant evaluated the object control skills and the other research assistant evaluated the locomotor skills. Each child was assigned a score for each skill on both the pre and the posttests. The timeline for the scoring was as follows: each research assistant spent a week evaluating the pretests; waited six weeks, and again evaluated the pretests. Two weeks later each research assistant evaluated the posttests; waited six weeks and again evaluated the posttests. Intrarater reliability for the first and the second evaluations of both the pretest and the posttest scores was evaluated using intraclass correlation and ranged from .968 - 1.00 for all of the motor skills, including both research assistants.

Lesson Objectives	**Participants will perform the mature OVERHAND THROW completing each of the four criteria correctly for two consecutive trials.** Day 1 will focus on teaching the overhand throw by providing the criteria, cues, visual task cards, demonstrations, and specific feedback about performance. Day 2 will focus on teaching again then practicing the throw by playing games that involve throwing a ball while providing cues, demonstrations, and specific feedback.
Equipment	Mats, music, poly-spots, stuffed animals, bean bags, tennis balls, whiffle balls, cones, targets, goals, buckets, etc. (see activities below)
Warm-Up Activities	Begin with your class's entry routine (sitting on the mat, stretching, etc.) **Day 1: Practice a Locomotor Activity:** • Set up a large rectangle around the gym, and mark each corner with a visual task card for a locomotor skill (run, gallop, slide, jump, etc.) As the participants move around the rectangle, they should perform the locomotor skill that is designated at the cone. • Set up cones about 6 feet from the wall. Have the participants perform a locomotor skill while moving around the outside of the cones. Give the directions to perform a locomotor skill, demonstrate the skill, then start the music. When the music stops, the participants "freeze" and look at you. Lead them in a stretching activity or ask them to identify a body part. Give directions for the next locomotor skill and repeat the procedure. **Day 2: Perform a Fitness Activity:** • Ask the participants to identify objects with wheels (train, plane, bicycle, or race car). Have them practice moving around the gym as that object, i.e., Train (sit on the floor and scooch yourself backwards using arms and legs. Plane (run with arms out and land in the airport—hula hoops). Bicycle (lie on the back and pedal with feet in the air). Race Car (run/skip/gallop/slide as fast as you can while driving your pretend car). • Select different animal walks and instruct the participants to do them around the gym to improve muscular strength and endurance.
Skill Development Activities	**Days 1 and 2: Teach the overhand throw:** • Demonstrate the overhand throw providing the teaching cues for each of the criteria as you perform them. • Show the participants the visual task cards and again demonstrate the mature throw. • Provide examples and nonexamples and have participants identify whether you are throwing the ball correctly or not. • Have selected participants demonstrate the throw. Give feedback while others watch and listen. **Day 1: Practice the Overhand Throw** • Station 1: Focuses on the wind up (cue = "arm back") • Station 2: Start with the arm back then focus on rotating the hip and shoulders (cue = "throw hard") • Station 3: Start with the arm back, hip and shoulders rotating, then focus on stepping forward (cue = "step forward"). Set out poly spot feet to show participants where to put their feet. • Station 4: Start with the arm back, hip and shoulders rotating, stepping forward, then focus on following through (cue = "follow through") with the throwing arm coming across the body after the ball is released.
	Select an activity to practice the overhand throw. • Throw animals back into their habitat—set up areas that represent the desert, forest, ocean, etc. and have the participants throw stuffed toys into the appropriate habitat. • Throw colored balls to the corresponding colored corners of the gym. • Throw balls at targets taped on the wall (make fun targets such as clown faces, pumpkins, superheros). *Note:* Sometimes having a target will change the focus of the activity. Instead of focusing on the correct performance of the skill, focus may be only on hitting the target. **Day 2: Review and Practice the Overhand Throw** After reteaching the overhand throw as described above, • Have participants play a modified game of baseball where there are assigned batters, fielders (equal number of fielders and batters), and runners. Set up a grid of poly spots for bases. Set up a tee for batters. Spread fielders out around the gym a safe distance from the tee. When the batter hits the balls, base runners will run between bases. They are not to pass the person in front of them and they try to tag as many bases as they can while the ball is still in play. When the ball is hit, fielders chase after the ball. They collect the ball and throw it into the far corner of the gym where a "coach" is waiting to collect the balls and place them back on the tee. Once the coach has the ball, runners must stop moving. *Note:* be sure base runners practice different locomotor skills and fielders practice throwing correctly.
Lesson Closure	Participants will sit on the mat and perform stretching exercises. Pose the following questions/statements (as a whole and individually) to review what was taught in class. • "What did you learn in class today?" • "What are the cues for the overhand throw?" • As you are demonstrating ask, "Is this a correct throw?" • Ask selected participants to demonstrate a throw. Give specific feedback. Give participants a high-five as they leave and compliment something each did well today.

Figure 1. Example of a Lesson Plan for the OVERHAND THROW

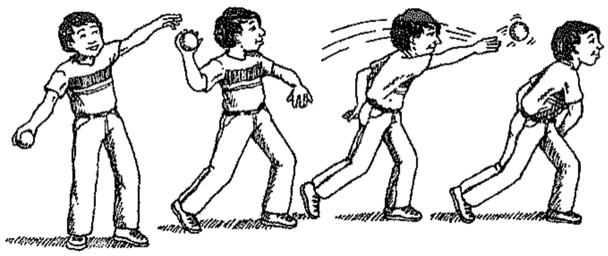

Figure 2. Picture task card of the overhand throw

Data Analysis

A pretest posttest repeated measures design was used to evaluate the effect of the six-month physical education program. Data were analyzed using paired *t*-tests to determine whether there was a significant change, on average, in each of the motor skill performance scores from pretest to posttest. Because the range of potential TGMD-2 scores is narrow (e.g., 0-6 for a skill with three criteria, 0-8 for a skill with four criteria, or 0-10 for a skill with five criteria), the potential for nonnormally distributed scores is high. Thus, we verified our parametric *t*-tests with nonparametric, related samples Wilcoxon signed rank tests. Statistical significance was set at $\alpha < 0.05$. All statistics were evaluated using SPSS v. 20.0 (IBM SPSS Statistics, Chicago, IL).

Results

In response to six months of a twice-a-week physical education class designed to improve motor skills in children with ASD, there were significant improvements in the mean performance scores of both locomotor and object control skills. Specifically, students improved their performance of the run ($t(36) = 2.42$, $p = 0.020$), jump ($t(36) = 5.56$, $p < 0.001$), hop ($t(36) = 2.62$, $p = 0.013$), and slide ($t(36) = 4.45$, $p < 0.001$) (Table 2). Similarly, there were significant improvements in each of the object control skills, including the underhand roll ($t(36) = 3.48$, $p = 0.001$), catch ($t(36) = 3.40$, $p = 0.002$), throw ($t(36) = 3.92$, $p < 0.001$), bounce ($t(36) = 4.59$, $p < 0.001$), kick ($t(36) = 5.301$, $p < 0.001$), and strike ($t(36) = 3.44$, $p = 0.001$). By contrast, there were no significant changes in the mean performance scores for the gallop ($t(36) = 0.97$, $p = 0.337$) and the leap ($t(36) = 1.15$, $p = 0.257$) (Table 2). Furthermore, all 10 of the average motor skill improvements were statistically verified by the nonparametric, Wilcoxon signed rank tests, which are interpreted as a greater preponderance of increases rather than decreases or no change in motor skill scores over six months (Table 2).

The percent improvement for each of the motor skills was also calculated (Table 3). The locomotor skill of the jump (108.78%) and the object control skill of the bounce (107.50%) showed the greatest improvement. The three other motor skills that showed marked improvement (greater than 50%) were the kick (67.59%), the throw (65.95%), and the underhand roll (60.49%).

Table 2
Differences Between Pre- and Posttest Motor Performance Scores for Children With Autism in Response to a Physical Education Class

Motor Skill	Pretest	Posttest	*p*-value*	*p*-value*
Locomotor Skills				
Run	5.22 ± 2.50	5.97 ± 1.68	0.020	0.025
Jump	2.05 ± 2.07	4.28 ± 2.84	<0.001	<0.001
Gallop	5.43 ± 3.38	5.84 ± 3.18	0.337	0.295
Hop	3.38 ± 3.66	4.65 ± 3.99	0.013	0.019
Slide	4.35 ± 3.22	6.08 ±2.73	<0.001	<0.001
Leap	2.08 ± 2.30	2.35 ± 2.31	0.257	0.252
Object Control Skills				
Underhand Roll	2.05 ± 2.02	3.29 ± 2.60	0.001	0.002
Catch	2.93 ± 1.97	4.10 ± 2.08	0.002	0.003
Throw	1.85 ± 2.30	3.07 ± 2.50	<0.001	<0.001
Bounce	2.00 ± 3.08	4.15 ± 3.64	<0.001	<0.001
Kick	2.16 ± 2.28	3.62 ± 2.24	<0.001	<0.001
Strike	4.43 ± 3.20	5.81 ± 2.93	0.001	0.003

**p*-value from a paired t-test
** *p*-value from a related-samples Wilcoxon Signed Rank test
Note: Values are means ± SD; Range is 0-10 depending on the skill

Table 3
Percent Improvement Between Pre- and Posttest Motor Performance Scores for Children With Autism in Response to a Physical Education Class

Motor Skill	Pretest Score	Posttest Score	Percent Improvement
Locomotor Skills			
Run	5.22	5.97	14.37
Jump	2.05	4.28	108.78
Gallop	5.43	5.84	7.55
Hop	3.38	4.65	37.57
Slide	4.35	6.08	39.77
Leap	2.08	2.35	12.98
Object Control Skills			
Underhand Roll	2.05	3.29	60.49
Catch	2.93	4.10	39.93
Throw	1.85	3.07	65.95
Bounce	2.00	4.15	107.50
Kick	2.16	3.62	67.59
Strike	4.43	5.81	31.15

* percent improvement = posttest – pretest/pretest
Note: Values are means; Range is 0-10 depending on the skill

Discussion

The literature is replete with studies documenting that children with ASD are below typically developing peers in the performance of motor skills (Berkeley et al., 2001; Breslin & Rudisill, 2011; Ghaziuddin & Butler, 1998; Manijiviona

& Prior, 1995). There are, however, no studies in the literature that have measured the effects of a physical education program focused on motor skills on the improvement of motor skill performance with children with ASD. Results of this study demonstrated that such an intervention can result in a significant improvement in motor skill performance for children with moderate to severe ASD ages 5 to 12.

In this study it was determined that there was a significant improvement in 10 of the 12 motor skills ($p \leq 0.020$). The only two skills in which there was not a statistically significant improvement were the locomotor skills of the leap and the gallop. However, as indicated by the normative data reported in the *TGMD-2 Test Manual*, only 50% of typically developing children aged 3-10 years are reported to have mastered the leap at age 10 (Ulrich, 2000). Nonetheless, a possible reason for the lack of a statistically significant improvement in the leap in this study is that the children who had performed the horizontal jump previous to the leap had difficulty differentiating the leap from the jump. These children tended to perseverate on the two-foot take off and proceeded to jump instead of leap.

Accordingly, the normative data from the TGMD-2 revealed that only 56% of the children in their standardization sample had mastered the gallop at age 10. Another possible reason for the lack of statistically significant improvement in the gallop and the leap in the current study is that both of these skills require a substantial amount of motor coordination that has been found to be significantly deficient in children with ASD (Ben-Sasson et al., 2009; Fournier et al., 2010). In their study, Staples and Reid (2010) found that children with ASD had particular difficulty with coordinating movements that involved both sides of their body or both arms and legs. They observed that children with ASD differed substantially from their matched, typically developing peers in the areas of momentum/force and timing/coordination; both of which are skills inherent to the gallop and the leap. Moreover, these movements require a great deal of practice. Although the gallop and the leap are skills that may be taught in physical education class, children with ASD do not readily practice these skills without being directed to do so. in simple activities played at recess or on the playground.

Similar to the observations of Berkeley et al. (2001), many of the participants in the current study were more focused on the function of the locomotor task instead of the process or form involved in performing the actual skill. This was an example of the product being more important than the process and was especially true for the gallop and the leap. When asked to gallop from point A to point B some of the children would start out with some form of a gallop and then revert to a more familiar locomotor skill such as walking or running to get to point B instead of the gallop that was requested and demonstrated. In addition, when the children were asked to perform the leap, a poly spot shark was placed on the floor and the children were asked to "leap over the shark." Often the goal became getting over the shark and not performing a leap over the shark. The children tended to revert back to the more familiar locomotor skill of jumping to get over the shark.

It should be noted that in this study we compared raw scores for each of the skills. Although we found statistically significant differences in the improvement of the means for 10 of the 12 skills, these results do not imply that that the participants are necessarily performing the skills functionally. By the same token, for the leap and the gallop in which there were not statistically significant differences, it does not mean that the participants are not performing these skills functionally.

We found many of the same qualities of performance in motor skills as Staples and Reid (2010). In brief, while the participants demonstrated improvement in their performance the criteria of the skills over the course of this study, qualitatively they lacked smooth coordination or control of their movements as well as poor use of momentum to impart force. For example with the horizontal jump, the participants would put their arms back sequentially then extend their arms forward and upward after take off as if following a checklist of cues before jumping. However, the timing of those movements was such that the force generated was insufficient to propel their bodies very far forward. Similarly, while performing the hop, they would flex their arms and swing them forward but this movement did not generate enough force to actually propel them forward. These nonfunctional movements of the arms were seen in all of the motor skills where the children needed to coordinate movements on both sides of the body in which the arms and legs worked together. For the object control skills the participants demonstrated similar difficulties in controlling their body, coordinating movements, and imparting force. For example, when kicking a stationary ball, they had difficulty coordinating the forward momentum of the elongated stride and placing their non-kicking foot next to the ball while swinging their kicking foot forward. As such, when approaching the stationary ball, they would often come to a complete stop before kicking the ball. This was also observed when the participants performed the overhand throw. Although the participant would transfer the weight by stepping forward with the foot opposite the throwing hand, the actual movement for the throw did not start until the weight was already transferred, therefore the momentum of the hip rotation and bringing the arm forward did not contribute to the force imparted to the ball. In summary, the participants in this study demonstrated both a lack of coordination of movements and poor use of momentum to impart force.

Our results were similar to those of Berkeley et al. (2001), in which participants scored lower on the locomotor skills than the object control skills. Of their 15 participants, 80% had a mean locomotor subtest standard score that was equal to or more than 1.5 standard deviations below the standard mean. These scores placed them in the "poor" and "very poor" categories of performance. By contrast, only 53% of their participants had a mean object control subtest standard score that was similarly low. Staples and Reid (2010) suggested that the performance of object control skills relies heavily on practice and experience performing these skills. In the current study, the object control skills were used frequently in simple games and activities in the physical education program, and these skills likely were also practiced

at recess, on the playground, and at home with parents or siblings. Although the locomotor skills were regularly practiced in the physical education classes, the participants would resort to the familiar run when asked to move from point A to point B. They needed to be prompted to practice the other locomotor skills of the slide, jump, hop, leap, and gallop. Therefore they were probably not performing these locomotor skills on their own at recess, on the playground, or at home.

Several instructional recommendations were considered in designing the pedagogical approach used in the current study. Obrusnikova and Dillon (2011) recommended that instruction be designed with high levels of cueing, prompting, physical assistance, and/or with assistance from a teacher, paraeducator, or selected peer. Specific instruction for all of the skills in the current study was provided using visual, verbal, and manual cues (Fronske, Blakemore, & Abendroth-Smith, 1997; Staples & Reid, 2010). Visual task cards were used in this study to direct the child's attention to the relevant stimuli within the task and to reduce confusion about the correct way to perform the skill similar to the task cards used by Breslin and Rudisill (2011). Their visual task cards, however, were single line drawings, In this study the actual skill illustrations provided in the *TGMD-2 manual* were used as task card (Figure 2). Similarly, as suggested by Obrusnikova and Dillon (2011), poly spots were used as visual cues for a variety of activities. For example, poly spots were used to indicate where the participant was to step to kick the ball and where to step to throw the ball. In addition, verbal cues such as "step and kick" were given to further assist the participant to perform the skill. These same visual task cards, verbal cues, and demonstrations were used during both the pre- and posttesting so as to increase the validity of the motor skill assessment by providing consistent information in a preferred modality and improving the chances that the participant understood how to do the skill (Breslin & Rudisill, 2011; Staples, Todd, & Reid, 2006).

It is possible that the improvement in motor skills could be attributed to the fact that the participants were exposed to the same picture task cards, verbal cues, and demonstrations that were used in the assessment and multiple times during instruction so that they better understood what to do when they performed the motor skills during the posttest. This is a limitation of this study but any time a teaching intervention is implemented, it is hoped that the participants will have learned the skill, will understand better how to perform the skill, and will perform it more accurately following the intervention.

Other teaching suggestions by Obrusnikova and Dillon (2011) were to decrease the size of classes and to have support from a trained teaching assistant. With the help of trained teacher aides our student-to-teacher ratio was no larger than 3:1. This afforded the participants a greater opportunity to repeatedly perform the skills with guided practice. As suggested by Staples, Todd, and Reid (2006), instruction was individualized and tailored to the participant's level of understanding (i.e., words, nonverbal behaviors) and preferred method of communication (i.e., signs, pictorial symbols, verbal feedback). In addition, instruction was systematic allowing the participant to focus on just one aspect of the skill at a time until it was mastered as suggested by Staples and Reid (2010). See Figure 1 for an example of how these techniques were incorporated into the lesson plans for this study.

It is possible that the improvements in the motor skills measured in the current study were the result of maturation that occurred during the six-month intervention period, posing a threat to internal validity. However, the change in the locomotor skill composite score was not found to be related to the age of the participants at the beginning of the study (r = 0.31, p = 0.059) nor at the six-month follow-up (r = 0.32, p = 0.050). Similarly, the change in the object control skill composite score was not correlated to participant age at the start of the study (r = -0.30, p = 0.069) nor at the six-month posttest (r = -0.264, p = 0.114). If maturation was a significant influencing factor on the changes in motor skill performance, the older students would have consistently had larger improvements in motor skill scores. Although the older students trended towards larger improvements in locomotor skill composite scores, the younger students trended towards larger improvements in the object control skill composite scores. However, it is also possible that there were too few participants in each age group (Table 1) to detect correlations between age and the composite score changes in locomotor and object control skills.

Another possible threat to interval validity was the fact that some of children in this study had participated in weekly physical education classes focused on improving motor skills the year before. In an effort to control for this, the pretest provided a baseline of the mastery of each of the 12 motor skills before the intervention was implemented.

The results of this study would have been strengthened had we included a control group. It would, however, have been unethical to include a control group that did not receive physical education classes for the majority of the school year. Additionally, access to physical education classes is federally mandated. As such, it was not possible in the current study to provide a wait-list control group that received no physical education. It would be beneficial for future research to compare physical education class programming to better identify those characteristics of the intervention that are particularly helpful in improving motor skill performance in children with ASD.

In this study, only a pre- and posttest were administered to determine change in motor skill performance. Without a midterm assessment, there is no way to determine whether these motor skills were mastered earlier during the intervention. According to Kelly, Dummer, and Sampson (2010), it takes approximately 442 minutes to teach one motor skill to mastery for typically developing students. Because children with ASD tend to learn motor skills more slowly and retain less than their typically developing peers, the researchers in this study chose not to take two weeks out of the instructional time to perform a mid year assessment. Future research might include a midterm assessment to examine whether a significant change in motor skill improvement occurred in three months. It is also recommended that future researchers implement and assess programs that have a greater amount of time dedicated to fewer skills, thus providing more opportunity to achieve a greater level of mastery.

Conclusions

The results of this study demonstrate that although children with ASD have severe deficits in motor skills, they can improve their motor skills when a 40-minute physical education program provided twice a week for six months is designed to focus on motor skill acquisition and emphasize controlled practice and repetition. The physical education program in this study was designed to provide individualized instruction, utilize visual, verbal, and manual cues as well as picture task cards to enhance learning, provide demonstrations, and give specific feedback. These combined teaching techniques proved to be effective in improving motor skill performance as measured by the participants' performance on the TGMD-2. However, the qualitative aspects of smooth coordination or control of their movements as well as the use of momentum to impart force was lacking. It is recommended that future research focus on interventions that attempt to improve these aspects of performance with children with ASD.

Developing interventions to improve motor performances involved with motor coordination in children with ASD should be a priority (Fournier et al., 2010; Riethmuller, Jones, & Okely, 2009). Perhaps with more proficiency in motor skills, children with ASD will be more likely to participate in physical activities (Okely, Booth, & Patterson, 2001; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006) which in turn will lead to more interaction with peers, increased social skills, improved levels of fitness, and better health outcomes.

References

Adrien, J. L., Lenoir, P., Martineau, J., Perrot, A., Hameury, L., & Larmande, C. (1993). Blind ratings of early symptoms of autism based on family home movies. *Journal of the American Academy of Child and Adolescent Psychiatry*, *32*, 617–626. doi:10.1097/00004583-199305000-00019

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Baio, J. (2014). Prevalence of autism spectrum disorders among children aged 8 years. Autism and developmental disabilities monitoring network, 11 sites, United States, 2010.

Centers for Disease Control and Prevention Morbidity and Mortality Weekly Report, *Surveillance Summaries, March 28, 2014 / 63(2),* 1-21. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6302a1.htm?s_cid=ss6302a1_w

Baranek, G. T. (1999). Autism during infancy: A retrospective video analysis of sensory-motor and social behaviors at 9-12 months of age. *Journal of Autism and Developmental Disorders*, *29*, 213–224. doi:10.1023/A:1023080005650

Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders*, *32*, 397–422. doi:10.1023/A:1020541906063

Ben-Sasson, A., Hen, L, Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *39*(1), 1–11. doi:10.1007/s10803-008-0593-3

Berkeley, S. L., Zittel, L. L., Pitney, L. V., & Nichols, S. E. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly, 18*, 405–416. Retrieved from http://journals.humankinetics.com/APAQ

Branta, C., Haubenstricker, J., & Seefeldt, V. (1984). Age changes in movement skills during childhood and adolescence. *Exercise and Sport Science Review, 12*, 467–520. Retrieved from http://journals.lww.com/acsm-essr/pages/default.aspx

Breslin, C. M., & Rudisill, M. E. (2011). The effect of visual supports on performance of the TGMD-2 for children with autism spectrum disorder. *Adapted Physical Activity Quarterly, 28*, 342–353. Retrieved from http://journals.humankinetics.com/APAQ

Center for Disease Control. (2014) CDC estimates 1 in 68 children has been identified with autism spectrum disorder. Retrieved from www.cdc.gov/media/releases/2014/p0327-autism-spectrum-disorder.html

Downey, R., & Rapport, M. J. K. (2012). Motor activity in children with autism: A review of current literature. *Pediatric Physical Therapy, 24:* 2–20. doi:10.1097/PEP.0b013e31823db95f

Emck, C., Bosscher, R. J., van Wieringen, P. C. W., Doreleijers, T., & Beek, P. J. (2010). Gross motor performance and physical fitness in children with psychiatric disorders. *Developmental Medicine and Child Neurology, 53,* 150–155. doi:10.1111/j.1469-8749.2010.03806.x

Fournier, K. A., Hass, C. J., Naik, S. K., Lodha, N. & Cauraugh, J. H. (2010) Motor coordination in autism spectrum disorders: A synthesis and meta-analysis. *Journal of Autism and Developmental Disorders, 40*, 1227–1240. doi: 10.1007/s10803-010-0981-3

Fronske, H., Blakemore, C., & Abendroth-Smith, J. (1997). The effect of critical cue on overhand throwing efficiency of elementary school children. *Physical Educator, 54*, 88–95. Retrieved from http://js.sagamorepub.com/pe/

Ghaziuddin, M., & Butler, E. (1998). Clumsiness in autism and Asperger syndrome: A further report. *Journal of Intellectual Disability Research*, 42, 43–48. doi:10.1046/j.1365-2788.1998.00065.x

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T. Simonoff, E., & Baird, G. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine and Child Neurology, 51*, 311–316. doi:10.1111/j.1469-8749.2008.03242.x

Kopp, S., Beckung, E., & Gillberg, C. (2010). Developmental coordination disorder and other motor control problems in girls with autism spectrum disorder and/or attention deficit/hyperactivity disorder. *Research in Developmental Disabilities, 31*: 350–361. doi:10.1016/j.ridd.2009.09.017

MacDonald, M., Esposito, P., Hauck, J., Jeong, I., Hornyak, J., Argento, A., & Ulrich, D. (2012). Successful bicycle training for youth with Down syndrome and autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 27*, 12–21. doi: 10.1177/1088357611428333

Manjiviona, J., & Prior, M. (1995). Comparison of Asperger Syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disabilities, 25*, 23–39. doi:10.1007/BF02178165

McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader[c], P. R., Berry, C. C., & Brennan, J. J. (2002). Childhood movement skills: Predictors of physical activity of Anglo American and Mexican American adolescents. *Research Quarterly in Exercise Science, 73*(3): 238–244. doi:10.1080/02701367.2002.10609017

Obrusnikova, I., & Dillon, S. R. (2011). Challenging situations when teaching children with autism spectrum disorders in general physical education. *Adapted Physical Activity Quarterly*, *28(2)*, 113–131. Retrieved from http://journals.humankinetics.com/APAQ

Okely, A. D., Booth, M. L., & Chey, T. (2004). Relationships between body composition and fundamental movement skills among children and adolescents. *Research Quarterly in Exercise and Sport, 75,* 238–248. doi:10.1080/02701367.2004.10609157

Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of cardiorespiratory endurance to fundamental movement skill proficiency among adolescents. *Pediatric Exercise Science, 13,* 380–391. Retrieved from http://journals.humankinetics.com/PES

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. doi: 10.1007/s10803-009-0813-5

Riethmuller, A. M., Jones, R. A., & Okely, A. D. (2009). Efficacy of interventions to improve motor development in young children: A systematic review. *Pediatrics, 12(4),* 782–792. doi: 10.1542/peds.2009.0333

Schieve, L. A., Rice, C., Yeargin-Alsopp, M. , Boyle, C. A., Kogan, M. D., Drews, C., & Devine, O. (2012). Parent-reported prevalence of autism spectrum disorders in U.S-born children: An assessment of changes within birth cohorts from the 2003 to the 2007 national survey of children's health. *Maternal and Child Health Journal, 16*: S151-S157. Doe 10.1007/s10995-012-1004-0

Schlosser, R.W., Laubscher, E., Sorce, J., Koul, R., Flynn, S., Hotz, L., Abramson, J., Fadie, H., & Shane, H. (2013). Implementing directives that involve prepositions with children with autism: A comparison of spoken cues with two types of augmented input. *Augmentative and Alternative Communication, 29*(2), 132–145. Doi: 10.3109/07434618.2013.784928

Sowa, M., & Meulenbroek, R. (2012). Effects of physical exercise on autism spectrum disorders: A meta-analysis. *Research in Autism Spectrum Disorders 6,* 46–57. doi.org/10.1016/j.rasd.2011.09.001

Staples, K. L., Todd, T., & Reid, G., (2006). Physical activity instruction and autism spectrum disorders. *ACHPER Healthy Lifestyles Journal, 53*(3-4), 17–23.

Staples, K. L., & Reid, G. (2010). Fundamental movement skills and autism spectrum disorders. *Journal of Autism and Developmental Disorders, 40,* 209–217. doi: 10.1007/s10803-009-0854-9

Teitelbaum, O. Benton, T., Shah, P. K., Prince, A., Kelly, J. L., & Teitelbaum, P. (2004). Eshkol-Wachman movement notation in diagnosis: The early detection of Asperger's syndrome. *Proceedings of the National Academy of Sciences, USA. 101(32)*, 11909–11914. doi: 10.1073/pnas.0403919101

Ulrich, D.A. (2000). *Test of Gross Motor Development* (2nd ed.) *Examiner's manual*. Austin, TX: ProEd, Inc.

Vernazza-Martin, S., Martin, N., Vernazza, A., Lepellec-Muller, A., Rufo, M., & Massion, J. (2005). Goal directed locomotion and balance control in autistic children. *Journal of Autism and Developmental Disorders*, *35(1),* 91–102. Retrieved from http://aune.lpl-aix.fr/~fulltext/2323.pdf.

Wrotniak, B. H., Epstein, L. H. Dorn, J. M., Jones, K. E., & Kondilis, V. A. (December, 2006). The relationship between motor proficiency and physical activity in children. *Pediatrics, 118,* 1758–1765. doi:10.1542/peds.2006-0742

Hester Henderson has been an assistant/associate professor at the University of Utah, where she has been teaching adapted physical education in the Department of Exercise and Sport Science since 1983. She has written several books on behavior management and teaches the behavior management course. She developed the physical education program at a Center for Children with Autism Spectrum Disorders in Salt Lake City, and her students taught in the program for 8 years.

Arwen Fuller is an assistant professor/lecturer in exercise physiology and the director of the Coaching Wellness Master's degree program at the University of Utah. Her overall research interest is to clarify the role of exercise in the prevention of obesity, diabetes, and cardiovascular disease and to discover and implement effective ways to enable positive behavior change for improving health and wellness.

Stacy Noren earned her BS in physical education from Brigham Young University, and she then completed a MS in exercise science/adapted physical education at the University of Utah. Her master's studies focused on motor skill development and curriculum for students with Autism Spectrum Disorders. Stacy has worked in various physical education, adapted physical education, and adapted dance/movement programs both in Utah and in North Carolina.

Vanessa Mortensen Stout completed her master's in adapted PE at the University of Utah in 2011. Vanessa is an adapted physical educator at Hartvigsen School in the Granite School District, in Salt Lake City, Utah. Hartvigsen School is a public school for students with severe disabilities age 6-22.

Daniel Williams is an assistant professor in the Department of Kinesiology at the University of LaVerne, CA. He has been teaching exercise physiology, clinical physiology, research design, and statistics in higher education for the past 21 years. In addition, he conducts research on body composition and health-related aspects of physical activity in individuals throughout the lifespan.