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Effects of Yoga on the Motor Skills of a Ten-Year-Old Male with Autism Spectrum Disorder

Amber Schmitt

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Effects of Yoga on the Motor Skills of a Ten-Year-Old Male with Autism Spectrum Disorder

Abstract
Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that is typically diagnosed in childhood due to the presence of atypical development, social interactions, and repetitive stereotypical patterns of behavior. The purpose of the present study was to examine the effects of a yoga intervention on a ten-year-old male diagnosed with ASD. It was hypothesized that the yoga intervention on select instructed poses would increase both pose duration and pose performance and that the results would generalize to longer pose duration and better pose performance on non-instructed poses. Pre-intervention assessments of motor functioning were administered, including the Movement ABC, BOT-2, TGMD, and video coding of yoga-related performance. Baseline and intervention sessions included 10 beginner yoga poses. Pose duration in instructed and non-instructed poses was significantly and positively affected. Instructed poses showed a positive increase in pose performance, but the results did not generalize to non-instructed pose performance.

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EFFECTS OF A YOGA INTERVENTION ON THE MOTOR SKILLS OF A TEN-YEAR-OLD MALE WITH AUTISM SPECTRUM DISORDER

By

Amber Schmitt

A Senior Thesis Submitted to the Eastern Michigan University Honors College in Partial Fulfilment of the Requirements for Graduation with Departmental Honors in Neuroscience

Approved at Ypsilanti, Michigan on November 27, 2017

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EFFECT OF YOGA ON MOTOR SKILLS

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Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that is typically diagnosed in childhood due to the presence of atypical development, social interactions, and repetitive stereotypical patterns of behavior. The purpose of the present study was to examine the effects of a yoga intervention on a ten-year-old male diagnosed with ASD. It was hypothesized that the yoga intervention on select instructed poses would increase both pose duration and pose performance and that the results would generalize to longer pose duration and better pose performance on non-instructed poses. Pre-intervention assessments of motor functioning were administered, including the Movement ABC, BOT-2, TGMD, and video coding of yoga-related performance. Baseline and intervention sessions included 10 beginner yoga poses. Pose duration in instructed and non-instructed poses was significantly and positively affected. Instructed poses showed a positive increase in pose performance, but the results did not generalize to non-instructed pose performance.

Keywords: Yoga, Motor Skills, Autism Spectrum Disorder, Intervention
Introduction

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental disorder characterized by atypical social interactions, communication deficits, and repetitive and stereotyped behaviors (American Psychiatric Association [APA], 2013). ASD is diagnosed in early childhood when parents and caregivers notice developmental delays or atypical features such as failure to respond to name, limited imaginative play, and reduced interest in others (American Psychiatric Association, 2016; Center for Disease Control, 2016). The prevalence of ASD has increased over two-fold since 2000. In 2000 it was estimated that 1 in 150 children had ASD, today it is estimated that 1 in 68 children now has ASD. It occurs in all races, ethnicities, and socioeconomic groups, and is 4.5 times more common in boys than in girls (Center for Disease Control, 2016). The Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-V) redefined Autism Spectrum Disorder by combining Asperger’s Syndrome and Pervasive Developmental Disorder-not otherwise specified (PDD-NOS) under one diagnostic label, instead of using the separate diagnostic labels listed in the DSM-IV. Criteria for diagnosis include two categories: persistent deficits in social communication and interaction, and restricted repetitive patterns of behavior. Social communication and interaction specifically include social-emotional reciprocity, nonverbal communicative behaviors, and developing, maintaining, and understanding social relationships. Repetitive patterns of behavior include stereotyped or repetitive motor movements, use of objects, or speech, inflexible adherence to routines, highly restricted interests, and hyper- or hypo-reactivity to sensory input (5th ed.; DSM-5; APA, 2013). Though repetitive motor movements are a category of the diagnostic criteria, motor skill deficits are not. Many individuals diagnosed with ASD display a wide variety of motor skill impairments and these deficits are of interest to researchers and clinicians who work with this population.
Motor Skills

Motor skill acquisition begins prior to the onset of language use and includes tasks such as sitting up, rolling over, playing with toys, and eventually, standing and walking. Teitlebaum, Teitlebaum, Nye, Fryman, and Maurer (1998) hypothesized that symptoms of ASD could be seen in motor movements of infants—years before a formal diagnosis is typically given. To test this hypothesis, they retrospectively examined home videos of 32 infant’s motor movements including lying down, crawling, and sitting. 17 of those infants were later diagnosed with ASD and 15 infants were typically developing. They found that every child later diagnosed with ASD displayed unusual patterns of motor skill development early in life. Using retrospective video analysis, they determined the presence of ASD symptoms within the first few months of life in contrast with the average age of diagnosis around 3 years of age. Similarly, Baranek (1999) hypothesized that sensorimotor measures could be used as early predictors of ASD during infancy. Home videos of children 9-12 months old were used to retrospectively investigate developmental differences in typically developing children and those later diagnosed with ASD. The author examined affect, response to name, looking at persons or objects, gaze aversion, motor stereotypes, social touch, and sensory modulation. The author concluded that children who were later diagnosed with ASD could be correctly identified as having ASD 93.7% of the time as early as 9 months old. It was suggested that motor movements could be used along with other social markers to identify ASD earlier.

As individuals with ASD develop during early childhood, the motor impairments become more apparent as motor demands increase. Vilensky, Damasio, and Maurer (1981) examined the symmetry and gait of 21 toddlers with ASD compared to 15 typically developing toddlers. It was found that toddlers with ASD displayed reduced stride length, increased stance times, and
abnormal hip and foot movements while walking. The authors noted that ASD may be associated with dysfunction of the motor pathway system that is comprised of several structures including the basal ganglia. Esposito, Venuti, Apicella and Muratori (2011) hypothesized that movement could be used as an early predictor of autism. They also used home videos of 55 children under the age of two to inspect the gait while walking and symmetry of the children diagnosed with ASD versus children who were typically developing. Their results indicated consistencies with Teitlebaum et al., (1999) in that the children with ASD displayed increased asymmetry when walking compared to typically developing children. They concluded that because many toddlers later diagnosed with ASD display motor abnormalities prior to the age of 18 months, atypical motor development could be a diagnostic marker for ASD. Other studies have examined gait in toddlers and have recorded significant differences in gait patterns (Calhoun, Longworth & Chester, 2011), impaired postural control (Fournier et al., 2010), and decreased stride velocity and increased step width in children with ASD (Lim, O'Sullivan, Choi & Kim, 2016).

Throughout development children perform various tasks and learn how to repeat the behavior of others. The learning sequence for motor tasks can be implicit or explicit (Gentile, 1998). Implicit learning, first coined by Arthur Reber to describe how one builds intuitive knowledge, occurs without conscious awareness of having learned anything (Reber, 1989). Motor learning is explicit when the learning is conscious and there is an awareness of what was learned. There are contradictory findings in the literature regarding the motor learning deficits of children with ASD. Some authors argue that implicit learning in children with ASD is unimpaired and does not differ from that of typically developing children (Izadi-Najafabadi, Mirzakhani-Araghi, Miri-Lavasani, Nejati & Pashazadeh-Azari, 2015; Travers, Klinger, Mussey
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& Klinger, 2010). Others propose that implicit learning is significantly impaired in children with ASD (Bo, Lee, Colbert, & Shen, 2016; Mostofsky, Goldberg, Landa, & Denckla, 2000). Furthermore, some authors suggest that impairments in implicit learning can be compensated for by recruiting explicit processes (Klinger, Klinger & Pohlig, 2007). Impairments in motor learning impacts motor skill acquisition and may also be associated with reduced communication and social development (Gernsbacher, Sauer, Geye, Schweigert & Goldsmith, 2008; Hirata et al., 2015; Mody et al., 2017).

Children with ASD and related diagnoses show increased engagement in sedentary activities with age (MacDonald, Esposito & Ulrich, 2011; Pan & Frey, 2006). Because increased sedentary behavior is correlated with decreased interactions with motor and socially proficient peers, deficits in motor learning not only affect motor skill development, but may subsequently impact communication and social skills as well. Children with ASD may engage in fewer interactions with their peers, display greater motor skill deficits, and poorer overall health (Pan, Tsia, Chu, Sung, & Ma, 2016). Both motor skills and social interaction may be improved by increasing physical activity which may provide more opportunities for interaction with peers (Srinivasan, Pescatello & Bhat, 2014).

Many studies indicate that motor delays are a core symptom of ASD. Green et al. (2009) reported that over 75% of children diagnosed with ASD have significant motor impairments. However, motor delays are not included as a criterion for the ASD diagnosis. There is a clear need for interventions to improve the motor deficits associated with ASD which may be associated with reduced physical activity and opportunities for social interaction.
Treatments and Interventions

Currently, there is no known cause or cure for ASD. However, there are some available interventions for the deficits associated with ASD which include various complementary and alternative medicine (CAM) treatments, as well as exercise. Some common CAMs are gluten-free diets, omega-3 supplements, music therapy, hippotherapy and hydrotherapy (Ajzenman, Standeven, & Shurtleff, 2013; Lofthouse, Hendren, Hurt, Arnold, & Butter, 2012; Yilmaz, Yanarda, Birkan, & Bumin, 2004). These CAM treatments, however, have limited empirically based research which make them controversial (O’Reilly, Cook, & Karim, 2012). While CAM treatments are debated and still not agreed upon in the medical community, other researchers have examined physical activity as a possible treatment option. A few studies have found positive effects of physical exercise on children with ASD. Changes were indicated in reduced maladaptive behavior and increases in adaptive behavior (Lang et al., 2010; Magnusson, Cobham, & McLeod, 2012). Currently, the most empirically supported treatment for ASD is Applied Behavior Analysis (ABA).

ABA has been used for many decades and is still used today in treatment for mental illness, developmental disabilities, and learning disabilities (Maine Administrators of Services for Children with Disabilities [MADSEC], 2000). ABA is an empirical approach that uses the principles of learning to improve behavior and systematically evaluate the effects of interventions on behavior (Baer, Wolf & Risley, 1968; Cooper, Heron, Heward, 2014). ABA aims to benefit persons with ASD in six ways: to increase adaptive behavior, teach new skills, maintain behavior, generalize behavior from one situation to another, restrict conditions in which interfering behavior occurs, and reduce interfering behavior (MADSEC, 2000). ABA has been shown to have significant positive impacts on educational and intellectual functioning in young
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children with ASD (Reed, Osborne & Corness, 2011). ABA principles can be applied to a wide variety of behavior and have more recently been applied to motor skills. Alstot, Kang, & Alstot (2013) conducted a meta-analysis which indicated that the use of ABA had a large, positive effect on motor skill acquisition and that when ABA is utilized, motor skill acquisition is likely to improve.

In addition to ABA, another empirically based treatment is the Treatment and Education of Autistic and Communication Handicapped Children (TEACCH) program. This was developed in 1972 by Eric Schopler to make activities clearer and easier for children with ASD and other disabilities to perform (University of North Carolina School of Medicine, 2016). The TEACCH program uses different methods of structuring the environment and activities including same locations and furniture placement during activities, graduated guidance, and use of visual activity schedules (Mesibov & Shea, 2010). This program allows for organization of the environment and the provision of meaningful visual information as a model instead of relying on verbal instruction (Mesibov, 1997). Bennett, Reichow, and Wolery (2011) aimed to evaluate structured teaching and its effect on engagement, task completion, and stereotypic behaviors. They found that when using structured teaching techniques such as the TEACCH program in a study of three preschool aged children with developmental disorders, participants displayed greater engagement in the activity, increased task completion, and reduced stereotypic behavior. Additionally, Pan (2011) used structured teaching techniques like picture schedules and organizing the surroundings to teach children with ASD various aquatic skills. It was found that physical fitness in children with ASD was positively impacted and that the children had significant improvements in motor skills like strength and endurance.
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Yoga

The word yoga means “unite” in Sanskrit and yoga practice aims to unite body, mind, spirit, and breath, allowing individuals to turn their attention to inward processes (Fouladbakhsh, 2011; Lee, 2014). A wide array of benefits from yoga practice include stress reduction, shortened labor duration in pregnant women, improved strength, reduced pain perception, increased flexibility, improved quality of sleep, and better immune system functioning (Diamond, 2012). The American Osteopathic Association (2017) reported that regular yoga practice can increase body awareness, relax the mind, and improve attention and concentration. Bubela and Gaylord (2014) reported improved balance, strength, and flexibility in typically developing preschool aged children following a 6-week yoga intervention. Similarly, Folleto, Pereira, & Valentini (2016) investigated the effects of yoga in physical education classes on motor skills and social behavior in children six to eight years old. They implemented a 45-minute yoga program twice weekly for 12 weeks to improve motor skills, physical capabilities, and promote positive behavior in a group of 16 children. One of the children in the study was diagnosed with ASD while the rest were typically developing. The authors administered the Bruininks-Oseretsky Test of Motor Proficiency - Second Edition (BOT-2) (Bruininks & Bruininks, 2005) to test the participants’ motor abilities prior to and following the yoga intervention. They reported that the scores on tasks such as balancing on a balance beam, walking on a line, and balancing with eyes closed improved in post-intervention testing. In addition to those motor skills, running speed, agility, strength, and flexibility also improved. Other studies have found improvements in upper body reaction time and coordination in typically developing children after engaging in a yoga intervention (Telles, Singh, Bhardwaj, Kumar, Balkrishna, 2013).

Although research is limited on yoga interventions with children and most of the
available literature was conducted on typically developing children, a few recent studies have examined the effects of yoga in children with ASD. Scroggins, Litchke, & Liu (2016) conducted a case study on a seven-year-old male who participated in an eight-week yoga study. The authors found that the participant displayed poses that were more accurate and held for a longer period of time. Accuracy was measured by their yoga pose rating scale which rated 31 poses on a five-point Likert scale where a score of 1 was ‘rarely’ and 5 was ‘mastery’. At the beginning of the study, the participants yoga pose rating was at a score of 80 and increased over the eight weeks to a final score of 115. It was also noted that he began to use breathing techniques learned in the yoga intervention to calm himself down during stressful situations. One of the most significant reports from this case study was the change in social behaviors. The authors reported that the participant was less shy and irritable. They found that he was also more confident and began to lead the yoga poses after engaging in the intervention. Other studies found decreased irritability, lethargy, hyperactivity, self-injurious behaviors, aggression, and social withdraw following the engagement in a yoga intervention (Koenig, Buckley-Reen, & Garg, 2012; Shanna & Shanna, 2016).

Additionally, one study by Radhakrishna, Nagrathna, & Nagendra, (2010) examined the effects of yoga on the social and imitation skills in children with ASD. This study included six children from the ages of eight to 14 who were diagnosed with ASD. The children received five hours of Integrated Approach to Yoga Therapy (IAYT) per week for two 10-month academic years with a two month break for summer. IAYT sequence included warm up exercises, strengthening poses, calming poses, breathing practices, and chanting. Three behavior checklists were completed by two special educators that were assessed at three points during the two-year study. The assessments were conducted at pre-intervention between sessions one and 12, mid-
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intervention between sessions 200 to 202, and post-intervention between sessions 389 to 391. One assessment was the Autism Research Institutes’ Form E-2 that analyzed eye-to-eye gaze, sitting tolerance, body posture, self-injurious behavior, and self-stimulatory behavior. This assessment was measured on a three-point scale where a score of 0=little, 1=moderate, and 2=a lot. A second assessment was the Imitation Test Battery which was measured imitation of vocalization, gross motor actions, complex motor actions, oral-facial movements, and breathing exercises. This assessment was measured on a three-point scale where a score of 0=rarely imitated, 1=occasional imitation, and 2=exact imitation. The final assessment was the Repetitive Stereotyped Behavior Test Battery which examined self-injurious, stereotyped, restricted, and repetitive behaviors. This assessment was measured on a four-point scale where a score of 0=no behavior, 1=mild behavior, 2=moderate behavior, and 3=severe behavior. Although the authors report substantial changes in every measure during the post-intervention assessment, there were significant methodological concerns regarding the findings. For example, there was no indication of how the measures were scored and it was stated that interrater reliability was calculated for the two special educators who scored the exam, but the values were not reported in the article. Additionally, as this study was conducted over a two-year time scale, the three-point scoring scales may have limited the accurate measurement and assessment of improvements in the participants over the time of the study.

Currently, there is very limited research on the effects of yoga therapy on the motor skills of persons with ASD. To our knowledge, only one study has attempted to implement yoga as a method of improving motor skills in children with ASD. Radhakrishna (2010) conducted a study to examine the effects of yoga on motor imitation skills in the six children eight to 14 years old with ASD. The study was conducted for 45 minutes per day for 10 months using IAYT. At the
beginning of the study all the children displayed poor imitation of gross motor functions and were characterized as clumsy and poorly coordinated. Prior to beginning the yoga intervention, all participants rarely imitated vocalization, oral-facial movements, and never imitated complex two-phase movements. Three assessments were given during the study, “pre” between sessions 1 and 12, “mid” between sessions 60-100, and “post” between sessions 180-182. A questionnaire was given to the participants parents at each assessment point to complete regarding any changes on the child’s behavior. Additionally, trained observers completed imitation assessments on each participant at each assessment point. Imitation was scored on a 3-point scale (2= exact imitation, 1 = occasionally producing imitation, and 0= rarely imitates). Average responses were reported by the observers. Imitation of gross motor actions was most improved on the three-point scale. Pre-assessment gross motor imitation was recorded at 0.18 rating of responsiveness, 0.9 at the mid-assessment point, and 1.8 at post-assessment. Complex imitation was recorded for pre-assessment at 0.17, mid-assessment at 0.6, and post-assessment at 1.4. The researcher concluded that some behavioral symptoms were improved as a result of the yoga intervention.

While the research conducted by Radhakrishna, Nagra, & Nagendra (2010) and Radhakrishna (2010) demonstrates the effects of yoga on aspects of motor performance, the measurement utilized was not sensitive enough to capture change. Specifically, since the interventions were conducted over a 10-month and two-year time scale, it would be expected that results would show at least a three-point change during this time. Radhakrishna (2010) recorded a difference of 1.62 points during the 10-month study from pre-assessment to post-assessment. On a three-point rating scale, 1.62 is significant, however, these results only provide information about how often a participant imitates an instructor. These studies did not examine the quality of participant engagement or imitation.
Given the limitations of the current literature, research evaluating the effects of a yoga intervention using frequent, systematic measurement of yoga quality is necessary. Moreover, because ABA and TEACCH principles can be modified for use in many activities and have shown positive results in motor skill acquisition, it is hypothesized that yoga skills could effectively be taught to children with ASD. The main hypothesis of the present study was that by using ABA and TEACCH principles with children diagnosed with ASD, an improvement in instructed yoga poses would be seen through increased pose duration and pose performance.

**Methodology**

**Methods**

**Background questionnaire.** The participants parents were asked to complete a background questionnaire in its entirety. The questionnaire contained basic demographic information (socioeconomic status, gender, ethnicity, age), an academic history (current school placement and accommodations), and a medical history (see Appendix A).

**Left and right identification.** To ensure the participant could perform requested tasks in the study, he was prompted to identify his left side followed by his right side in which he did correctly.

Prior to administering the yoga intervention, the principal investigator administered objective measures to the participant that examined the presence and absence of his motor skills. Additionally, the participants parents completed questionnaires, or lists of statements that were designed to evaluate the participants motor abilities that were observed by the parents in everyday settings. Objective measures were conducted during the first session to establish the initial motor skills and deficits of the participant. From these measures, the intervention aims
were established.

**Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2).** The Participant was administered the BOT-2 Short Form (Bruininks & Bruininks, 2005) during the first session to determine motor abilities pre-intervention. The BOT-2 was developed to as measure of gross and fine motor abilities for children ages 4-21 years. The BOT-2 consists of 53 test items and the BOT-2 Short Form includes four motor composites each with two subtests. Categories include Fine Manual Control (Fine Motor Precision and Fine Motor Integration), Manual Coordination (Manual Dexterity and Upper-Limb Coordination), Body Coordination (Bilateral Coordination and Balance), and Strength and Agility (Running Speed and Agility and Strength). The Total Motor Composite was obtained.

**Movement Assessment Battery for Children, Second Edition (Movement ABC-2).** The participant was administered the Movement Assessment Battery for Children, Second Edition (Henderson & Sugden, 1992; Henderson, Sugden & Barnett, 2007) during the first session to assess aiming and catching, and balance. The Movement ABC-2 can be used to assess motor skills in children ages 3 to 16 and is broken into 3 age bands: 3-6 years, 7-10 years, and 11-16 years. The Movement ABC-2 consists of eight tasks across three domains of functioning including Manual Dexterity, Ball Skills, and Static and Dynamic Balance. Since manual dexterity was assessed using the BOT-2, the participant was only administered two catching tasks (i.e., catching a ball with dominant and non-dominant hands), a throwing task (i.e., throwing a ball at a target) and four balance tasks (i.e., two-board balance, walking toe-to-heel backwards, and zig-zag hopping with dominant and non-dominant legs) (Henderson, Sugden & Barnett, 2007). Each Component Score was analyzed rather than obtaining a Total Test Score in
order to evaluate each domain individually.

Test of Gross Motor Development, Second Edition (TGMD-2). The TGMD-2 (Ulrich, 2000) was administered to the participant during the first session to determine locomotor and gross motor abilities pre-intervention. Ulrich developed the TGMD-2 to identify children who are significantly behind their peers in gross motor skill development and who should receive motor interventions or special education services for physical education. This measure consists of locomotor (i.e., run, gallop, hop, leap, horizontal jump, slide) and object control subtests, each containing several tasks using standard playground equipment (i.e., striking a stationary ball, stationary dribble, kick, catch, overhand throw, and underhand roll) (Ulrich, 2000). Standard scores for the locomotor and object control subtests were analyzed in addition to the Gross Motor Quotient.

Childhood Autism Rating Scale, Second Edition (CARS-2). The CARS-2 (Schopler, Van Bourgondien, Wellman, & Love, 2010) was completed by the participants' parents during the first session to determine ASD symptoms and behavioral patterns. The CARS-2 is one of the most widely used and empirically validated assessments for ASD that can be used to assess individuals two years and older. The CARS-2 consists of 15 items that address symptoms including interpersonal relations, imitation, emotional response, body use, object use, adaptation to change, visual response, listening response, taste, smell, and touch response and use, fear or nervousness, verbal communication, nonverbal communication, activity level, level and consistency of intellectual response, and general impressions (Schopler, Van Bourgondien, Wellman, & Love, 2010). The examiner rates the individual on each item, using a 4-point rating scale. Ratings are based on frequency of the behavior as well as on its intensity,
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peculiarity, and duration. The total score was obtained for this measure.

**Video coding.** Undergraduate research assistants were trained by the principal investigator using the coding manual to evaluate the yoga sequences that were video recorded during each yoga session. Proper coding procedures were established as indicated in the coding manual and used to evaluate each criterion (see Appendix B). Data obtained by the videos included pose duration, pose performance, as well as trial attempts and prompting levels.

**Pose duration.** Pose duration was measured by timing the duration of each yoga pose. The timing began at the initiation of pose after all prompting was given by the principal investigator and timing was sustained until the participant stopped engaging in the pose.

**Pose performance.** Pose performance was evaluated at the midpoint of the pose (as measured by pose duration) using the pose performance rating scale (see Appendix C) to examine how accurate the participant’s pose attempt was compared to the model pose of the principal investigator. There were multiple performance aspects that were evaluated for each pose including but not limited to limb position, gaze direction, and overall body shape. In total, there were 69 total criteria for pose performance over all 13 poses.

**Trial and prompting.** Number of trials of each pose were recorded as well as levels of prompting from the principal investigator. A trial was defined by a new attempt at a pose following instruction or change in prompting level by the principal investigator (see Appendix B). Prompting levels included verbal instruction as level 1, picture of correctly executed pose as level 2, doing the pose alongside the principal investigator as level 3, using a prop or device for stabilization as level 4, and the principal investigator physically guiding the participant into the pose as level 5. Prompting was first given from lowest level (1) to highest level of prompting (5).
Participant

The participant was recruited from an online social media outreach effort and consent for the study was given by the participant’s parents. The participant also assented to participation. The participant was a Caucasian, right-handed, ten-year-old male diagnosed with ASD. It was noted by the parents that the participant had difficulties with attention, speech, language, social adjustment, and emotional control but did not engage in self-injurious behaviors. He began speech and occupational therapy two months prior to beginning the study and was not prescribed any medications at the time of the study. The participant did not present with seizure disorders, brain injury, attention deficit hyperactivity disorder, or developmental coordination disorder. No other medical conditions or significant illnesses were reported. The child previously played t-ball and participated in karate lessons and Irish dance lessons once per week during the study. The participant’s parents both have Bachelor’s Degrees and the participant was an only child. Of 60 possible points, a score of 31.5 on the CARS-2 was recorded, placing the participant in the mild-to-moderate range for autism symptoms.

Table 1 shows that the participant’s raw score on the BOT-2 was 35, his performance fell at the 7th percentile and he was therefore classified in the below average range compared to typically developing children his age. He struggled with strength tasks such as pushups and situps on the BOT-2.

| Table 1 |
| Bruininks-Oseretsky Test of Motor Proficiency, Second Edition |
| Raw | 52 |
| Standard Score | 35 |
| Percentile | 7 |
| Classification | Below Average |
Table 2 shows the participant’s scores on the Movement-ABC. Each composite score was analyzed individually, instead of obtaining a Total Test Score. The best of 10 attempts were scored for each aiming and catching task. As indicated, the participant scored seven raw points for throwing and zero for catching. His composite score for aiming and catching was eight, which placed this participant in the 25th percentile of motor skills for his age group. On the balance composite, the participant’s performance fell in the Average range with a composite score of nine, however, analysis of the individual subtests reveals a pattern of strengths and weaknesses. His performance fell in the Average range for three tasks within the balance domain (heel-to-toe walking, and both hopping tasks). The participant performed poorly on tasks requiring him to balance on one foot, however. Because of the participant’s poorer performance on one-foot balancing tasks, the principal investigator provided instruction on poses that required balance (opposite arm and leg extension and tree pose).

<table>
<thead>
<tr>
<th>Aiming + Catching</th>
<th>Raw scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throw Beanbag</td>
<td>7</td>
</tr>
<tr>
<td>Catching Two Hands</td>
<td>0</td>
</tr>
<tr>
<td>Composite Score</td>
<td>8</td>
</tr>
<tr>
<td>Percentile</td>
<td>25</td>
</tr>
<tr>
<td>Classification</td>
<td>Average</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One board balance-Best</td>
<td>4</td>
</tr>
<tr>
<td>One board balance-Other</td>
<td>8</td>
</tr>
<tr>
<td>Heel-to-toe forward</td>
<td>15</td>
</tr>
<tr>
<td>Hopping on mats-best</td>
<td>5</td>
</tr>
<tr>
<td>Hopping on mats-other</td>
<td>5</td>
</tr>
<tr>
<td>Composite score</td>
<td>9</td>
</tr>
<tr>
<td>Percentile</td>
<td>37</td>
</tr>
<tr>
<td>Classification</td>
<td>Average</td>
</tr>
</tbody>
</table>
Table 3 provides both the raw and standard scores, as well as classification, percentile, and Gross Motor Quotient for the locomotor and object control tasks of the TGMD. The participant scored in the average range for both locomotor and object control tasks and was given a Gross Motor Quotient of 82. This score places the participant in the low average range at the 12th percentile, compared to other children his age.

<table>
<thead>
<tr>
<th>Procedure</th>
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</thead>
<tbody>
<tr>
<td>Undergraduate research assistants were trained by the principal investigator in coding procedures. Recruitment for participants began in November 2016 using social media. All sessions were conducted at the participant’s home by the principal investigator. Prior to any testing procedures, the participants parents read and signed all questionnaires and consent forms. The principal investigator then read the participant an assent form which the participant verbally agreed to and signed.</td>
</tr>
</tbody>
</table>
This study used a single-subject AB design to examine the effects of weekly yoga intervention on the motor skills of a ten-year-old male with ASD.

**Baseline Phase**

Baseline phase consisted of sessions in which the participant was verbally instructed on 10 shortened beginner yoga poses. Three poses were completed on first the right side followed by the left side, for a total of 13 poses (see Appendix B). Each baseline session varied in duration from five to 12 minutes. Verbal instruction was given to the participant by the principal investigator for each pose along with a picture activity schedule depicting the poses. The principal investigator instructed the participant to maintain the pose attempt for as long as possible. If the participant maintained the pose for 10 seconds, instructions were given to move to the next pose. If the pose was not attempted for 10 seconds during baseline, they were not instructed to re-attempt the pose. During the baseline phase the participant was not provided with additional prompting for the purposes of establishing an accurate baseline estimate of his abilities. Sessions were video recorded and coded by the undergraduate research assistants. Coding data was analyzed by the principal investigator to determine when the participant reached a stable baseline. The participant had a stable pose duration determined by the principal investigator if responses differed by no more than five seconds across sessions. The participant had stable pose performance, determined by the principal investigator, if responses differed by no more than two points across sessions. When both pose performance and pose duration were determined to be stable, at baseline session 4, the participant was moved to intervention phase.

**Intervention Phase**

Poses for intervention were selected based on the participant’s specific motor skill
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deficits as measured by the initial assessment. Each yoga intervention session varied in duration from six to 20 minutes. During the intervention phase, the instructed poses were initially instructed by the principal investigator using least-to-most prompting hierarchy. Prompting levels included verbal instruction as level 1, picture of correctly executed pose as level 2, doing the pose alongside the principal investigator as level 3, using a prop or device for stabilization as level 4, and the principal investigator physically guiding the participant into the pose as level 5. The principal investigator increased the prompt level if the participant could not perform the pose after verbal instruction, if the pose was not attempted for at least 10 seconds, and if the pose attempt did not meet pose performance quality requirements. If the pose attempt met the pose performance quality requirements, the participant was verbally praised by the principal investigator. Varying levels of labeled verbal praise were given to the participant for achieving aspects of pose performance. No praise was awarded if these criteria were not met.

At intervention session 7, the prompting hierarchy was changed to a most-to-least (MTL) hierarchy. The principal investigator hypothesized that beginning with the highest level of prompting during the intervened poses would reduce participant fatigue and improve pose duration and performance. Toward the end of the intervention, the principal investigator hypothesized that giving the participant a stopwatch to monitor his engagement would increase the pose duration. The participant was given a stopwatch to view during all poses of the last two intervention sessions.

Data Analysis

Video Coded Variables

Graphs were constructed and visually analyzed for trends in the participant’s pose
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duration and pose performance. Pose duration and performance were each depicted three ways: total, average instructed, and average non-instructed. Total pose duration and pose performance were constructed to examine overall trends in the data. Two instructed poses were repeated on each side for a total of four poses. Eight poses were non-instructed, of which one pose was done bilaterally for a total of nine poses. The participant showed higher total pose duration and total performance on non-instructed poses due to there being more non-instructed poses. To examine the trends that were accompanied by instruction on the pose, instructed poses needed to be analyzed independently of non-instructed poses. Due to the higher number of poses for non-instructed than instructed poses, the average duration and performance for each category needed to be analyzed for accurate comparison. Phase changes were indicated for transition from baseline to intervention, change in prompting hierarchy, and stopwatch incorporation.

Interrater Reliability

Trained undergraduate research assistants coded each session independently. To ensure that data was consistent across coders, the principal investigator analyzed inter-rater reliability. Pose duration and pose performance inter-rater reliability was calculated using the formula: (absolute value of (smaller value/ larger value) *100). Discrepancies in coding were identified by the principal investigator and reviewed in meetings with the undergraduate research assistants to ensure fidelity with the coding procedures.

Percent of non-overlapping data

Percent of non-overlapping data (PND) was calculated to evaluate the quality of the intervention using the guidelines established by Scruggs and Mastropieri (1998). PND is a
commonly used method of measuring the effectiveness of interventions in single subject research. When the goal is to increase behavior, as in the present study, PND is calculated by determining the number of intervention sessions that exceed the maximum value of the baseline divided by the total number of intervention sessions. PND scores are out of 100 and indicate how many intervention observations exceed the highest baseline data. This provides a quantifiable measure of intervention effectiveness. Scores over 90 (i.e. 90% of treatment sessions exceed maximum baseline value) are regarded as “very effective”. Scores ranging from 70 to 90 are regarded as “effective”. Scores of 50 to 70 are regarded as “questionably effective”. Scores below 50 are regarded as “ineffective interventions”. PND scores were calculated for pose duration and pose performance.

Results

Pose Duration

Pose duration was hypothesized to increase due to the participant’s difficulties maintaining each pose for the full 10 seconds. Total pose duration was calculated by summing the duration of all 13 poses (10 types of poses of which three were repeated on both left and right sides).
Figure 1. Total Pose Duration. Total pose duration in seconds for each session. The solid line represents the primary phase change from baseline to the beginning of intervention after session 5. The dashed lines represent secondary phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23.

Baseline. Figure 1 shows a negative trend in pose duration during baseline. In baseline, if the pose was not attempted for 10 seconds, the participant was not instructed to reattempt the pose. If the pose was held for 10 seconds, the participant was instructed to move to the next pose. Using this 10 second rule per pose, the participant should have had a maximum of 130 seconds for total pose duration. Of note, sessions 1 and 2 were not included in this 10 second pose rule because the principal investigator did not instruct the participant to attempt the next pose after 10 seconds during these sessions. The participant displayed total pose durations higher than 130 seconds during these sessions. The participant frequently requested to stop engaging in poses during the first nine sessions. The number of requests decreased from 15 requests during the...
initial session to zero requests by intervention 4.

**LTM prompting phase.** There were no significant changes in pose duration during the LTM prompting phase. After intervention 4 the participant stopped engaging in poses without requests or permission. During the intervention, the participant was prompted to repeat the pose if pose performance or duration criteria were not met. Because the participant stopped engaging in the poses and did not perform the poses to criterion, he was prompted to repeat them across trials which resulted in fatigue. During the LTM prompting phase there was an average of four trial attempts per side for opposite arm and leg extension, and an average of three trial attempts per side for tree pose.

**MTL prompting phase.** Pose duration in the MTL prompting phase displayed minimal variability and no change in overall trend. At session 12, the participant was switched to a MTL hierarchy because the principal investigator hypothesized that beginning with the highest prompt level would reduce participant fatigue by decreasing the number of trials of the pose. Therefore, it would be expected that MTL prompting would increase pose duration and performance. During the MTL prompting phase there was an average of one trial attempt per side for both opposite arm and leg extension and tree pose. No significant change in trend was observed between the LTM and MTL prompting phases.

**Stopwatch phase.** A positive level shift was observed when the stopwatch was introduced for all poses at session 24 (See Figure 1). The stopwatch was also used for all poses during session 25 in which a slight reduction of the effect of the stopwatch was observed, however, pose duration remained higher than baseline and previous intervention sessions.
**Average instructed pose duration.**

*Figure 2.* Average Instructed Pose Duration. The average duration of the four instructed poses per session is shown. The solid line represents the primary phase change from baseline to the beginning of intervention after session 5. The dashed lines represent secondary phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23. Average instructed pose duration was calculated by summing all durations for the four instructed poses (opposite arm and leg extension, and tree on both sides) and dividing the sum by four.

**Baseline.** During sessions 1 and 2, the principal investigator did not prompt the participant to move to the next pose if he engaged in the pose for longer than 10 seconds. Due to this and that the participant began to stop engaging in the pose before prompted to, a negative trend in average instructed pose duration was seen during baseline.

**LTM prompting phase.** There was no change in average instructed pose duration during the LTM prompting phase.
**MTL prompting phase.** It was hypothesized that by having less trials of the pose, that average instructed pose duration would increase. A slight positive trend with some variability was seen in the MTL prompting phase.

**Stopwatch phase.** It was hypothesized that the introduction of the stopwatch would increase average instructed pose duration. There was a positive level shift between the MTL prompting and stopwatch phases. Figure 2 shows an increase in the average duration of instructed poses with the use of the stopwatch.

**Average Non-Instructed Pose Duration.**

![Average Non-Instructed Pose Duration](image)

*Figure 3. Average Non-Instructed Pose Duration.* This figure shows the average duration of the nine non-instructed poses per session. The solid line represents the major phase change from baseline to the beginning of intervention after session 5. The dashed lines represent minor phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23. Average non-instructed pose duration was calculated by
summing the duration of all nine non-instructed poses (8 types of poses of which one was repeated on both right and left sides) and dividing the sum by nine.

*Baseline.* During sessions 1 and 2, the principal investigator did not prompt the participant to move to the next pose if he engaged in the pose for longer than 10 seconds. Due to this and that the participant began to stop engaging in the pose before prompted to, a negative trend in average non-instructed pose duration was seen during baseline.

*LTM prompting phase.* No significant changes were observed during the LTM prompting phase.

*MTL prompting phase.* No significant changes were observed during the MTL prompting phase.

*Stopwatch phase.* A positive level shift was observed for average non-instructed pose duration during the stopwatch phase. Non-instructed pose duration increased significantly upon stopwatch implementation during sessions 24 and 25.

*Pose duration PND scores.* The PND scores for the stopwatch phase indicate that the intervention was very effective when using the stopwatch. No effects were observed during the overall intervention, and the LTM and MTL prompting phases, however.

Table 4

<table>
<thead>
<tr>
<th>Pose Duration PND Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pose Duration</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Instructed</td>
</tr>
<tr>
<td>Non-Instructed</td>
</tr>
</tbody>
</table>

*Note: This PND value is an underestimate of the intervention effectiveness due to outlier values during baseline
Pose performance

Pose performance was hypothesized to increase with instruction. It was also hypothesized that the improvements on instructed poses would generalize to non-instructed poses.

**Total pose performance.**

*Figure 4.* Total Pose Performance. This figure shows the total pose performance points for all poses combined per session. The solid line represents the major phase change from baseline to the beginning of intervention after session 5. The dashed lines represent minor phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23.

*Baseline.* There were no significant changes observed in the baseline phase.

*LTM prompting phase.* No significant changes were seen in the LTM prompting phase.

*MTL prompting phase.* No significant changes were observed during the MTL
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prompting phase.

*Stopwatch phase.* A slight negative level shift in performance was observed during the stopwatch phase compared to his performance during the LTM and MTL prompting phases. The slight decline in total performance is likely due in part to the motivation to hold the pose for a longer duration and a reduction in effort in performance due to the shift in attention to pose duration. It was hypothesized that since he was attending to the stopwatch and pose duration, he was not attending to his pose performance.

Average instructed pose performance.

*Figure 5.* Average Instructed Pose Performance. This figure shows the average performance of the four instructed poses per session. The solid line represents the major phase change from baseline to the beginning of intervention after session 5. The dashed lines represent minor phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23. Average instructed pose performance was calculated by summing the total received points by the number of instructed poses which was four.
Baseline. No trends or significant changes were observed during the baseline.

LTM prompting phase. A positive level shift was observed in the LTM prompting phase indicating that even with an increased number of pose trials, there was still an improvement in pose performance at the highest level of prompting on the final pose trial.

MTL prompting phase. There was a slight positive overall trend in instructed pose performance during the MTL prompting phase.

Stopwatch phase. During the stopwatch phase, the positive trend toward improvement continued. This differs from both overall pose performance and the average non-instructed pose performance where a decline in pose performance was observed with the implementation of the stopwatch. These results indicate that the performance on instructed poses did not generalize to non-instructed poses.

Average non-instructed pose performance.

Figure 6. Average Non-Instructed Pose Performance. This figure shows the average performance
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of the nine non-instructed poses per session. The solid line represents the major phase change from baseline to the beginning of intervention after session 5. The dashed lines represent minor phase changes which include implementation of MTL prompt hierarchy after session 11, and use of the stopwatch after session 23. Average non-instructed pose performance was calculated by summing the total pose performance scores for the nine non-instructed poses and dividing the sum by nine.

**Baseline.** No significant changes were observed during the baseline.

**LTM prompting phase.** There was a slight positive level shift in non-instructed pose performance during the first two LTM prompting sessions, however, there was a slight negative trend following these sessions during the LTM prompting phase.

**MTL prompting phase.** There were no significant changes during the MTL prompting phase.

**Stopwatch phase.** There was a slight negative trend in the average non-instructed pose performance compared to the LTM and MTL prompting phases. This is likely due to the participant’s attention to pose duration and reduced focus on pose performance.

**Pose performance PND scores.** The intervention had significantly increased effectiveness from the LTM to the MTL prompting phases on instructed poses. An increase from questionable effectiveness in the LTM prompting phase to effective in the MTL prompting phase was determined for total pose performance. The stopwatch phase for instructed poses was considered to be very effective. Overall, the instructed poses had a higher rating of effectiveness than total pose performance and non-instructed pose performance.
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Table 5

Pose Performance PND Scores

<table>
<thead>
<tr>
<th>Pose Performance</th>
<th>Overall</th>
<th>LTM</th>
<th>MTL</th>
<th>Stopwatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>65</td>
<td>67</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>Instructed</td>
<td>75</td>
<td>33</td>
<td>91</td>
<td>100</td>
</tr>
<tr>
<td>Non-Instructed</td>
<td>35</td>
<td>50</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>

Interrater Reliability

Three undergraduate research assistants were trained in coding procedures by the principal investigator. All undergraduate research assistants coded each session independently. The principal investigator determined the inter-rater reliability for each pose for pose duration and pose performance which is represented in Table 6. Reliability ranged from 91% to 97% across phases for total pose duration. Reliability ranged from 80% to 94% across phases for total pose performance. These results indicate that the independent coders maintained high levels of consistency throughout the study.

Table 6

Mean Inter-Rater Reliability for Pose Duration and Pose Performance

<table>
<thead>
<tr>
<th>Pose Duration</th>
<th>Baseline</th>
<th>LTM</th>
<th>MTL</th>
<th>Stopwatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain</td>
<td>70%</td>
<td>92%</td>
<td>92%</td>
<td>85%</td>
</tr>
<tr>
<td>Forward Fold</td>
<td>76%</td>
<td>86%</td>
<td>94%</td>
<td>90%</td>
</tr>
<tr>
<td>Plank</td>
<td>85%</td>
<td>87%</td>
<td>93%</td>
<td>88%</td>
</tr>
<tr>
<td>Cobra</td>
<td>92%</td>
<td>86%</td>
<td>90%</td>
<td>93%</td>
</tr>
<tr>
<td>Down Dog</td>
<td>85%</td>
<td>89%</td>
<td>94%</td>
<td>83%</td>
</tr>
<tr>
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<td>79%</td>
<td>82%</td>
<td>87%</td>
<td>75%</td>
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<tr>
<td>Opposite Arm and Leg-Right</td>
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<td>83%</td>
<td>93%</td>
<td>91%</td>
</tr>
<tr>
<td>Opposite Arm and Leg-Left</td>
<td>87%</td>
<td>87%</td>
<td>87%</td>
<td>85%</td>
</tr>
<tr>
<td>Chair</td>
<td>84%</td>
<td>77%</td>
<td>88%</td>
<td>91%</td>
</tr>
<tr>
<td>Warrior-Right</td>
<td>81%</td>
<td>80%</td>
<td>88%</td>
<td>91%</td>
</tr>
<tr>
<td>Warrior-Left</td>
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<td>93%</td>
<td>92%</td>
<td>76%</td>
</tr>
<tr>
<td>Tree-Right</td>
<td>91%</td>
<td>83%</td>
<td>81%</td>
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<tr>
<td>Tree-Left</td>
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<td>98%</td>
<td>88%</td>
<td>71%</td>
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<table>
<thead>
<tr>
<th>Pose Performance</th>
<th>Baseline</th>
<th>LTM</th>
<th>MTL</th>
<th>Stopwatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain</td>
<td>80%</td>
<td>78%</td>
<td>89%</td>
<td>92%</td>
</tr>
<tr>
<td>Forward Fold</td>
<td>100%</td>
<td>83%</td>
<td>88%</td>
<td>75%</td>
</tr>
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<td>Plank</td>
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<td>93%</td>
<td>90%</td>
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<tr>
<td>Warrior-Left</td>
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<td>93%</td>
<td>93%</td>
<td>80%</td>
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<td>67%</td>
</tr>
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<td>Tree-Left</td>
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<td>94%</td>
<td>90%</td>
<td>83%</td>
</tr>
<tr>
<td>Total</td>
<td>80%</td>
<td>94%</td>
<td>90%</td>
<td>83%</td>
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Discussion

The current study examined the effects of a yoga intervention on the motor performance of a ten-year-old male with ASD. Variables were measured using objective tests of motor skills, video-coded pose duration, and video-coded pose performance. It was hypothesized that pose duration and performance would increase on instructed poses. The hypothesis was supported by the results. While the participant showed no significant overall changes between baseline, LTM prompting, or MTL prompting, the stopwatch phase showed a strong positive effect on instructed and non-instructed pose duration. Other visual cues used throughout the study such as the picture references of poses, or completion of the pose with the principal investigator did not produce the same strong positive effect on pose duration as the stopwatch did. This suggests that the use of the stopwatch gave the participant performance feedback which allowed the participant to continuously monitor his engagement and that the feedback was effective in increasing pose duration. Self-monitoring of performance and engagement has been shown to produce positive
results in individuals with ASD during physical activities, social interaction, and academic engagement (Boudreau & Harvey, 2013; Todd & Reid, 2006; Xu, Wang, Lee, & Luke, 2016). Future studies should further examine the effects of self-monitoring strategies and engagement in yoga poses.

Though pose duration and pose performance were increased for instructed poses, the improvement in pose performance did not generalize to non-instructed poses. There were patterns of improvement across instructed poses, but limited improvement on non-instructed poses. This suggests that being able to apply what was learned during instructed poses to non-instructed poses was challenging to the participant. The term generalization is defined as the ability to transfer a strategy used in one context to a similar context (de Marchena, Eigsti, & Yerys, 2015). The findings of the current study are similar to other research that has shown that in a group of children with ASD, just under half of the participants displayed difficulties in generalizing behavior that was previously learned in a different setting (Rincover & Koegel, 1975). It is recommended that future studies implement specific generalization strategies to further examine generalized changes in behavior.

Conclusion

The prevalence of ASD in children has increased over two-fold since 2000. Motor deficits are not currently a criterion in the diagnosis of ASD even though many studies indicate the observation of motor deficits in a large majority of persons diagnosed with ASD. Due to motor skill impairments that are reported in the literature, researchers have been interested in developing interventions to effectively reduce motor deficits. The current study aimed to examine the effects of yoga on motor skills of a ten-year-old male with ASD.
There were several limitations to the study which included limited generalizability and frequency of intervention. This study had limited external validity because it utilized a single-subject AB design which provided an in-depth analysis of individual idiosyncrasies but did not allow the results to be generalized to other children ASD. The results may differ for populations of children with ASD that are lower functioning or have more severe social or motor impairments. Future studies should examine the effects in a larger population of children with ASD.

A second limitation to the study was the frequency of intervention. Though the participant did engage in other activities such as Irish dance and karate between sessions, it was unknown if the participant engaged in yoga between sessions. Many researchers that have conducted studies on the effects of physical activity on persons with ASD implemented the intervention multiple times per week. A few studies that used multiple intervention sessions per week reported increases in motor skills in children with ASD (Bremer, Balogh, & Lloyd, 2014; Pan, Chu, Sung, Huang, & Ma, 2016). The present study implemented the intervention once per week based on the schedule of the participant’s parents and the principal investigator. Future studies should examine effects of yoga interventions conducted multiple times per week and for a longer duration.

It was not necessary to obtain a control group (such as typically developing children) as the larger study was a single subject between groups design, and each participant’s baseline served as their own control. However, it could prove beneficial to compare the performance of children with ASD to the performance of TD children. Several previous studies have examined motor deficits in children with ASD compared to TD children and have reported that children
with ASD have increased deficits (Kaur, Srinivasan, & Bhat, 2018; Kennedy Krieger Institute, 2007, Memari, et al., 2013). Use of typically developing (TD) children as a comparison may aid to further the current knowledge of motor limitations in children with ASD and is recommended for future studies.

Overall, the results supported the proposed hypothesis that pose duration and pose performance would improve on instructed yoga poses. While future research is warranted, the present findings suggest that yoga is an appropriate physical activity for this population that can increase motor performance.
References


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EFFECT OF YOGA ON MOTOR SKILLS

Education Limited.


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Radhakrishna, S. (2010, January). Application of integrated yoga therapy to increase imitation
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Interdisciplinary Studies in Humanities, 8(2), 56-63. doi:10.21659/rupkatha.v8n2.06


Appendix A
Background Questionnaire

Demographic Information

1. Name of Participant: ____________________________

2. Gender: (circle) MALE FEMALE

3. Ethnicity: ____________________________

4. Date of Birth: ____________________________

5. Age: ____________________________

6. Handedness (right, left, or ambidextrous): ____________________________

7. Home Address

____________________________________
____________________________________
____________________________________

8. Phone Number: ____________________________

9. Parents’ level of education (for example: GED, high school diploma, bachelor’s degree, master’s degree, doctoral degree, etc.

   Father: ____________________________

   Mother: ____________________________

Academic History
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1. Participant’s current grade or highest grade completed: _____________________________

2. Has the participant been held back one (or more) year(s) in school? (circle) YES NO
   If yes, in what grade and for how many years:
   __________________________________________

3. Has the participant obtained special services (e.g., applied behavior analysis (ABA),
   special education, speech therapy, occupational therapy, physical therapy etc.)?
   __________________________________________
   __________________________________________

4. Place a check mark (✓ ) in the box next to any of the following conditions the participant
   has experienced: (check all that apply)

   o birth related injuries
   o developmental delay / developmental disorder
   o speech/language impairment
   o head injury with loss of consciousness
   o seizure disorder / epilepsy
   o tic disorder / Tourette’s disorder
   o substance use / abuse
   o other neurological condition (please specify)
   __________________________________________

5. Place a check mark (✓ ) in the box next to any of the following conditions the participant
   been diagnosed with: (check all that apply)
   __________________________________________
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- Attention Deficit Hyperactivity Disorder
- Autism Spectrum Disorder
- Depression
- Anxiety
- Obsessive-Compulsive Disorder
- Conduct Disorder / Oppositional Defiant Disorder
- Other neurological condition (please specify) ________________

6. Is the participant currently prescribed medication? (circle) YES NO

If yes, please name the medications and for what they are prescribed:

<table>
<thead>
<tr>
<th>Medication</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

7. Please note any other medical conditions or events (chronic illnesses, major illnesses, medical emergencies, surgeries, hospital stays, imaging scans):

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
Appendix B
Coding Manual

Coding Procedure:

- Code each video within one week after the data has been collected unless otherwise indicated; if coding multiple videos for the same participant, code them in order of data collection.
- Please inform the principal investigator if you are unable to code the video before the one-week deadline and provide a new deadline that is no more than 14 days after data collection.
- Please inform the principal investigator of the days and times you will code each video. If you are able to set a weekly recurring time, please inform the principal investigator of this and notify her when changes must be made.
- Carefully review the code and behavior definitions before coding.
- Record all scores on the Coding Data excel sheet.
- If questions arise during coding or if something is unclear, report this to the principal investigator via email and cc the other coders.
- Tips for coding: First code pose duration, then the pose midpoint, then rate the pose performance, then posture codes, then prompt required (for intervention phase), then the pose completion, then replay the full video to code social/additional behaviors

Note: Begin coding when instruction of poses has begun on the video and stop coding when all poses have been attempted

General Coding:

Video Length (minutes)
- Record the length of the video, excluding any footage that goes beyond the final attempt of the last pose of the video
- Record this time in whole minutes. If the video length is less than 30 seconds from the next whole minute, round down. If the video length is 30-59 seconds, round up.

Pose Duration (seconds; from attempt of full pose to exit of pose)
- Time the length of each pose using the time stamp at the bottom of the video. For example, if the pose begins at 12:10 and ends at 12:26, record the pose duration as 16
- Begin timing the pose when the participant first attempts the full pose (has completed all prompts and no further instructions are given)
  - When coding you will need to listen to all of the prompts, then rewind to start timing after the final prompt or instruction ends (usually the participant achieves the pose before the final prompt, but adjustments may be made with further prompts/cues so begin timing as soon as the final instruction is given)
  - DO NOT CODE “keep holding it like that” or suggestions such as “it may be helpful to lower your leg to be more balanced” as a prompt/instruction
- Stop timing when the participant stands up or steps out of pose. Do not stop recording if the participant loses balance and reattempts the pose immediately.
- If the pose is completely stopped and restarted, only count the first attempt. (Pausing and resuming complicates calculation of the midpoint)
- If the participant steps out of the pose briefly before continuing (e.g., briefly touches their foot to the ground during Tree) or moves within the pose slightly, continue measuring the pose duration for that attempt.

**Pose Midpoint**
- Calculate the *Pose Midpoint* by dividing the *pose duration* in half. Instead of recording this number in seconds, determine and record the time stamp for this midpoint using the start and end points of the pose. For the example above, the *Pose Midpoint* would be 12:18.
  - If the *pose duration* is an odd number, round the *Pose Midpoint* down.

**Pose Completion**
- Record the manner in which the pose ends as Principal Investigator or Participant Initiated using the codes PI or PART
  - PI (Principal Investigator Initiated) is defined as the principal investigator indicating to the participant that the pose is complete (e.g., “OK you can put your foot down” “OK now we’re going to do Cobra)
  - PART (Participant Initiated) is when the Principal Investigator does not indicate that the pose has ended but the participant stops attempting the pose or the participant receives permission after a request to stop the pose

**Pose Performance (See Reference Photos and Pose Performance Rating Scale)**
- Pause the video at the *Pose Midpoint*
- Rate each pose on the qualities listed in Appendix B
  - If the quality is present, score 1; if absent, score 0
  - Some poses (as listed in Appendix B) have modifications that are scored .5
- Total and record the score for each pose as well as the total for all poses

**Flow (See Flow Rating Scale)**
- Flow is defined as the ability to transition between two poses within a sun salutation with coordination
- A sun salutation consists of the following poses: mountain, forward fold, plank, cobra, and downward dog
- Flow will be coded during the transitions between the poses within the sun salutation
  - Mountain to Forward Fold
  - Forward Fold to Plank
  - Plank to Cobra
  - Cobra to Downward Dog
To find the correct place to start coding, use the midpoint of the pose being flowed into and rewind the video slowly to view the flow into the attempt.
- Begin coding flow at the beginning of the flow movement and stop coding when the pose has been fully attempted.
- Rate each pose on the qualities listed in Appendix C
  - If the quality is present, score 1; if absent, score 0
  - Some poses (as listed in Appendix C) have partial scores and are rated out of 2 points.
- Total and record the score for each pose as well as the total for all poses.

**Posture/Angle Coding** (Kinovea) (See Angle Placement Guidelines)
- Posture is defined as a participant's spine position in various body positions.
- Posture will be coded using Kinovea software that is installed on the lab computer.
- Open the application and select the video files to be coded.
- Pause the video at the **Pose Midpoint**
- Use the angle tool such that the center of the angle is on the center point identified for the specific pose you are coding, drag the endpoints of the angle to each end point identified for the pose. (Details below)
- Record the angle on the Coding Data excel sheet and save a screenshot of the image with the lines using Kinovea's screenshot tool.
- Save the screenshot as “PARTICIPANT #, SESSION #, POSE, YOUR INITIALS” in the Yoga Videos folder on the desktop of the lab computer.

**Spine Alignment Coding**
- Downward dog and forward fold require additional codes for measuring the rounded portion of the participants' backs.
  - First, draw the angles as described above.
  - Next, use the line tool to draw a line directly on top of the line from the participant's ear to hip.
  - Drag this line up and place it at the roundest part of the back so that it is parallel to the original line.
  - Draw two additional lines – one from one endpoint of the line (the line that extends from ear to hip) to the center of the parallel line and one from the other endpoint of the line to the center of the parallel line (you should now have a triangle between the two parallel lines).
  - Now go to the dropdown menu and look for the coordinate grid overlay.
  - It will take you to a smaller image of the pose.
  - As soon as you click it will place (0,0) wherever your cursor is, so place this point at the apex of the triangle (center of the parallel line).
  - Now DO NOT click again or you will move the (0,0) point. Instead, place your cursor over the two other points of the triangle WITHOUT CLICKING to determine the coordinates of those points.
  - Enter these coordinates into the excel sheet under “Coordinates of triangle base”
  - This will calculate the midpoint of the base of the triangle and then automatically calculate the height of the triangle using that midpoint.
Number of Prompts Required (Intervention phase only)
- Record the number of prompts required to achieve each pose during the intervention phase of the study
- The prompts will be given in a hierarchy in the following order: (1) verbal, (2) visual, (3) model, (4) partial physical, (5) full physical
  - First, the principal investigator will guide the participant using only verbal cues (i.e., instructions). If the pose is not achieved, then a visual aid (i.e., photo) will be used to prompt the pose. If the pose is not achieved, then the principal investigator will model the pose for the participant. If the pose is not achieved or is lacking in quality, the principal investigator will provide a prop (e.g., block, strap) or modify the pose when possible (e.g., allow the participant to bend their knees or place knees on mat). Finally, if the pose is not achieved the principal investigator will physically guide the participant into the pose.
- Each prompt will be coded using its number in the prompting hierarchy
  - For example, if the participant requires a verbal and visual prompt, the code for this is 2
  - Not all poses will have partial physical prompts; if no partial physical prompt is given and the pose is achieved using a full physical prompt code this 5
- Prompt types include: verbal, visual, model, partial physical, and full physical
  - Verbal cues are defined as verbal instructions given by the principal investigator without the provision of additional assistance
  - Visual models are defined as photographs or visual aids of the desired pose
  - Modeling is defined as the principal investigator modeling the pose for the participant
  - Partial Physical prompts are defined as props (e.g., block, strap) or modifications to the desired pose (e.g., allowing the participant to bend their knees or place knees on mat)
  - Full Physical prompts are defined as physical guidance by the principal investigator into the pose

Participant Specific Coding:

Requests to get out of pose (P2)
- Tally the number of requests to get out of the pose during the video and total these requests
- Requests are defined as asking to get out of the pose or stating an inability to continue (e.g., “Can I stand up now?” “I can’t do this anymore” “It hurts”)
- Divide the number of requests by the total pose duration; this is the request-time ratio
- Record the total number of requests and the request-time ratio

Response to request (encouragement, permission to get out of pose, ignore) (P2)
- Record the type of response given by the principal investigator to these requests
- Each request should have a labeled response
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- Encouragement is defined as any attempt to keep the participant in the pose (e.g., “you’re doing a great job!” “I think you can do it!” “You’re doing it right now!”)
- Permission to get out of pose is defined as allowance for the participant to get out of the pose (e.g., “OK you can stand up” “Yes”)
- Ignoring the request is defined as no response to the participant’s request before the participant’s next request or within 10 seconds of the request

Intervention Process Coding:

General Guidelines
- Record total counts for each trial on the Intervention Process Coding Excel Sheet

Social Engagement
- Record each instance of each level of social engagement initiated by the participant toward the principal investigator
- Social engagement is defined as social comments directed toward the principal investigator resulting in the initiation or maintenance of a social conversation
- Begin coding social engagement when instruction for the first pose begins or the participant begins to attempt the first pose
- Stop coding social engagement when the final pose has been completed
Level 1 - Comment or joke unrelated to what is happening right now or socially appropriate response to a social question
  Examples: “I went swimming this weekend!”
Level 2 – Question unrelated to what is happening right now that initiates social conversation but does not continue ongoing conversation with the principal investigator
  Examples: “Do you have other kids doing this study?” “What did you do this weekend?”
Level 3 - Comment or question that pushes conversation forward in response to the principal investigator’s answer to their initial comment or question (2+ push for conversation)
  Examples: “How was your weekend?” “Good.” “Where did you go?”
Level 4 - Anything more than 2 pushes for a conversation
  Examples: “How was your weekend?” “Good.” “Where did you go?” “I went to the movies.” “Did you have fun?”

Interrater Reliability:

- To ensure that interrater reliability is established, the coders will be trained to code by the principal investigator.
- For behavior codes measured numerically, the coder’s ratings will be divided by those of the principal investigator’s and multiplied by 100 to obtain a percentage of agreement.
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- The coder will practice coding videos that have been coded by the principal investigator until 80% agreement is achieved.
- For behavior codes measured qualitatively (e.g., posture coding), the coder's line angles will be divided by those of the principal investigator's and multiplied by 100 to obtain a percentage of agreement.
- The coder will practice coding videos that have been coded by the principal investigator until 80% agreement is achieved.
- Once the coders have been successfully trained and their ratings have been compared to the principal investigator, each coder will be assigned to participants.
- Two coders will code each video to ensure continued reliability.
- For behavior codes measured numerically, the first coder's ratings will be divided by those of the second coder's and multiplied by 100 to obtain a percentage of agreement.
- For behavior codes measured qualitatively (e.g., posture coding), the first coder's line angles will be divided by those of the second coder's and multiplied by 100 to obtain a percentage of agreement.
Pose Reference Photos

Mountain

Forward Fold

Plank

Cobra

Table Top

Opposite Arm and Leg Extension-Right
Opposite Arm and Leg Extension-Left

Downward Facing Dog

Warrior-Right

Warrior-Left

Chair
EFFECT OF YOGA ON MOTOR SKILLS

Tree- Right

Tree- Left
Appendix C
Pose Performance Rating Scale

Mountain Pose
- Feet flat on ground about hip distance apart
- Shoulders rolled back and down
- Arms extended by sides, about 3 inches from sides of body
- Palms facing forward
- Head tilted about 30° upward
- Gaze shifted upward
  = 6

Forward Fold
- Feet flat on ground about hip distance apart
- Bent forward at hips
- Back flat
- Hands on or toward mat in front of feet (1) (on block with partial physical prompt (.5))
- Legs straight (1) (knees bent (.5))
  = 5

Plank Pose
- Arms extended directly under shoulders (arms and back are 90°)
- Both legs are fully extended with feet about 6 in apart (1) (knees may be on mat with modification (.5))
- Hands and balls of feet support weight of body (1) (knees may be on mat with modification (.5))
- Hips are in a neutral position
- Gaze shifted down at the mat
  = 5

Cobra Pose
- Hands are placed on the mat about 12 inch in front of pelvis
- Shoulders rolled back and down
- Chest lifted off mat with slight backbend
- Arms extended completely (1) (arms remain bent and pointed back behind the body (.5))
- Top of legs and feet actively engaged and pressed down into the mat (tops of feet pressed into mat)
- Head tilted about 30° upward
- Gaze shifted upward
  = 7

Table Top
- Knees placed on mat directly under hips
- Toes tucked under feet
- Arms directly under shoulders (arms and back are 90°)
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- Flat back (belly lifted, hips lowered)
- Gaze shifted down at the mat
  = 5

**Opposite Arm and Leg Extension**
- Knee placed on mat directly under hips
- Arm on mat directly under shoulders (arm and back are 90°)
- Flat back (belly lifted, hips lowered)
- Leg fully extended behind the body
- Opposite arm fully extended
- Extended foot in line with body
- Arm in line with body
- Gaze shifted down at the mat
  = 16

**Downward Facing Dog**
- Body in shape of an inverted V
- Legs extended (1) (knees can remain bent to keep back flat (.5))
- Back flat, not rounded
- Arms straight next to ears
- Feet flat on ground
  = 5

**Chair Pose**
- Arms fully extended overhead next to ears
- Knees bent forward
- Weight in heels (weight not shifted forward/ not standing on balls of feet)
- Hips lowered back and down (torso and thighs form 90°)
  = 4

**Warrior I**
- Arms extended next to ears
- Leg lunged forward with toes facing forward
- Front leg bent 90°
- Back foot placed on mat turned 45° (toes facing side of mat, away from bent knee)
- Back leg fully extended behind body
  = 10

**Tree Pose**
- Palms placed together with thumbs against chest
- Knee turned outward about 90°
- Foot placed on inside of leg with toes pointed toward the mat (foot placed above knee (1), below knee/on ankle (.5))
  = 6

Total: 69