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Effects of Learned Exercises on Gross Motor Coordination in Children with ASD

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Contents

Abstract

The effectiveness of a teaching progression to teach three "Olympic" exercises and improve gross motor coordination was evaluated with four children (3 boys, 1 girl) diagnosed with autism spectrum disorder (ASD). A multiple baseline design across children and within children across activities was used to evaluate the effectiveness of the teaching progression used to teach the physical exercise program, which consisted of three "Olympic" events (long jump, 50 foot dash, and a relay race). Results showed all four participants learned the three "Olympic" exercises, with all four participants mastering at least one of the three exercises. Two participants mastered all three "Olympic" exercises. Additionally, all four participants experienced a significant improvement in gross motor coordination. A posttest follow-up was done one week after the participant finished the third test phase, or mastered the final exercise. These results show that physical modeling, focused feedback, and focused physical modeling can be successfully used to teach children with ASD how to perform physical exercises, as well as the fact that learning how to perform, and actually performing, physical exercises increased gross motor coordination in children with ASD.

Literature Review

Autism spectrum disorder, or ASD, is a developmental disability that manifests itself as difficulties in communication, social skills, and body control (American Psychiatric Association, 2013). Recent surveys suggest 1 in 68 children are diagnosed with ASD (Centers for Disease Control & Prevention, 2014). Recently, ASD has been recognized as one of the most common neurodevelopmental disorders affecting children due to the rising number of diagnoses (Fombonne, 2009). Individuals with ASD struggle in controlling their bodies and engaging in activities that require fine motor skills (Pan, Tsai, & Chu, 2009; Emck, Bosscher, van Wieringen, Doreleijers, & Beek, 2011). These deficits in motor coordination persist over time and may contribute to a lack of physical exercise, which can cause serious health risks (Sowa & Meulenbroek, 2012).

There is little research concerning individuals with ASD, or ASD, and physical exercise. This is important because research shows 32% of teenagers with ASD are obese (Phillips et al., 2014). Research also suggests young children with ASD have somewhat similar (but still lower) physical activity levels as typical children; however, as children age, those with ASD show lower levels of physical activity, and those who are typical functioning show increased levels of physical activity (MacDonald, Lord, & Ulrich, 2011; Pan, 2008). Obesity is not the only issue. Due to their sedentary lifestyle, individuals with ASD represent a high-risk group, who are at an increased risk of developing heart disease and diabetes (World Health Organization [WHO], 2002). Because physical exercise has shown to be a successful way to reduce the risks of these diseases and health issues in a typical functioning population, it is probable that it is also effective in reducing risk in an ASD population (Sowa & Meulenbroek, 2012). A study conducted in 2007 showed that a walking program improved the physical condition of ten adolescents with ASD, while also reducing their BMIs (Pitetti, Rendoff, Grover, & Beets, 2007). In addition to making individuals with ASD physically healthier, physical exercise has shown to improve the sleep quality of children with ASD and reduce problem behaviors, both of which are known to be common problems for individuals diagnosed with ASD (Lancioni & O'Reilly, 1998).

Prior research concerning ASD and exercise often utilized activities that did not require any kind of teaching or training. A study looking at how a cycling program affected children with ASD divided children into three treatment groups, assisted cycling, unassisted cycling, and no cycling (Rigenbach, Lichtsinn, & Holzapfel, 2015). The motor in the assisted cycling condition forced the children to keep a constant pace of 80 revolutions per minute, as there was no coaching or teaching measured in the study (Rigenbach, Lichtsinn, & Holzapfel, 2015). The study found that cycling benefitted the children by increasing their cognitive planning, while decreasing their off-task behavior and feelings of inhibition (Rigenbach, Lichtsinn, & Holzapfel, 2015).

Due to the low levels of physical exercise in populations with ASD in relation to typically developing populations, it is important to examine and identify ways in which individuals with ASD can be motivated to exercise (Drahelm, Williams, & McCubbin, 2002). A study concerning motivation showed that goal setting and reinforcement substantially increased walking in young adults with ASD (LaLonde et al., 2014). Each participant wore a pedometer and established a baseline for number of steps within a day (LaLonde et al., 2014). After the baseline period, each individual was allowed to pick objects that would act as reinforcers (LaLonde et al., 2014). Each child would receive these reinforcers after reaching a number of steps that were set as a goal for the day (LaLonde et al., 2014). The results from this study provide evidence that reinforcement based interventions can be used to increase physical exercise in populations with ASD (LaLonde et al., 2014). These findings are also supported by a study done by Todd and Reid (2006). They examined how fading out a positive reinforcement schedule affected the physical activity of teenage boys with ASD (Todd & Reid, 2006). Their findings suggest physical exercise can continue to increase as the reinforcers are faded out (Todd & Reid, 2006). This increase in exercise as reinforcement decreases provides evidence that individuals with ASD can experience an increase in self-motivation and independence through physical exercise (Todd & Reid, 2006).

Motor control is a major component of physical exercise, and something individuals with ASD struggle with (Sowa & Meulenbroek, 2012). Children with weak motor control and coordination were shown to also have greater social skills difficulties (MacDonald, Lord, & Ulrich, 2014). In addition to gross motor control predicting social skills in children with ASD, fine motor skills predicted the severity of autism diagnosis; the worse an individual's fine motor skills, the more severe of a diagnosis he or she had (MacDonald, Lord, & Ulrich, 2014). Weak motor and social skills were again targeted in a study where teenagers and adults with ASD participated in exercise programs (Sowa & Meulenbroek, 2012). Few studies have examined the relationship between physical exercise and gross motor coordination, but one study doing so showed physical exercise (in the form of martial arts) increased gross motor coordination in young adults with Down Syndrome (Aguiar et al., 2008).

ASD is not always an easy disability to observe (Braun & Braun, 2015). Because of this, individuals with ASD participating in work behaviors, exercise behaviors, youth sports, or other activities may be labeled as lazy or as having a poor work ethic, when in reality, they have a disability. Braun and Braun examined strategies and techniques that may be able to encourage and motivate children diagnosed with ASD in an attempt to better their sports experience (Braun & Braun, 2015). The importance of developing strategies specifically shown to help individuals diagnosed with ASD was illustrated in a study where coaches admitted to feeling overwhelmed and ill prepared to handle children who had developmental disabilities (Weirsma & Sherman, 2005). It has been suggested that instructional strategies involving teaching individuals with ASD should address three main areas: development of strategies related to sensory overstimulation, facilitation of appropriate language, and development of appropriate social skills (Falk-Ross, Iverson, & Gilbert, 2004; Safran, 2002). Creating a structured environment where the coach, or instructor, had the potential to work with the individual with ASD in a one on one manner proved to be the most beneficial (Braun & Braun, 2015). Furthermore, a safe zone, or area where the individual with ASD could escape stimulus, was encouraged to be created in the event the individual with ASD became over stimulated (Braun & Braun, 2015). These findings are echoed in Sowa and Meulenbroek's work (2012), where they found individual interventions were more successful than group interventions in teaching both adults and children with ASD physical exercise behaviors.

When considering the best teaching progression for teaching children with ASD athletic activities, a study done by Rogers, Hemmeter, and Wolery (2010) showed a constant time delay (or CTD) procedure was successful in teaching children with ASD swimming behaviors. Constant time delay procedure is a process where an instruction and a prompt are given at the same time, and after a set number of trials, the instruction is given, but the prompt is not given, or delayed, until after a previously specified number of seconds (Rogers, Hemmeter, & Wolery, 2010). Three children who could not perform the target behaviors were included in the study (Rogers, Hemmeter, & Wolery, 2010). A trainer was present in the water with each child, and she played with each child during a 20 minute screener session to find out what water games and activities, such as splashing and jumping, each child found reinforcing (Rogers, Hemmeter, & Wolery, 2010). The trainer provided minimal assistance to the child during baseline (Rogers, Hemmeter, & Wolery, 2010). Every session (through all conditions, baseline, treatment, and posttest) were done in a one on one setting (Rogers, Hemmeter, & Wolery, 2010). Three target behaviors were examined in the study (flutter kick, front crawl arm strokes, and head turns to the side) all of which were related (Rogers, Hemmeter, & Wolery, 2010). Probe sessions, without any prompting, were conducted after a child reached criterion for at least one of the three exercises (Rogers, Hemmeter, & Wolery, 2010). During treatment, a 4 second delay was used between the instruction and the prompt being given to the child (Rogers, Hemmeter, & Wolery, 2010). If the child went through multiple attempts without correctly performing the exercise, the instruction and prompt reverted to being delivered at the same time (Rogers, Hemmeter, & Wolery, 2010). In addition to teaching swimming behaviors, CTD has also shown to be successful in teaching a variety of behaviors, such as naming pictures and reading sight words, to individuals with ASD (Wolery et al., 1992).

Another type of teaching progression, most to least prompting schedules, was shown to be successful in teaching adults with severe autism how to kick a soccer ball with the side of their foot (Luyben et al., 1986). The kicking behavior was broken down into nine separate components in which the adult was trained in (Luyben et al., 1986). Three low functioning adult males with ASD were selected for the study after it was established that they could respond to basic instructional commands such as “stop” and “go” (Luyben et al., 1986). The motor skills of the three males were described as fair at best, with the most advanced individual being able to run and sometimes catch a ball (Luyben et al., 1986). During baseline, participants were told to pass the ball, and their attempts were recorded (Luyben et al., 1986). During treatment, the researcher modeled the exercise for the participant, and then provided verbal and physical prompting and reinforcement as needed after each of the participants’ attempts (Luyben et al., 1986). The participants would attempt to do one of the nine components of the exercise, and the researcher would provide a positive reinforcer, such as a good job, if the individual performed the component correctly, or a descriptive correction if the individual did not perform the component properly (Luyben et al., 1986). The participants were prompted through each component until they completed it correctly (Luyben et al., 1986). Once a participant successfully performed a component of the soccer ball kicking exercise three times in a row, the next component of the kicking exercise was added to the training (Luyben et al., 1986). All three low functioning males with ASD reached criterion in less than 30 sessions (Luyben et al., 1986).

The components of a physical exercise were again broken down into components in a case study involving teaching a boy with Asperger’s Disorder how to throw a ball using a changing criterion design (Matsushita & Sonoyama, 2010). A changing criterion design is a design in which the participant goes through an initial baseline and treatment phase, but once the first treatment phase stabilizes, it becomes a baseline for the next treatment phase (Matsushita & Sonoyama, 2010). The exercise of throwing the ball was broken down into ten different components, each of which were taught and reinforced using picture modeling and behavioral coaching, which proved to be successful (Matsushita & Sonoyama, 2010). The participant was 11 years old, diagnosed with Asperger's Disorder, and had poor gross and fine motor skills (Matsushita & Sonoyama, 2010). The participant was brought into a university for a session once every two weeks for eight months (Matsushita & Sonoyama, 2010). The participant was placed in front of a bullseye that was taped to a white board (Matsushita & Sonoyama, 2010). The participant was given ten throws to try and score the highest score he could by hitting the bullseye target (Matsushita & Sonoyama, 2010). A graduate student participated in the study as the participant's "competitor" (Matsushita & Sonoyama, 2010). The rules and the scoring sheet were taped on the white board in large text next to the bullseye target, and the participant, "competitor," and researcher were able to see all three objects at all times (Matsushita & Sonoyama, 2010). The game was video recorded, and prompting cards were shown displaying part of the ball throwing behavior in each phase (Matsushita & Sonoyama, 2010). A new prompt card was shown in each phase, totaling four phases and four prompt cards (Matsushita & Sonoyama, 2010).

Baseline consisted of two sessions where the participant stood 5 meters from the bullseye target on the whiteboard and threw the ball at the bullseye target without any prompting cards (Matsushita & Sonoyama, 2010). The researcher presented the participant with a rules sheet and issued verbal warnings if the participant did not follow the rules outlined in the sheet (Matsushita & Sonoyama, 2010). If the participant hit the target with the ball, verbal praise, such as "good job," was administered by one of the graduate students (Matsushita & Sonoyama, 2010). If the participant did not hit the target with the ball, the researcher provided suggestions on how to throw the ball (Matsushita & Sonoyama, 2010). In the first treatment phase, three of the behaviors the action of throwing the ball was broken down into were shown using picture prompt cards (Matsushita & Sonoyama, 2010). The researcher, who acted as the referee of the bullseye game, showed the picture prompt cards to the participant and then modeled the behaviors depicted on the cards before the participant attempted to throw the ball at the target (Matsushita & Sonoyama, 2010). The researcher praised the participant when he successfully completed the three behaviors depicted on the prompt card (Matsushita & Sonoyama, 2010). When the participant did not hit the target, the researcher offered feedback (Matsushita & Sonyama, 2010). Once the participant reached the criterion of successfully performing 30% or more of the behaviors on five consecutive trials, he moved into the next treatment phase, where three more behavior prompt cards were introduced (Matsushita & Sonoyama, 2010). This process continued until the participant was in phase four, where he was being prompted by all ten of the behavior items the action of throwing the ball was broken down into (Matsushita & Sonoyama, 2010). The success criterion of each phase rose: phase one was 30%, phase two was 60%, phase three was 80%, and phase four was 100% accuracy (Matsushita & Sonoyama, 2010).

Because children diagnosed with ASD live a sedentary lifestyle and exhibit such poor motor skills, it is important to study how these motor skills can be improved through physical exercise. The present study intended to train children with autism how to compete in "Olympic" events and examine if the "Olympic" events (physical exercise) affected the children's gross motor coordination. Three track and field events were utilized in the present study due to the ease with which they can be taught in a one on one setting. There were two main hypotheses in the present study. First, the teaching progression of first modeling, then providing verbal feedback, and finally, modeling the specific area of difficulty again would successfully teach the children how to complete the "Olympic" events to criterion (Luyben et al., 1986; Matsushita & Sonoyama, 2010; Rogers, Hemmeter, & Wolery, 2010). Second, the learning and performing of the "Olympic" events would lead to improvements in the childrens' gross motor coordination, as measured by the Charlop-Atwell Scale of Motor Coordination (Charlop, M. & Atwell, W. C., 1980; MacDonald, Lord, & Ulrich, 2014; Sowa & Muelenbroek, 2012).

Method

Participants

The participants in the study consisted of four children diagnosed with ASD between the ages of 8 and 15 (more demographic information shown in *Table 1*). Seven participants were originally considered to be included in the experiment, but three of the participants had to be dropped due to attendance issues at the university center. Participants were selected from a population of children diagnosed with ASD, diagnosed using the CARS-II scale (childhood autism rating scale), who are currently enrolled in a university based afterschool treatment center (Schopler, Reichler, & Renner, 2002). Requirements for participation in the current study were observed through normal treatment activities. To participate, the children must have shown they lacked an ability to follow simple instructions. The researcher obtained informed consent from parents of all seven participants prior to the start of the study.

Table 1

Demographic Information for the Four Participants in the Current Study

Name	Age (Years)	Gender	Ethnicity	CARS-II
Matt	12	Male	Italian-American	Severe
Ally	8	Female	Korean-American	Severe
Leonardo	15	Male	Mexican-American	Severe
Brandon	9	Male	European American	Severe

Note: Age listed is chronological age at the beginning of the pretest phase of the current study.

Matt was a twelve year old boy with severe autism, as measured by the CARS-II diagnostic scale. He attended an after school social skills program at a university center. Matt was on a fixed ratio reinforcement schedule and did not receive any one on one therapy at the clinic. He was overweight and had a history of engaging in problem behaviors while receiving behavioral therapy. His problem behaviors often took the form of inappropriate gestures, touching, and cursing. Matt showed an interest in engaging in physical exercise when playing games such as freeze tag at the university center, but he showed difficulty in controlling his body. He would frequently bump into other children, touch other children in a strong, aggressive manner, and run out of bounds.

Ally was an eight year old girl with severe autism, as measured by the CARS-II diagnostic scale. She received social skills therapy, which included a fixed ratio reinforcement schedule, at the after school university center. Ally had a history of engaging in aggressive behaviors with her younger sister. Ally would yell at and hit her younger sister, who did not have ASD. Ally enjoyed playing games outside with the other children at the center. She showed difficulty controlling her body and completing fine motor tasks during everyday activities at the university center. Ally was deemed a good candidate for the current study due to her lack of fine motor skills.

Leonardo was a fifteen year old boy with severe autism, as measured by the CARS-II diagnostic scale. Leonardo was on a fixed ratio reinforcement schedule during the social skills sessions he attended at the after school university center. Leonardo typically showed no aggressive behaviors, but from time to time, he would make aggressive gestures toward Matt, one of the other participants in the study. These aggressive behaviors took the form of aggressive posture and facial expressions. When playing outside, Leonardo's movements often appeared jerky and unnatural. Leonardo was a deemed a prime candidate for the current study due to his jerky, unnatural movements.

Brandon was a nine year old boy with severe autism, as measured by the CARS-II diagnostic scale. He was on a fixed ratio reinforcement schedule at the after school university center. He received social skills therapy in a group setting, like the other three participants. Brandon had a history of engaging in inappropriate behaviors, such as yelling or becoming distracted, with his younger sister, who accompanied him to the university center and was typically functioning. Brandon also had a history of noncompliance, where he would lay on the ground or elope from the group. Brandon had poor to fair motor skills and almost always walked on his toes. His movements were not fluid and quite spasmodic. Brandon would fling his body about randomly in jerky motions. Brandon was deemed a good candidate for the present study due to his spasmodic body movements and lack of focus on controlling his body.

Materials

The researcher used nylon webbing (as the track), duct tape (as markers), two white cones, a measuring tape, a stopwatch, 6 foam number tiles (as a "sand pit"), an iPad for recoding purposes, a clipboard, a pen, and paper towel rolls (as a baton). Although the participants had experience with individual items (stopwatch, paper towel rolls, iPad, and a measuring tape), they did not have experience with all of the items being used together, or experience with using the materials in the way they were used. The researcher chose a paper towel roll to be used as a baton for a relay race due to the fact that the children could not use them to hurt each other. Additionally, paper towel rolls are readily available and easily replaced.

Four other materials included in the study were coding sheets. One sheet was used to code how well each child performed the long jump (see *Appendix A*), one sheet was used to code how well each child performed the 50-foot dash (see *Appendix B*), and a third sheet was used to code how well each child performed the relay race (see *Appendix C*). A fourth coding sheet was part of the Charlop-Atwell Scale of Motor Coordination and was used to code the pretest and posttest assessments during the present study.

Charlop-Atwell Scale of Motor Coordination

The Charlop-Atwell Scale of Motor Coordination was developed in 1980 and was designed to make a quick and easy way to measure gross motor coordination of children

(Charlop, M. & Atwell, W. C., 1980). This scale was validated and standardized on typically functioning children between the ages of four and six years old (Charlop, M. & Atwell, W. C., 1980). The scale was comprised of six items: jumping jacks, jump and about face, hopping on 1 foot, prehistoric animal, scarf twirl, and tip toe balance (Charlop, M. & Atwell, W. C., 1980). Each item had a set of written instructions that the individual administering the scale read aloud to the children (Charlop, M. & Atwell, W. C., 1980). After the individual administering the scale read the directions to the child, he or she modeled the exercise for the child (Charlop, M. & Atwell, W. C., 1980). Once the child was told to perform the exercise, he or she attempted the exercise, and the individual administering the scale graded the child in-vivo (Charlop, M. & Atwell, W. C., 1980). If the child did not understand the instructions for the item, the individual administering the scale reread and remodeled the item for the child (Charlop, M. & Atwell, W. C., 1980). For example, these were the directions for the jump and about face item: "I want you to jump up into the air, turning around so that you face the wall behind you, and land with both feet on the ground. Watch me. (Demonstrator jumps into the air turning 180 degrees to face the opposite direction and lands with both feet touching the ground at the same time.) Now you try it" (Charlop, M. & Atwell, W. C., 1980). The child received an objective score and a subjective score for each item (Charlop, M. & Atwell, W. C., 1980). The objective score measured if the child did the item as instructed and modeled by the individual administering the scale, and the subjective score measured how fluid or natural the child looked while performing the item (Charlop, M. & Atwell, W. C., 1980). The Charlop-Atwell Scale of Motor Coordination took roughly nine to fifteen minutes to administer and score, depending on the child being measured (Charlop, M. & Atwell, W. C., 1980).

Setting

The training sessions took place on a grass field located in close proximity to the university center at a college in Southern California. The grass field was approximately 50 feet by 75 feet and surrounded by academic buildings. The children often played on this grass field during normal university center hours and were familiar with the field. The walk back from the grass field to the university center was less than 100 yards. At least one graduate student working at the university center accompanied each participant on the trip to the grass field and back, ensuring every child was safe and accounted for.

Design

A multiple baseline design across participants and within participants across activities was used to examine if the children learned the "Olympic" exercise behaviors. Behavioral skills training, or BST, was used to teach the "Olympic" events to the children in the present study. The three "Olympic" exercises were counterbalanced, so that no one participant did the three exercises in the same order as any other participant. Baseline was the pre-treatment measurement of the goal behavior. Before treatment was introduced, baseline was established for each child. Each child entered the treatment phase at different times; when the first participant entered the treatment phase, the other participants were still in baseline. This staggered introduction of the treatment to each child allowed the researcher to conclude the change in behavior from baseline to treatment resulted from the intervention (Cooper et al., 2007). This could be concluded because the staggered design allowed for control of confounding variables, which in turn, allowed the researcher to determine that the change seen was not due to chance (Cooper et al, 2007).

In the present study, the children were given a pretest, consisting of the Charlop-Atwell Scale of Motor Coordination, and observed during baseline, allowing the researcher to examine the social behaviors and motor skills present before introduction of the treatment. The three exercises were counterbalanced, so that the children did not complete the baseline, and enter treatment, at the same time for each exercise. The treatment for all three “Olympic” events, the long jump, 50-foot dash, and relay race, was introduced at different times for each participant. The children were videotaped throughout the entirety of the study (pretest, baseline, treatment, test, and posttest). The Charlop-Atwell Scale of Motor Coordination was administered again in the posttest phase of the current study. This was to examine what effect, if any at all, the learning and performing of the “Olympic” exercises had on the gross motor coordination of the participants. A paired-samples t-test was run to examine the pretest and posttest mean scores on the Charlop-Atwell Scale of Motor Coordination.

Procedure

For this study, the researcher had children engage in physical activities that are frequently seen at the Olympics: the long jump, 50-foot dash, and a relay race. The children needed to work on controlling their bodies to complete each activity in the exact way the researcher designated. The participants entered baseline, where they received no treatment for a predetermined number of attempts for each exercise. After baseline, the participants entered the treatment phase, where they were exposed to the teaching progression used in the current study. The participant needed to perform two consecutive attempts at 100% accuracy in order to enter the test phase of the current study. Once the participant entered the test phase, he or she had two attempts at baseline procedure to meet the mastery criterion, which was two consecutive attempts at 100% accuracy. If the participant met the mastery criterion, he or she no long performed the exercise he or she had mastered. If the participant did not meet the mastery criterion, he or she received a booster session, where he or she was re-exposed to the teaching progression. This was called a booster and session, and it was a repeat of the treatment phase. The participant had to requalify for the test phase by meeting the learning criterion for the exercise again. Each participant had a maximum of two booster sessions per exercise. If after two booster sessions, three total test sessions, the participant still could not complete two consecutive attempts at 100% accuracy in the test phase, the treatment portion of the study for that particular exercise was ended.

Teaching progression. The teaching progression for the current study was influenced by progressions used in previous studies done by Matsushita and Sonoyama (2010), Luyben et al. (1986), and Rogers, Hemmeter, and Wolery (2010). The teaching progression was used during the treatment phase of the current study and broken down into three parts: physical modeling, focused verbal feedback, and focused physical modeling. During the treatment phase, the children received positive reinforcement after every attempt, and if an attempt was completed perfectly, the child would receive a reinforcer that was known to be preferred. This process allowed the researcher to gain a foundational understanding of what each participant did and did not do well. After this foundation was established, the researcher could focus his instructions and teaching on the parts of each exercise that the particular participant struggled with. There was an initial command for each “Olympic” exercise. The initial command for the long jump was, “[name of participant] stand behind this piece of tape. When I say go, I want you to run and jump in the numbers.” The initial command for the 50-foot dash was, “[name of participant] stand behind this line. When I say go, I want you to run down to those cones.” The initial command for the relay race was, “[name of participant] stand behind this line. When I say go, I want you to run down and hand the baton to [name of research assistant].” The appropriate initial command was given before every attempt of an “Olympic” exercise. It was important that the researcher said the same initial command before every attempt to ensure different instruction was not the reason for any change in performance. When the researcher was modeling, he gave the initial command to himself before modeling the exercise. The first physical modeling of each exercise took place before the child’s first attempt of an “Olympic” exercise in the treatment phase of the current study. As stated earlier, the researcher stated the initial command before modeling for the participant. The participant was asked to stand at the end of the track or long jump runway (both of which were made out of nylon webbing) in order to observe the researcher. The participant then gave the “Ready, Go” command, and the researcher modeled the “Olympic” exercise, while narrating what he was doing. After this physical modeling session, the researcher walked with the child to the starting point, the start of the track for the dash and relay and a piece of tape marking 25 feet for the long jump. Once at the starting point for the “Olympic” exercise that was being performed, the researcher would give the initial command and the start stimulus. The participant would then attempt the exercise. After the child’s first attempt, he or she received verbal, focused feedback from the researcher. The feedback was tailored to what the child was struggling with. For example, if a child was struggling starting before the researcher gave the start stimulus, the researcher would tell the child to make sure he or she did not move until the start stimulus was given. The researcher made sure to address the correct things each child did after their attempt as well. The researcher would first highlight something the child did correctly, and then address the incorrect parts of the child's attempt. This allowed the researcher to correct the errors in each attempt without breaking the will of the child. After the child received the feedback, he or she attempted the "Olympic" exercise again. After the second attempt, the researcher provided some coaching points and modeled the part of the exercise the child was struggling with. Continuing our earlier example, if the child was struggling with the start, the researcher would emphasize the start in the second physical modeling of the exercise. The researcher still modeled the entire exercise, but emphasis was put on the point the particular child was struggling with. After the sequence of physical modeling, verbal feedback, and focused physical modeling was complete, each modeling attempt done by the researcher was done with an emphasis on the part of the exercise the child was having the most difficulty completing correctly. This teaching progression allowed the researcher to tailor each treatment session to the particular needs of each participant. Doing this made teaching the "Olympic" exercises to the children more efficient due to the emphasis on what the child needed to improve on. If the child was struggling with the start, but doing everything else as instructed, time was focused on the start and not wasted on other aspects of the exercise.

Pretest. Each child enrolled at the university center was observed in everyday activities to see if he or she had difficulties with motor coordination. The children that exhibited difficulties with motor coordination were given the Charlop-Atwell Scale of Motor Coordination. One research assistant coded the test, while the researcher led the participants through the measure. All pretest sessions were video recorded. All pretest sessions were also done in a one on one setting. Since the study was looking at increasing gross motor coordination through learning physical exercises, this was a strong pretest.

Baseline. During baseline procedure, the participants did not receive the teaching progression. Instead they only received the initial command for each exercise and the start stimulus. The initial command for the long jump was, "[name of participant] stand behind this piece of tape. When I say go, I want you to run and jump in the numbers." The initial command for the 50-foot dash was, "[name of participant] stand behind this line. When I say go, I want you to run down to those cones." The initial command for the relay race was, "[name of participant] stand behind this line. When I say go, I want you to run down and hand the baton to [name of research assistant]." The start stimulus for all exercises was "ready, go." After the participant attempted to perform an exercise, he or she was told "good try" and instructed to walk back to the researcher. The participant was instructed to walk back to the researcher in an attempt to minimize the unnecessary running the participants did during the study. The participant performing the exercise was video recorded and coded, watching to see if the participant completed the attempt as operationally defined. The number of baseline attempts for each exercise were staggered, increasing by one for every participant, so the first participant completed 3, 5, and 7 baseline attempts, and the last participant completed 6, 8, and 10 baseline attempts. After each baseline session, the participant was told exercise time was over, and he or she was allowed to leave the grass field. Each participant endured multiple baseline sessions before treatment was introduced. The first participant was introduced to the treatment while the other three participants were still in baseline, and the fourth participant was in the baseline phase the longest before being introduced to the treatment. Additionally, each participant entered baseline for the first exercise while he or she was still in baseline for the other two exercises.

Treatment. In the treatment condition, the researcher gave the participants the initial command and start stimulus for each exercise, but the researcher also used the teaching progression outlined above to teach the participants how to perform each "Olympic" exercise properly, as operationally defined in dependent measures below. The researcher modeled the exercise for the participant, then he or she attempted to perform the exercise as the researcher did. After the participant's first attempt, the researcher provided feedback to the participant, focusing on what the participant did not do correctly, and the participant attempted the exercise a second time. After the second attempt, the researcher modeled the exercise again, but this time emphasized what the participant was struggling with. This emphasis on what the participant was struggling on allowed the researcher to maximize the teaching time. This process was repeated for each exercise (long jump, 25-yard dash, and the relay race). This teaching progression was done for each treatment session until the participant successfully performed the exercise, as the researcher modeled, two times in a row at 100% accuracy. This was defined as the learning criterion, and once a participant reached this criterion, he or she entered the test phase of the current study. The researcher went back to baseline procedure and only gave the participant the initial command and start stimulus. The participant attempted the exercise after the start stimulus and was told “good job” if he or she performed the exercise at 100% accuracy, or “good try” if the participant did not perform the exercise at 100% accuracy. No modeling, feedback, or reinforcers were given to the child during the test phase of the current study. If the participant met the mastery criterion for the exercise, 100% accuracy on two consecutive test attempts, he or she showed he or she had mastered the exercise as operationally defined, and was no longer required to perform the exercise. If the child did not meet the mastery criterion he or she received a booster session, where the teaching progression was restarted. Each participant received a maximum of two boosters sessions, three total test phases, for each exercise. If a participant was not able to meet the mastery criterion by the end of the second booster session, it was decided that he or she did not master the exercise, and was no longer required to attempt it. This sequence was continued until the child met the mastery criterion, or reached three test sessions, for all three exercises. All attempts to do the three exercises, including the test phase, were video recorded and coded, looking to see if the participant completed the attempt as operationally defined. At the end of every treatment session, the child was told that exercise was done for the day, and that he or she could return to the university center. The same procedure was used for all four children. The treatment phase ended when the child met the mastery criterion, or reached a total of three test phases, for all three exercises. No intervention plan was implemented for gross motor coordination, as the researcher wanted to see what effects, if any, physical exercise had on gross motor coordination.

Posttest. The posttest observation session occurred one week after the child met the mastery criterion, or reached a total of three test phases, on the last exercise. The posttest assessment was a posttest of the Charlop-Atwell Scale of Motor Coordination. The researcher and the research assistant followed the same procedure that was used during pretesting. During posttest, the children were video recorded and coded.

Dependent measures

The dependent measures included learning the "Olympic" exercises and gross motor coordination, as measured by the Charlop-Atwell Scale of Motor Coordination.

"Olympic" Exercises

Long jump. The operational definition of the long jump was broken down into four parts in an attempt to make coding easy and obvious. The four components each comprised 25% of the total exercise, which added up to the 100% accuracy a participant needed to score on two consecutive attempts in order to meet the learning criterion. The four components of the long jump were: started upon the start stimulus, stayed in the lane for the duration of the exercise, jumped within six inches of the jump line, and jumped a minimum of two and a half feet. The child could not start before he or she heard the start stimulus, nor could he or she step backwards after hearing the start stimulus. He or she had to move forward. The child could not touch the lane line, or step outside the lane line, at any point during the exercise. The child had to transition from the running motion to the jump motion within six inches of the jump line. He or she could not transition from the running motion to the jump motion after the jump line, or before he or she was six inches from the jump line. If he or she had any part of his or her foot on the jump line, it was coded as jumping on the jump line. When the track was set up every day, a distance of two and a half feet was measured from the jump line, and that is where the number tiles the children jumped into were placed. If the child's first body part that touched the ground after the jump did not land on the number tiles, then it was known that the child did not jump the minimum distance.

Relay race. Like the long jump, the relay race was operationally defined into four parts in order to make coding easy and obvious. As with the long jump, the four parts each represented 25% of the exercise and added up to 100% accuracy. The child had to score two consecutive attempts at 100% accuracy in order to meet the learning criterion. The four components of the relay race were: started upon the start stimulus, stayed in the lane for the duration of the exercise, ran the entire duration of the exercise, and handed the baton (paper towel roll) to the outstretched hand of the research assistant. The child could not start before he or she heard the start stimulus, nor could he or she step backwards after hearing the start stimulus. He or she had to move forward. The child could not touch the lane line, or step outside the lane line, at any point during the exercise. The child had to run the entire 50 foot distance. He could not jump, skip, gallop, or walk at any time during the 50 foot distance. When the child reached the research assistant (who was holding a hand out like he or she was preparing to receive a baton during a relay race), the child had to place the baton in the outstretched hand of the research assistant. The child could not hit the research assistant with the baton, throw the baton, drop the baton, or try and place the baton in the research assistant's other hand.

50-foot dash. As with the previous two "Olympic" exercises, the dash was operationally defined into four parts in order to make coding easy and obvious. The four parts each represented 25% of the exercise and added up to 100% accuracy. The child had to score two consecutive attempts at 100% accuracy in order to meet the learning criterion. The four components of the dash were: started upon the start stimulus, stayed in the lane for the duration of the exercise, ran the entire duration of the exercise, and finished through the cones at the end of the lane. The child could not start before he or she heard the start stimulus, nor could he or she step backwards after hearing the start stimulus. He or she had to move forward. The child could not touch the lane line, or step outside the lane line, at any point during the exercise. The child had to run the entire 50 foot distance. He could not jump, skip, gallop, or walk at any time during the 50 foot distance. At the end of the dash, the child had to run through the two cones at the end of the lane before he or she started to slow down. The child could not start to slow down until he or she passed the cones at the end of the lane.

Gross Motor Coordination

The gross motor coordination variable was measured by the Charlop-Atwell Scale of Motor Coordination that was outlined in detail earlier. An increase in a participant's gross motor coordination was defined as an increase in his or her Charlop-Atwell Scale of Motor Coordination total score from the pretest assessment to the posttest assessment.

Inter-rater reliability

The researcher and research assistant were familiar with the operational definitions of the two variables in the study. The research assistant was trained in how to observe and code the "Olympic" exercises and the Charlop-Atwell Scale of Motor Coordination. Both the researcher and the research assistant observed all four phases of the experiment: pretest, baseline, treatment, and posttest. If researcher and research assistant disagreed, they would watch the video recording of the session in question to resolve any inconsistencies. Inter-rater agreement was calculated by dividing the number of agreements by the sum of the observations (agreements plus disagreements) and multiplying the quotient by 100. Inter-rater agreement ranged between 90% and 100% for all participants in the current study.

Results

All four participants met the learning criterion for the "Olympic" exercise behaviors, which were the long jump, 50-foot dash, and relay race. All four participants also showed mastery (two consecutive attempts at 100% accuracy in the test phase) of at least one "Olympic" exercise. Two participants showed mastery of all three exercises (see *Figure 1*). In addition to the "Olympic" exercises, all four participants showed a significant increase in their Charlop-Atwell Scale of Motor Coordination scores (see *Table 2* and *Figures 3, 4, & 5*). A paired samples t-test was run to examine the means of total scores earned during the pretest and posttest assessments of the Charlop-Atwell Scale of Motor Coordination. There was a significant difference in the Charlop-Atwell Scale of Motor Coordination total scores for the pretest (M = 50.75, SD = 5.5) and the posttest (M = 63.00, SD = 4.40) conditions; t (3) = -4.27, p = 0.024 (see *Table 3* and *Figure 2*).

"Olympic" Exercises

Matt Performed at chance levels, 50% accuracy or less, for all three exercises during baseline. The first exercise he entered treatment for was the long jump. Matt met the learning criterion for the long jump quickly, only taking four attempts. He passed his first test for the long jump, performing two consecutive attempts at 100% accuracy. This meant that Matt had met the mastery criterion for the long jump and no longer needed to perform the exercise. Matt also met the mastery criterion for the relay race. Matt needed one booster session in order meet the mastery criterion for the exercise. After Matt mastered the relay race, he was left with only the 50-foot dash. Matt met the learning criterion for the 50-foot dash three times, but he did not meet the mastery criterion for the exercise. Matt received the maximum of three tests but was not able to show mastery of the dash exercise. Matt received three treatment sessions before he met the learning criterion for all three exercises

Brandon performed at chance levels during baseline for all exercises. The first exercise Brandon began treatment for was the relay race. Brandon reached the learning criterion for the exercise after his first two attempts. During the first test, Brandon did not reach the mastery criterion, so he received a booster session. Brandon again reached the learning criterion for the relay race during the booster session. Brandon met the mastery criterion for the relay race during the second test. After Brandon showed mastery of the relay race, he only attempted the long jump and 50-foot dash. The second exercise Brandon entered the treatment phase for was the dash. Brandon met the learning criterion for the dash after three attempts in the treatment condition. During the test condition, Brandon performed two consecutive attempts at 100% accuracy, meeting the mastery criterion for the dash. Brandon also met the mastery criterion for the last exercise he was exposed to, the long jump. The long jump was the exercise Brandon took the longest to meet the learning criterion for. He went through three full cycles of the teaching progression before he attempted his first test. In the first test, Brandon did not show mastery of the long jump, so he received a booster session. Brandon's first two attempts in the booster session were at 100% accuracy, and thus, he qualified for the test condition again. In the second long jump test, Brandon met the mastery criterion by performing two consecutive attempts at 100% accuracy. Brandon received three treatment sessions before he met the learning criterion for all three exercises.

Ally performed baseline attempts for all exercises at chance levels. The first exercise Ally entered treatment for was the 50-foot dash. Ally met the learning criterion for the dash after two cycles of the teaching progression. She met the mastery criterion for the dash during the first test condition. The long jump was the second exercise Ally entered treatment for. Ally went through one cycle of the treatment progression before she met the learning criterion for the long jump. During the first test, Ally did not perform two consecutive attempts at 100% accuracy. Because of this, Ally received her first booster session. Ally went through three complete cycles of the teaching progression before she met the learning criterion again. Ally's second long jump test was an improvement on the first, but again, she did not meet the mastery criterion. Ally entered the second booster session for the long jump after failing to meet the mastery criterion in the second test. In the second booster session, Ally experienced two complete cycles of the teaching progression before reaching the learning criterion for the third time. In the final long jump test, Ally performed one attempt at 75% accuracy and one attempt at 100% accuracy. Although Ally met the learning criterion for the long jump, she was not able to meet the mastery criterion. The relay race was the last "Olympic" exercise Ally entered treatment for. Like with the long jump, Ally met the learning criterion for the relay race, but she did not meet the mastery criterion. Ally received both boosters, but she was not able to meet the mastery criterion for the relay race. Ally received three treatment sessions before she met the learning criterion for all three exercises.

Leonardo was the last participant in the present study. He performed all baseline attempts at chance levels for each of the three “Olympic” exercises. Leonardo was the last participant to enter treatment for all of the “Olympic” exercises. This meant he spent the longest amount of time in baseline. This was because Leonardo was expected to take the longest to learn the exercises and meet the learning criterion, but he met the learning criterion for every exercise rather quickly. Leonardo was the fastest participant to reach the mastery criterion for every exercise. The first exercise Leonardo was exposed to was the long jump. Leonardo went through one full cycle of the teaching progression before meeting the learning criterion for the long jump. In the first test, Leonardo improved upon his baseline, but he did not show mastery of the exercise. Due to this, he was reintroduced to the treatment and received a booster session. He met the learning criterion again before completing one full cycle of the teaching progression. In the second long jump test, Leonardo performed two consecutive attempts at 100% accuracy, showing mastery of the long jump exercise. As with the other participants, Leonardo no longer attempted the long jump after he met the mastery criterion. The second exercise Leonardo experienced the teaching progression for was the 50-foot dash. Leonardo met the learning criterion for the dash before going through one full cycle of the teaching progression. Leonardo met the mastery criterion for the dash in the first test, meaning he did not receive any booster sessions and no longer needed to attempt the dash. The last exercise Leonardo was introduced into the treatment condition for was the relay race. Like with the dash, Leonardo met the learning criterion for the relay race before he endured one full cycle of the teaching progression. In the first relay race test, Leonardo improved upon his baseline scores, but he did not meet the mastery criterion. Because of this, he received a booster session. Leonardo again met the learning criterion for the relay race before experiencing one full cycle of the teaching progression. In the second relay race test, Leonardo performed two consecutive attempts at 100% accuracy, meeting the mastery criterion for the relay race. After he met the mastery criterion for the third exercise, Leonardo was done with the treatment portion of the present study. Leonardo received three treatment sessions before he met learning criterion for all three exercises.

Charlop-Atwell Scale of Motor Coordination

Matt had the second highest Charlop-Atwell Scale of Motor Coordination total score (a score of 55) in the pretest condition. He was the most fluid of all the participants, showing few strained, jerky movements. Matt was the only participant that was able to complete the scarf twirl, the most difficult item in the Charlop-Atwell Scale of Motor Coordination, in the pretest. Matt showed difficulty performing the two balance items in the Charlop-Atwell Scale of Motor-Coordination, the tiptoe balance and hopping on 1 foot, during the pretest assessment. His scores on these items improved drastically during the posttest assessment, and the increase in the two balance items comprised the majority of his score increase from the pretest condition to the posttest condition. The other three items, the jumping jacks, jump and about face, and prehistoric animal, saw little to no change from the pretest to posttest assessment, as Matt scored high on these items during the pretest assessment. Matt's posttest total score of 68 was the highest Charlop-Atwell Scale of Motor Coordination total score any participant obtained during the current study. Additionally, Matt's total score increase from the pretest assessment to the posttest assessment on the Charlop-Atwell Scale of Motor Coordination was the second highest of any participant during the current study. A more detailed breakdown of Matt's scores on the Charlop-Atwell Scale of Motor Coordination can be found in *Figure 6*.

Brandon had the highest pretest Charlop-Atwell Scale of Motor Coordination total score (a score of 56). Brandon was quite athletic, but his movements were strained and jerky through most of the pretest assessment. Because of this, his subjective scores suffered. Brandon was not able to complete the scarf twirl as modeled by the researcher during the pretest Charlop-Atwell assessment, but during the posttest assessment, he was able to perform it correctly. This pattern was also seen with the jumping jacks item. Brandon did not receive full points for his jumping jacks during the pretest assessment, but he did receive maximum objective points for the item during the posttest assessment. These two improvements accounted for the majority of Brandon's increase from the pretest to posttest scores. Brandon performed well on the balancing items during both the pretest and posttest assessments. The last two items, the prehistoric animal and the jump and about face, were performed below maximum point value but saw no improvement from pretest to posttest. Although Brandon earned the third highest posttest score on the Charlop-Atwell Scale of Motor Coordination, his improvement from the pretest assessment to the posttest assessment was the smallest of the four participants in the current study, at only a five point increase. A more detailed breakdown of Brandon's scores on the Charlop-Atwell Scale of Motor Coordination can be found in *Figure 7*.

Ally, and the last participant, had the lowest pretest scores (scores of 46) on the Charlop-Atwell Scale of Motor Coordination. Like Brandon, Ally was athletic, but her movements were jerky and stiff. Ally performed well on the jumping jacks and jump and about face items during both the pretest and posttest assessments, earning maximum points for both items. Her scores on the prehistoric animal item were respectable during the pretest assessment, but she was able to improve them during the posttest assessment. The items Ally struggled with were the scarf twirl, hopping on 1 foot, and tiptoe balance items. Ally's score on the scarf twirl increased from the pretest assessment to the posttest assessment, but she was still not able to earn maximum points on the item. Ally showed drastic improvement on the hopping on 1 foot item in the posttest assessment. She was not able to perform the item at all during the pretest assessment, earning zero objective points for the item, but she earned the maximum number of objective points during the posttest assessment, meaning she was able to perform the item as modeled by the researcher. This increase of six points accounted for the majority of her total score increase from the pretest assessment to the posttest assessment. Ally's score on the tiptoe balance item did not improve from the pretest assessment to the posttest assessment. She struggled balancing on her tiptoes just as much during the posttest assessment as she did during the pretest assessment. Ally's increase in total score on the Charlop-Atwell Scale of Motor Coordination from the pretest assessment to the posttest assessment was the third highest increase of any of the participants during the present study. A more detailed breakdown of Ally's scores on the Charlop-Atwell Scale of Motor Coordination can be found in *Figure 8.*

Leonardo was the last participant in the current study, and like Ally, he scored a 46 on the pretest assessment of the Charlop-Atwell Scale of Motor Coordination. Leonardo was a good athlete, and was rather fluid in his movements, but he struggled in performing the exercises as modeled by the researcher. In the pretest assessment, Leonardo earned maximum points for the jumping jacks, jump and about face, and hopping on 1 foot items, but he struggled with the prehistoric animal, scarf twirl, and tiptoe balance items. Leonardo did not earn any objective points for the prehistoric animal item during the pretest assessment, but in the posttest assessment, he received eight points. This accounted for the majority of his nineteen point total score increase on the Charlop-Atwell Scale of Motor Coordination from the pretest assessment to the posttest assessment. Similar to the prehistoric animal item, Leonardo could not perform the scarf twirl item as operationalized by the Charlop-Atwell Scale of Motor Coordination during the pretest assessment, but in the posttest assessment, he earned the maximum number of objective points for the item. Leonardo improved his score on the tiptoe balance item from the pretest to the posttest assessment, but he did not receive the maximum number of objective points for the item in either assessment. Leonardo improved or equaled the number of objective and subjective points he earned on every item from the pretest to the posttest assessment, which led to the largest increase in total score on the Charlop-Atwell Scale of Motor Coordination from the pretest assessment to the posttest assessment by any participant in the current study. A more detailed breakdown of Leonardo's scores on the Charlop-Atwell Scale of Motor Coordination can be found in *Figure 9*.

Discussion

The results of the present study indicated that the children learned to perform the "Olympic" exercises correctly as if they were competing in a track meet, as well as increased their gross motor coordination, as measured by the Charlop-Atwell Scale of Motor Coordination. All of the children reached the learning criterion (two consecutive attempts at 100% accuracy) for the "Olympic" exercises. All of the children also met the mastery criterion (two consecutive attempts at 100% accuracy at baseline procedure) for at least one of the "Olympic" exercises, with two children meeting the mastery criterion for all three of the "Olympic" exercises. All four children displayed rapid acquisition of the targeted skills, meeting the learning criterion for each exercise after one treatment session, where they were exposed to the teaching progression. All four children also met the mastery criterion for at least one "Olympic" exercise after one treatment session. Two of the four children met the mastery criterion for all three "Olympic" exercises after one to four treatment sessions. These children demonstrated chance levels of accuracy (50% or less) during baseline. Ally and Matt were the two children who did not meet the mastery criterion for all three of the "Olympic" exercises. It is difficult to pinpoint exact reasons as to why they did not meet the mastery criterion for all of the "Olympic" exercises, but a possible reason was motivation. Ally and Matt both had difficulty running the entire distance of the exercises (25 feet for the long jump and 50 feet for the dash and relay race). This likely could be contributed to the fact that the positive reinforcers the researcher used during treatment to reinforce Matt and Ally's correct attempts quickly became undesirable. At the start of the current study, Matt preferred cookies and dinosaur related items, but as treatment progressed, Matt showed disinterest in the cookies and dinosaurs. When asked if he wanted a cookie or a dinosaur sticker after a correct attempt, he would reply, “No thanks, I don’t want them.” This made it difficult for the researcher to keep Matt interested in performing the “Olympic” activities as modeled. The same was true for Ally. At the beginning of the current study, Ally preferred potato chips, but when she was offered a potato chip after a correct attempt, she declined the chip. If the researcher was able to find another preferred reinforcer for Ally and Matt before they reached the two booster limit of the present study, they likely would have met the mastery criterion for all three “Olympic” exercises, like the other two participants.

Previous physical exercise research has demonstrated that modeling (physical, video, and picture card) led to successfully teaching children with ASD how to perform a physical act, and this study is no exception (Luyben et al., 1986; Matsushita & Sonoyama, 2010; Rogers, Hemmeter, & Wolery, 2010). As mentioned earlier, all children demonstrated that they learned all three “Olympic” exercises, and they did so faster than in previous studies (Luyben et al., 1986; Matsushita & Sonoyama, 2010; Rogers, Hemmeter, & Wolery, 2010). This is an important finding because it shows the teaching progression, physical modeling, focused feedback, and focused modeling, utilized in the present study not only successfully taught the exercise behavior, but also led to faster learning. The ability to focus on what each individual child was struggling with allowed the researcher to emphasize that part of the exercise and repeat and reteach it. This way, the child spent more time working on what he or she needed to work on, not continually repeating the parts of the exercise he or she already knew and performed well.

The dash was expected to be the easiest "Olympic" exercise for the children to perform, and for the most part, it was. All of the participants, with the exception of Matt, met the learning and mastery criterion for the dash. All the other participants did not require a booster session for the dash, as they met the mastery criterion for the exercise during the first test phase. Matt went through both boosters for the dash and did not meet the mastery criterion. This is likely due to the fact that it was the last exercise Matt entered the treatment phase for, and by the time he reached the first booster, the cookies and dinosaur items the researcher was using to reinforce correct attempts were no longer preferred, as mentioned earlier. Because of this, the researcher struggled in motivating Matt to put full effort and focus into performing the dash exercise correctly (as operationally defined).

With the exception of Matt, the long jump took the most time for the children to meet the learning and mastery criterion for. Matt was again the outlier and met the learning and mastery criterion for the long jump faster than any other participant in the present study. This was likely due to the fact that Matt was the most fluid and natural athlete in the present study, and the long jump was the first exercise he entered treatment for. Matt had not lost motivation at this point and performed equal to his potential. The other three participants, Ally, Brandon, and Leonardo, either did not master the long jump or needed at least one booster to do so. Ally, Brandon, and Leonardo likely had difficulty with the long jump due to the fact that it combined two different movements into one exercise. The children had to transition from running to jumping without slowing down. The majority of the modeling for the long jump was spent on the transition from running to jumping.

The relay race was the exercise the researcher expected the children to have the most difficulty with, due to the action of handing the baton to the outstretched hand of the research assistant, but this was not the case. All of the children, with the exception of Ally, met the mastery criterion for the relay race. As discussed earlier, Ally's failure to meet the mastery criterion for the relay race was likely due to the researcher not being able to motivate her with the potato chip reinforcers. With that being said, Ally still met the learning criterion for the relay race three times, showing the effectiveness of the teaching progression used in the present study. It was important to note that the relay race and 50-foot dash were similar exercises, with the only difference being the fine motor task of handing the baton to the outstretched hand of the research assistant at the end of the 50-foot run. This could have been an explanation as to why the children in the study did not struggle with the relay race as the researcher expected them to.

The effectiveness of the teaching progression used in the present study was important, as it provided evidence that modeling the entire exercise in an unfocused manner time and time again, although shown to be effective, was not the most efficient or beneficial way of teaching things to children with ASD.

The present study also provides evidence of physical exercise improving gross motor coordination in children with ASD. All four children showed an increase in their gross motor coordination scores from the pretest assessment to the posttest assessment. This was an important finding, as little research has examined the link between physical exercise and gross motor coordination in children with ASD. Leonardo, the child with the largest difference in pretest to posttest scores on the Charlop-Atwell Scale of Motor Coordination showed an increase in three of the four items that participants had the most difficulty with in the present study. The prehistoric animal and scarf twirl were the two most difficult exercises for Leonardo to complete during the pretest assessment of the Charlop-Atwell Scale of Motor Coordination. In the posttest assessment, he performed the objective portion of the scarf twirl item, an exercise where the participant held a scarf in a locked arm held perpendicular to the ground and spun while walking a straight line for twelve feet, exactly as the researcher had modeled. This was impressive, as Leonardo was not able to spin in circles with his arm held out to his side, let alone walk and spin at the same time, during the pretest assessment. The same was evident for the prehistoric animal item, an exercise where the child got in a push up type position and walked on command, moving only one hand or foot at a time. Leonardo was not able to complete the exercise at all during the pretest assessment, but in the posttest assessment, Leonardo was able to do the exercise after two attempts. This phenomena was seen across all four children, with Leonardo having the largest increase in gross motor coordination and Brandon having the smallest. This is important because it showed the treatment (teaching progression) used in the current study not only taught the children the "Olympic" exercises, but the act of learning how to perform the exercises correctly improved the childrens' gross motor coordination. The present study provided an incentive to getting children with ASD outside and active by providing evidence physical exercise can be used as a therapy technique to improve children with ASD's gross motor coordination.

Limitations and Future Directions

There were several limitations to the current study. Although the teaching progression was successful in teaching the children how to perform the three "Olympic" exercises as operationally defined, the three "Olympic" exercises were not overly complex. Because of this, it was proposed that future studies examine how effective the teaching progression is in teaching more complex exercises, such as weight lifting movements and martial arts, as well as things outside of the physical exercise world, such as cooking or other household tasks. In addition to making the exercises more difficult for the teaching progression, future research should make the exercises more difficult for the participants. Using physiological measures such as heart monitors to measure how more strenuous exercises affect the health and gross motor coordination of children with ASD is an important next step. It would also be interesting to see how long the learning effects of the teaching progression used in the present study lasted. Because the current study had time constraints that eliminated the possibility of a true follow-up, it would be interesting to see how long the participants who met the learning criterion for the three "Olympic" exercises continued to perform the exercises at above chance levels (above 50%) with no teaching progression present. This would provide insight into the long term effects of the focused, individualized modeling procedure. Finally, the current study did not measure stereotypy while the participants were performing the "Olympic" exercises. Examining how physical exercise affects stereotypy could provide answers as to how to reduce stereotypy in children with ASD.

Conclusion

In conclusion, the teaching progression used in the present study showed to be effective in teaching children three "Olympic" exercises in a more efficient manner than previous teaching progressions had done. Additionally, the learning of how to perform the "Olympic" exercises, as well as actually performing the exercises, led to an increase in gross motor coordination in four children with ASD. This provided a push to get children with ASD physically active, as it can both improve their health and be used as a therapy technique to improve motor function deficits.

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Tables

Table 1

Demographic Information for the Four Participants in the Current Study

Name	Age (Years)	Gender	Ethnicity	CARS-II
Matt	12	Male	Italian-American	Severe
Ally	8	Female	Korean-American	Severe
Leonardo	15	Male	Mexican-American	Severe
Brandon	9	Male	European American	Severe

Note: Age listed is chronological age at the beginning of the pretest phase of the current study.

Tables

Table 2

Charlop-Atwell Scale of Motor Coordination Total Scores

Name	Pretest Total Score	Posttest Total Score
Matt	55	68
Brandon	56	61
Ally	46	58
Leonardo	46	65

Note. All participants received the Charlop-Atwell Scale of Motor Coordination as outlined in the scale directions.

Tables

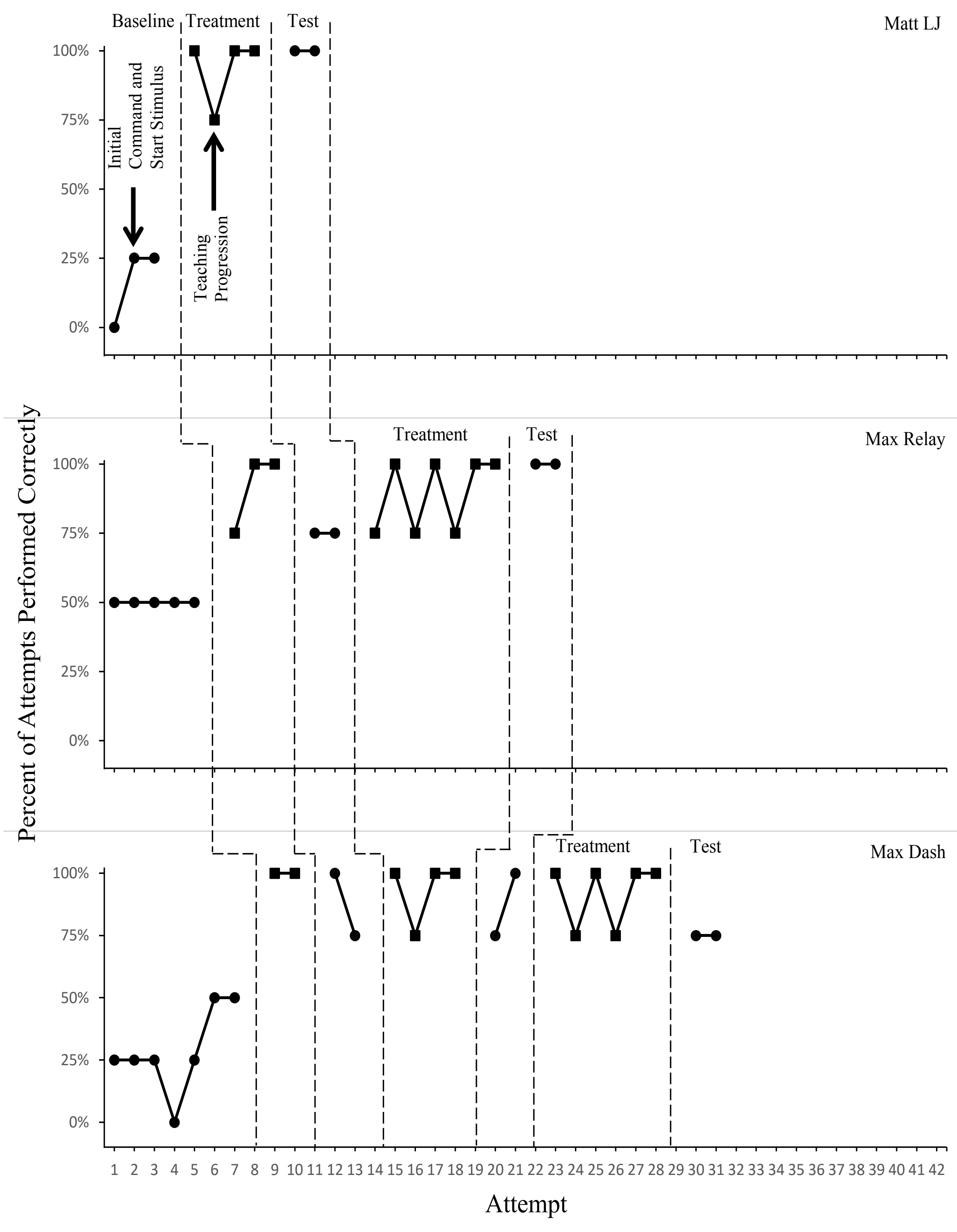
Table 3

Charlop-Atwell Scale of Motor Coordination Pretest and Posttest Means

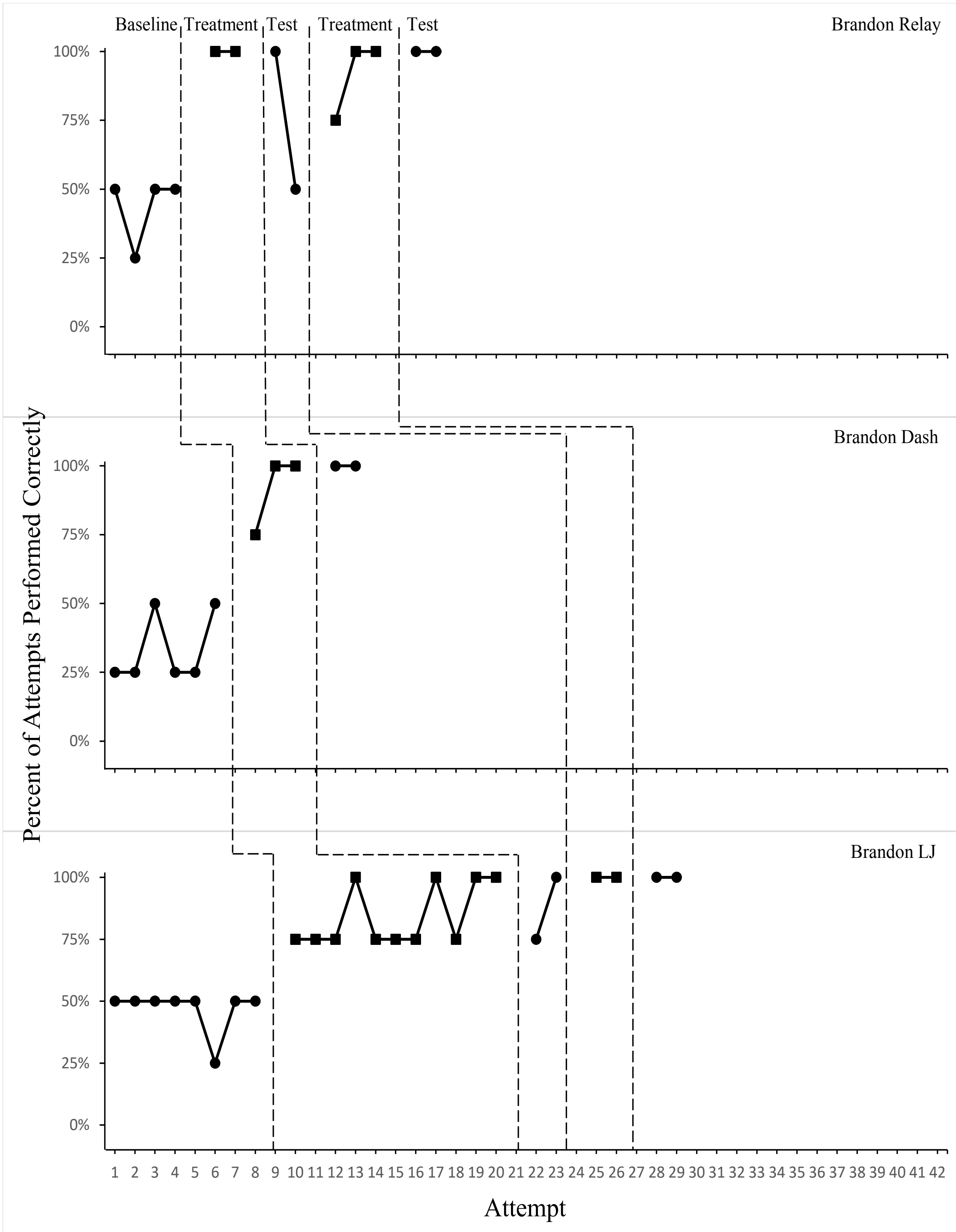
	Mean	*t*	*df*
Pretest	50.75 (5.50)	-4.27**	3.00
Posttest	63.00 (4.40)		

Note. Standard deviation is in parenthesis under the mean. ***$p \leq 0.05$. N= 4

Figures


Baseline
Treatment
Test
Matt LJ
Initial Command and Start Stimulus
Teaching Progression
Treatment
Test
Max Relay
Treatment
Test
Max Dash
100%
75%
50%
25%
0%
Percent of Attempts Performed Correctly
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Attempt

Figures


Baseline
Treatment
Test
Treatment
Test
Brandon Relay
Brandon Dash
Brandon LJ
100%
75%
50%
25%
0%
Percent of Attempts Performed Correctly
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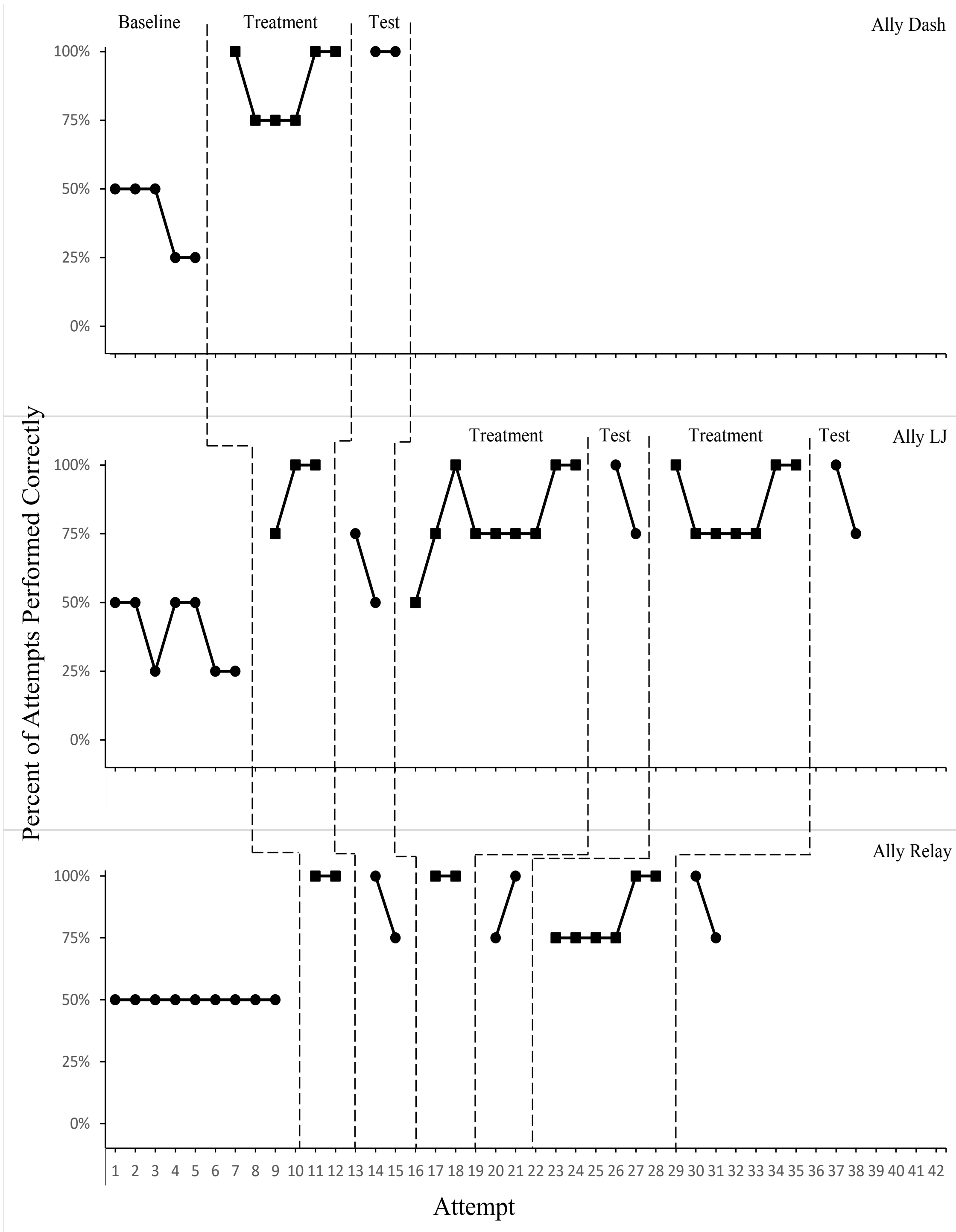
Attempt

Figures


Baseline
Treatment
Test
Ally Dash
Ally LJ
Ally Relay
100%
75%
50%
25%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Percent of Attempts Performed Correctly
Attempt

Figures

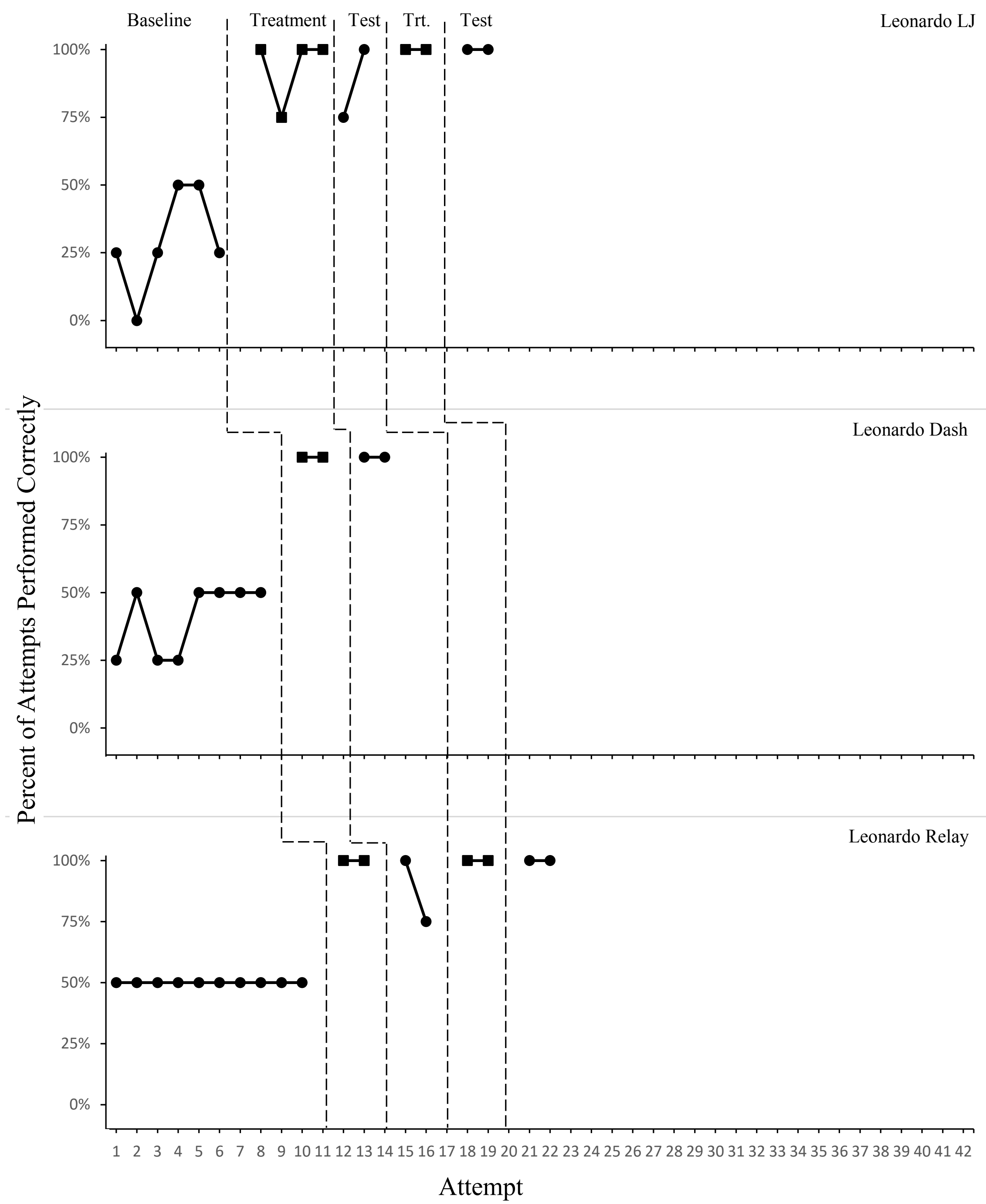


Figure 1. Multiple baseline design across participants and within participants across activities analyzing learned "Olympic" exercises

Figures

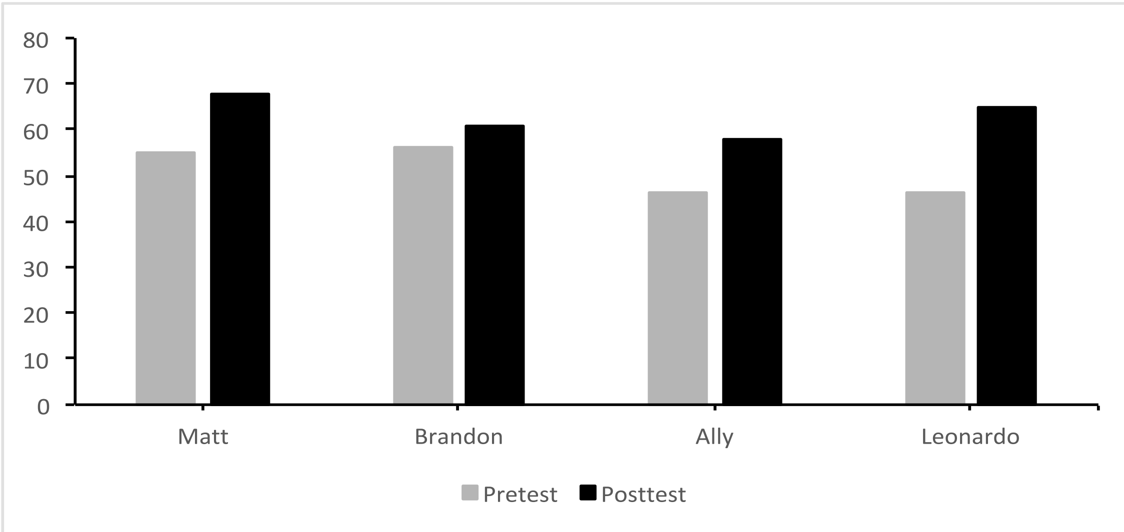


Figure 2. Charlop-Atwell Scale of Motor Coordination total scores

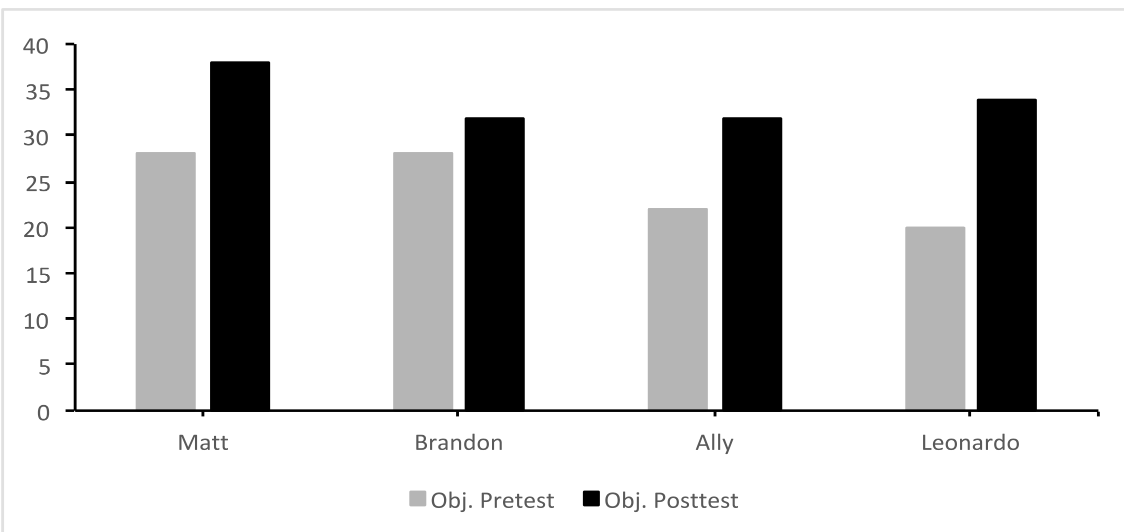


Figure 3. Charlop-Atwell Scale of Motor Coordination objective scores

Figures

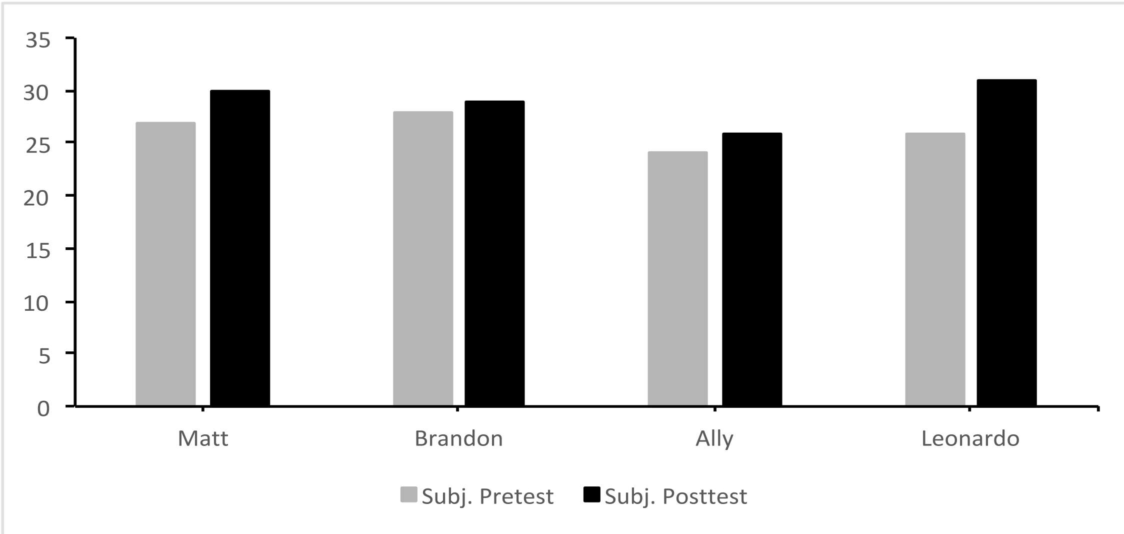


Figure 4. Charlop-Atwell Scale of Motor Coordination subjective scores

Figures

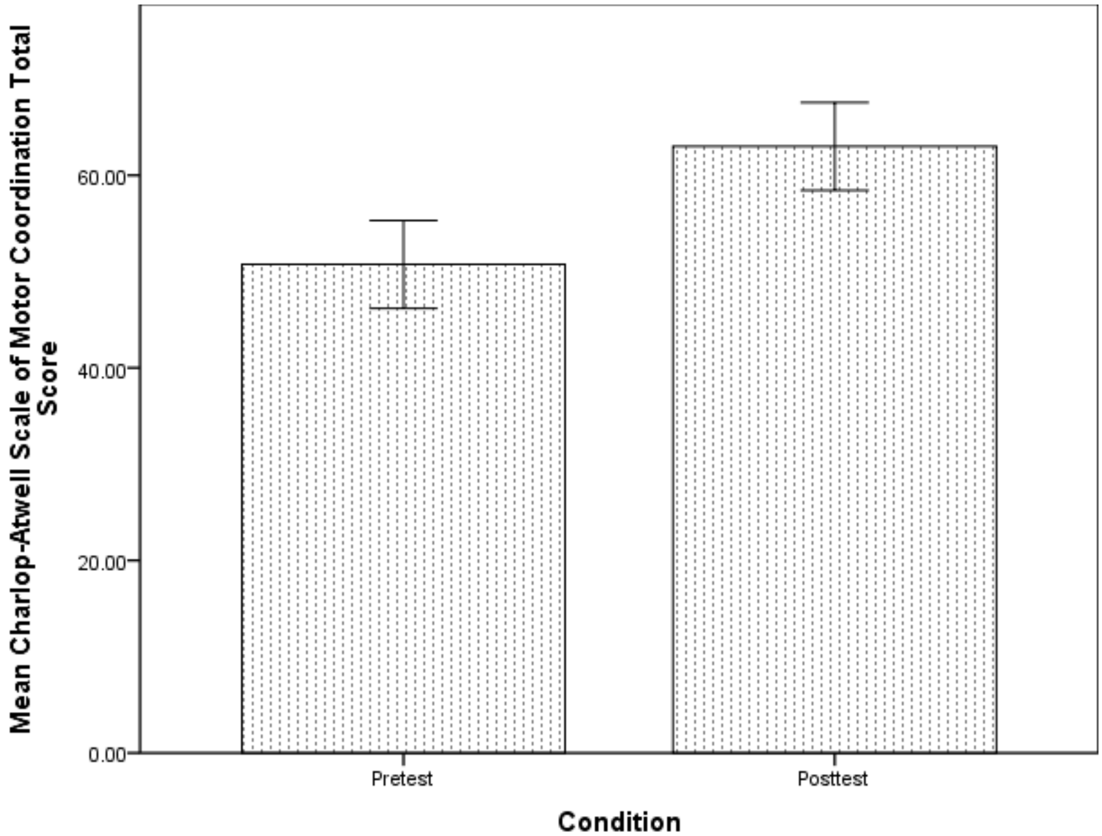


Figure 5. Charlop-Atwell Scale of Motor Coordination pretest and posttest means

Figures

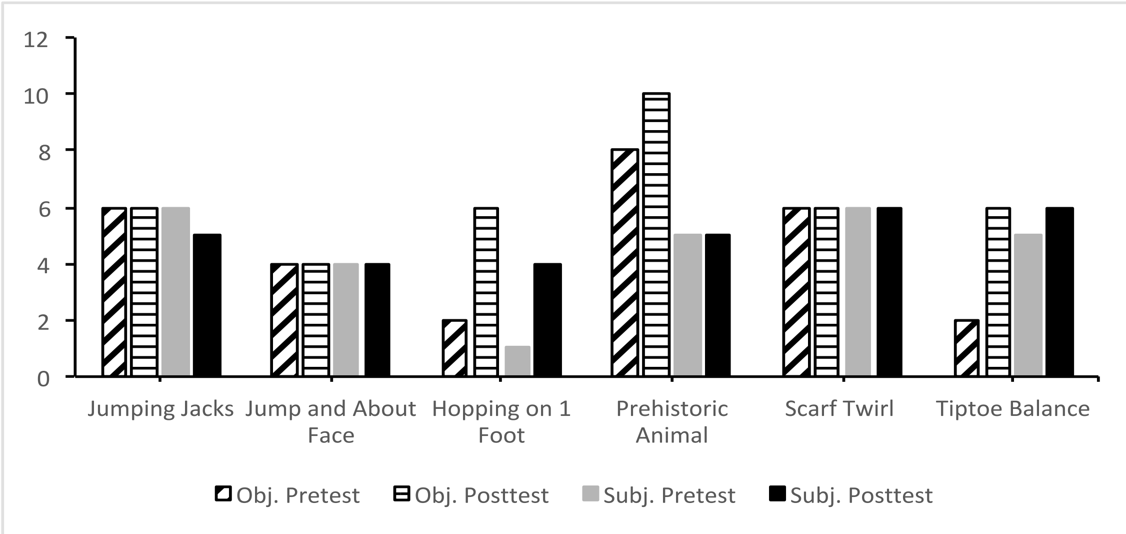


Figure 6. Charlop-Atwell Scale of Motor Coordination itemized breakdown for Matt

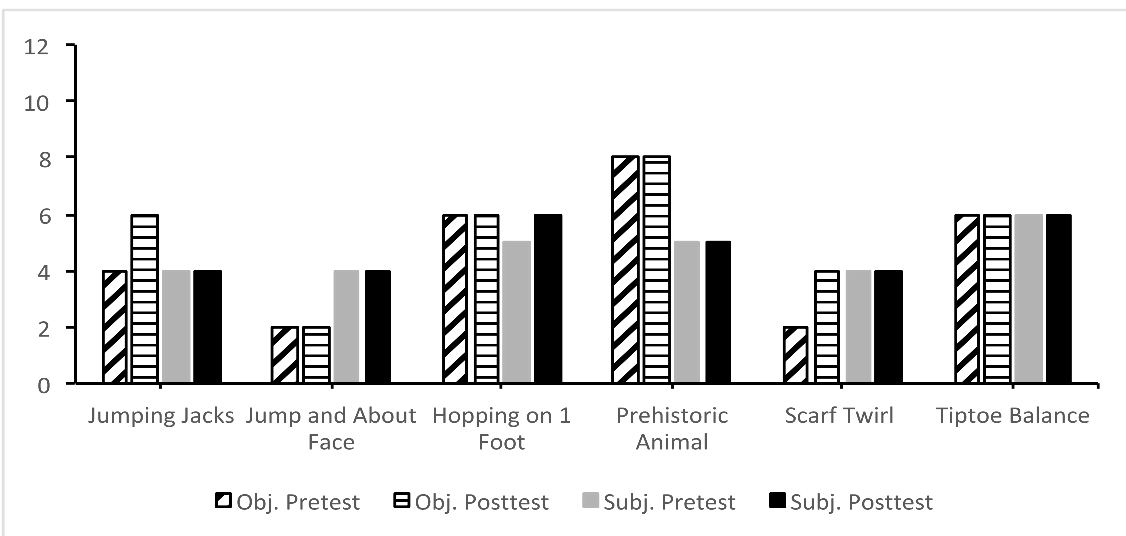


Figure 7. Charlop-Atwell Scale of Motor Coordination itemized breakdown for Brandon

Figures

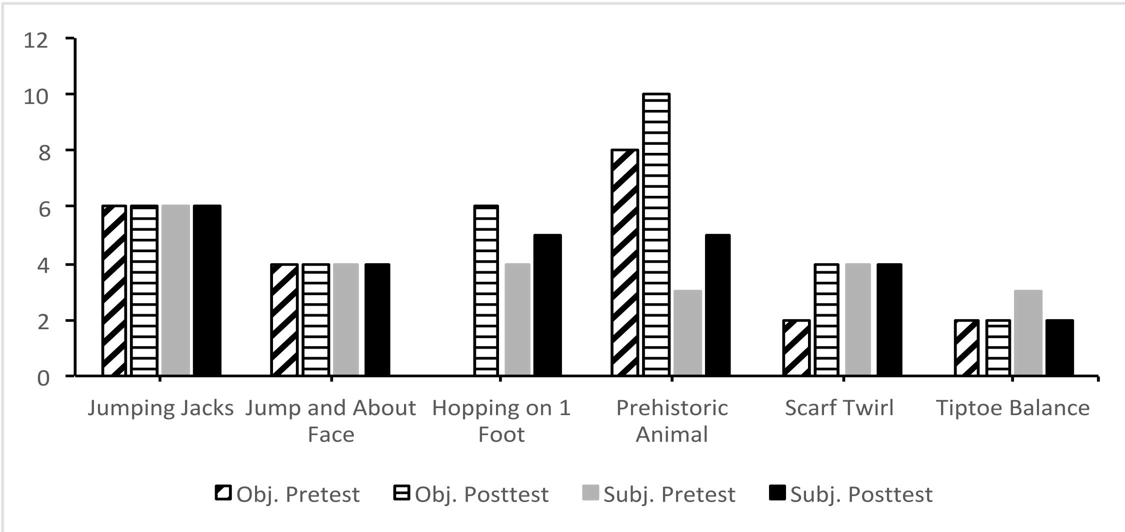


Figure 8. Charlop-Atwell Scale of Motor Coordination itemized breakdown for Ally

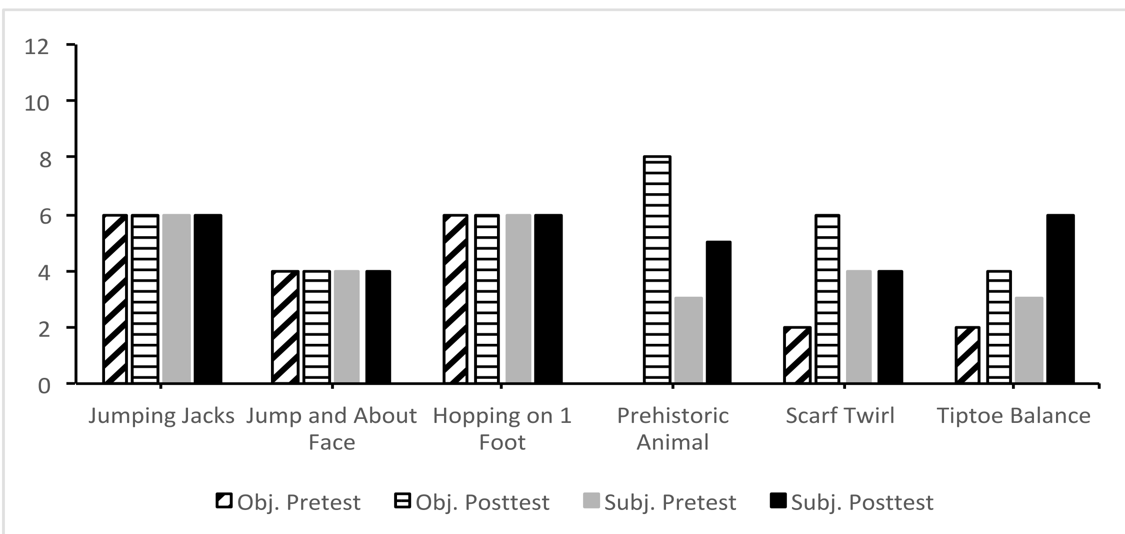


Figure 9. Charlop-Atwell Scale of Motor Coordination itemized breakdown for Leonardo

Appendix A. Long jump coding sheet

Body Control Coding Sheet

Name of Coder: Child Initials: Date:

Session Number: Phase:

Trial	Stays w/in the Lane	Runs to the Line	Starts Upon Stimulus	Jumps Minimum 2.5 feet

Appendix B. 50-Foot dash coding sheet

Body Control Coding Sheet

Name of Coder: Child Initials: Date:

Session Number: Phase:

Trial	Stays w/in the Lane	Runs the Entire Distance	Starts Upon Stimulus	Finishes Through the Cones

Appendix C. Relay race coding sheet

Body Control Coding Sheet

Name of Coder: Child Initials: Date:

Session Number: Phase:

Trial	Stays w/in the Lane	Runs the Entire Distance	Starts Upon Stimulus	Hands Baton to Hand