The Effectiveness of Play-Based Interventions Delivered Face-to-face and via Telehealth on Motor and Social Skills of Children with Autism Spectrum Disorder

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The Effectiveness of Play-Based Interventions Delivered Face-to-face and via Telehealth on Motor and Social Skills of Children with Autism Spectrum Disorder

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Acknowledgments

First and foremost, I would like to thank Dr. Sudha Srinivasan for her guidance and support throughout my research and thesis-writing experience. Her attentiveness, knowledge, passion, and encouragement are just some of the qualities that contributed to making this experience so incredible and engaging. She has been an amazing mentor to me and many other undergraduate students. I would also like to thank the families that participated in this study. Additionally, I would like to thank Bansri Patel and Sharanya Charnayuda for cross-checking my coded data and engaging in conversations about the data we are analyzing. Lastly, I would like to thank the UConn Honors Program for creating a small and enriching community within UConn Nation as well as my honors advisor, Cheryl Eckert for all of her support.
Abstract

Objective: Autism Spectrum Disorder (ASD) is a developmental disability affecting 1 in 54 children in the US today. This thesis investigates whether music-based whole-body movement games are effective in improving the motor and social skills of children with ASD. A secondary aim of the thesis is to investigate any differences in the improvement of these individuals by delivery mode, face-to-face or via telehealth.

Methods: 9 children with ASD diagnoses underwent training for 8 weeks with 2 sessions delivered per week using music, dance, and yoga-based activities that were focused on imitation, synchrony, multi limb coordination, and balance in a synchronous fashion within a small group format. 5 children received interventions face-to-face. 4 children received interventions via telehealth platforms (i.e. Zoom, Webex). Children were tested at pretests and posttests on the BOT-2 Test of Motor Proficiency, a standardized test of motor performance and the JoinT Attention Test (JTAT) which assesses the child’s ability to share attention with an examiner. Dependent t tests were used at a significance level of 0.05.

Results: Results showed significant improvements in the bilateral coordination ($p < 0.001$), running speed ($p = 0.018$) and strength ($p = 0.003$) subtests from pretest to posttest, but not in the balance and upper limb coordination subtests of the BOT-2. Results did not show significant improvement in the JTAT. There were no significant differences in the improvements between delivery modes across children seen face-to-face versus via telehealth.

Conclusions: The results show promise for the use of movement games and music programs for the improvement of motor deficiencies in children with ASD. Moreover, our preliminary data suggest that the telehealth mode of intervention delivery seems to be a feasible and effective mode of instruction for children with ASD and their families.
Keywords: ASD, music, motor skills, social skills, movement interventions
Introduction

Autism Spectrum Disorder (ASD) is classified as a developmental disability that causes various social, communication, and behavior challenges for the affected individual (Centers for Disease Control and Prevention, 2020). There are various signs and symptoms of ASD and no known cure. The Centers for Disease Control and Prevention report suggests that ASD now affects 1 in 54 children in 2016 as opposed to 1 in 150 in 2000 (Maenner et al., 2020). With this increase in the prevalence of ASD, the need to develop effective therapies for these children is more urgent than ever before. Determining effective interventions will allow these individuals to better integrate themselves with society and improve their overall quality of life. There is an urgent need to investigate and develop training programs that can be used in clinical and school settings in order to improve the lives of these individuals.

As described above, ASD affects many children and there is research continuously being conducted to better understand the trajectories of these individuals and which methods of therapy are most effective to reduce complications. A study conducted in 2007 with 56 different children 21-41 months of age some with ASD, some with developmental disabilities, and others with developmental concerns but no motor delay showed that the motor trajectories of children with ASD are compromised (Provost, Lopez, & Heimerl, 2007). A similar study was conducted with an older group of participants with ASD, ages 9-12. The movement skills of these 25 children with ASD were compared to the scores of typically developing groups. The results of this study show that movement skills of children with ASD are delayed and deficient by late childhood (Staples, Reid, 2010), adding on to the observations seen by Provost and team in early childhood. Both of these studies confirm that motor skills are compromised in children with ASD at both early and late childhood, but fail to present interventions to tackle the problem. Further research
has shown that the prevalence of motor impairment in individuals with ASD is extremely high. These impairments create difficulties with the dynamics of movement such as starting, stopping, combining, and switching movements (Leary & Hill, 1996). These impairments are also seen in gait, posture, speed, and coordination (Donnellan, Hill, & Leary, 2013). Evidently, motor impairments are pervasive in ASD and therefore interventions are needed to address these issues since they impact a child’s ability to play, socialize, communicate, and learn.

Many intervention strategies have been trialed with children with ASD. Sarabzadeh and team tested the effectiveness of Tai Chi Chuan training on the motor skills of children with ASD. The 18 participants in this study were 6-12 years old and were randomly divided into either the treatment or control groups. The results of this study indicate that there was a significant improvement in ball skills and balance performance of these children, but no improvements in manual agility following the training intervention (Sarabzadeh, Azari, & Helalizadeh, 2019). The findings of this study suggest that full-body movement and exercise can improve the motor skills of children with ASD.

Another group of researchers investigated two unique interventions, Sports, Play and Active Recreation for Kids (SPARK) and exergaming (Kinect), and their effect on the motor skills and executive functions of children with ASD. They recruited 60 children ages 6-10 with ASD diagnoses and randomly assigned them to either the SPARK, Kinect, or control groups. Their work indicates that there was a significant improvement in motor skills for the SPARK group, specifically in aiming and catching (Rafiei Milajerdi, et. al., 2021). Although these researchers did not find as much significant improvement as anticipated, they found improvement in ball skills, which is worth further investigation with similar full-body movement programs. Overall, a review of the literature on movement-based interventions in ASD suggests
that these programs have the potential to positively impact the motor difficulties faced by children with ASD; however, this literature is limited at present with predominantly small sample size studies lacking control groups that compare movement interventions with standard-of-care therapies in ASD. There is a clear need for systematic and rigorous studies on whole-body movement programs in large samples of children with ASD to establish conclusively the value of adding movement interventions to the standard treatment of children with ASD.

Our lab has also conducted a pilot randomized controlled trial examining new interventions that involve full-body movement as opposed to the standard, seated treatment for ASD. Their pilot study finds that the children with ASD in the movement-based treatment groups improved their body coordination whereas the individuals that partook in the standard, seated treatment only saw significant improvement in fine motor coordination (Srinivasan, Kaur, Park, Gifford, Marsh, & Bhat, 2015). This study highlights where the current standard of care is insufficient. The typical treatment methods are effective at targeting fine motor skills but do not address the gross motor skills, revealing the need to reevaluate standard practices. Moreover, this group of researchers also looked at the improvement in communication skills of these same 36 children with ASD. Their findings show that movement-based interventions are a promising tool to enhance communication skills in children with ASD (Srinivasan, Eigsti, Gifford, & Bhat, 2016). Previously, it was assumed that standard, seated treatment was the best therapy for children with ASD, however, this pilot study suggests that full-body movements could be more effective in improving the gross motor and social skills of these individuals.

While the kind body movement is important when creating training programs, the type of program is also something to consider. Researchers from two universities in India explored various studies and presented the promise of music therapies in improving the development of
play interventions and motor and social skills

children with ASD. They predict that social interaction with eye contact, turn-taking, synchrony, and imitation can enhance the social skills of children with ASD. They also conclude that rhythmic stimulus can enhance the neural networks and improve social and communication skills (Bharathi, Jayaramayya, Balasubramanian, & Vellingiri, 2019). Again our lab has also conducted a similar review of various studies across many disciplines to guide future intervention development for individuals with ASD and the potential of music therapies. They feel as though multisystem music and movement therapies are promising and should be a priority in ASD intervention research and considered moving forward (Srinivasan & Bhat, 2013). Both groups of authors are presenting the potential of music therapies in improving the lives of those with ASD, which is a reason to investigate this kind of treatment.

Despite these findings suggesting promising intervention methods, it is imperative to investigate the influence of COVID-19 and the transition to telehealth on these proposed treatment methods. In light of the COVID-19 pandemic, I found it impossible to continue my research and analysis without considering the potential implications of the necessary shut-downs and restrictions. These mitigation efforts for COVID-19 have complicated all areas of life, leading me to wonder how the individuals with ASD who need regular interventions, typically conducted in person, are affected by the restrictions during their journeys of improving their quality of life while living with ASD. Limited research has been conducted on telehealth methods for ASD treatment but one study shows that it can be effective and useful to target individuals that cannot be seen in-person easily (Johnsson, Kerslake, Crook, 2019). Another group of researchers saw the gap in this research and compared the outcomes of 30 children with ASD undergoing parent-mediated interventions in-person and via telehealth. The 15 participants in each group showed no difference in the outcome measures (Hao, Franco, Sundarrajan, &
Chen, 2021). The results from this study imply telehealth interventions are just as effective as in-person interventions. Currently, telehealth interventions for children with ASD have looked almost exclusively at speech therapy and applied behavior analysis interventions. There is no research comparing the effects of movement-based interventions delivered face-to-face or online in children with ASD. Our lab’s study fills this gap.

All of this research looks at two main things. The first set of studies has looked at music-based movement interventions in children with ASD and the second has looked at movement interventions delivered in the absence of music in children with ASD. At the moment, it is unclear how these compare with each other. To identify the key ingredients that are crucial in movement-based interventions, we are conducting this study to compare both types of movement interventions compared to a standard-of-care, seated intervention. This thesis, however, will add to the existing research on whether the play, rhythmic, and music-based training results in improvements in motor and social skills of children with ASD. Additionally, this thesis will investigate whether or not the outcomes for this group differ between those that received the treatment in-person or via telehealth due to COVID-19 restrictions. We predict that individuals will improve their motor skills after training. We also predict that individuals will develop better social skills and will display an increase in the ability to share attention with others after training. Additionally, based on the existing literature, we also predict there to be no difference in the improvements between the individuals receiving face-to-face interventions and those receiving telehealth treatments.
Methods

Research Design

The data reported in this thesis is part of a larger ongoing multisite intervention study, the Play & Move study, conducted at the University of Connecticut and University of Delaware. This randomized controlled trial aims at evaluating the differential effects of three different types of interventions on children with ASD. Children in the study were randomly assigned to one of the three groups: play, move, or create groups. While the play and move groups engaged in whole-body movement games either to music (play group) or without music (move group), the create group engaged in seated play activities that resembled standard-of-care special education and occupational therapy-based interventions that children with ASD conventionally receive within school settings. For the sake of this thesis, my primary aim will involve assessing changes in motor and social skills in the play group from pretest to posttest using a within-subjects design. In the light of COVID-19, mid-way during the study, the research team had to switch from face-to-face, in-person research to telehealth intervention delivery using web conferencing platforms such as Webex/Zoom. Therefore, my secondary, exploratory aim will involve a comparison of the effectiveness of face-to-face (F2F) and telehealth intervention delivery in children receiving music and movement-based activities as part of the play group.

Participants

In order to qualify for the study, participants had to meet certain inclusion criteria. Participants had to be between the ages of 6 and 14 years with a diagnosis of Autism Spectrum Disorder. Parents were asked to provide medical records confirming the child’s diagnosis. The study excluded children who had additional visual, orthopedic, auditory, or neurological comorbidities that limited study participation. All of the participants’ parents and guardians were
well-informed about the study throughout the entire process and signed consent forms. The study is IRB approved and participants are compensated with a $100 gift card following study completion. I will report data from 9 participants who received play group training. Five of these participants received face-to-face intervention and the other four received interventions via telehealth.

The Intervention Protocol

Participants within the play group underwent training for 8 weeks with 2 sessions a week lasting approximately 90 minutes. The play group participants received creative movement training using music, dance, and yoga-based activities that were focused on imitation, synchrony, multi limb coordination, and balance practice in a synchronous fashion. An instructor was present at each session along with a model in order to create a sense of a collective group activity. For children who received the intervention via telehealth, in addition to the trainer and the model, the child’s caregiver was also present during the training sessions to facilitate the child’s compliance with the virtual interactions.

Each session was structured with the same eight components: hello song, action song, warm-up, music time, moving game, yoga, breathing game, and farewell song. First, children engage in a hello song consisting of a song paired with a variation of hand clapping. These activities promote singing, communication, and upper-limb coordination. The action song required participants to copy the movements presented. The action song had two parts. One incorporated the entire body, the other focused on fine motor hand movements. The warm-up involved all parts of the body with a song to get the child ready to engage in whole-body movements. Music time included activities with instruments such as maracas and tambourines. Each music time also had a drumming segment that was used to practice multi-step directions
and rhythmic patterns using both hands. The moving game engaged all parts of the body with practice of locomotor skills including running, skipping, hopping, galloping, leaping, etc. Moves were chosen to promote multi-limb coordination. Yoga was a combination of four different poses performed either to a song or while reading through a story. Three of these poses were as an individual and the fourth was a partner pose. The yoga activity aimed to build strength, balance, coordination and to promote cooperation between the child and their social partners. The breathing game promoted breathing control and relaxation. The goal of this is to have the participant relax and tune in to themselves. The farewell song promoted communication by having the children sing goodbye to the therapist and the model. The song was paired with a clapping pattern, similar to the hello song.

In addition to this structured schedule, strategic training principles were followed in the sessions. The sessions consist of the child, a trainer, and a model. As mentioned above, for the telehealth sessions, it may be hard to get the child to engage with the virtual partners and in these cases, parents and caregivers are also part of the sessions to help facilitate the interactions, ensure child compliance with training activities, and to provide manual assistance and in-person prompting as required for the child. The role of the trainer is to lead all the activities and facilitate the session. The role of the model is to create a sense of group play, be the child’s buddy, and encourage the child to complete training activities and games. The trainer and model also incorporated Picture Exchange Communication System (PECS) to provide structure and facilitate communication (Bondy, Frost, 1985) and Applied Behavior Analysis (ABA) principles throughout each session. These strategies aim to increase language and communication skills, improve attentional focus, social skills, memory, and decrease problem behaviors (Autism Speaks, 2021). Additional principles are used following PRREBS: graded prompting, repetition,
positive reinforcement, exploration, boards, and structure. Graded prompting involves modeling all moves before the child and providing hands-on assistance for the child to copy (note that hands-on assistance was provided by the trainer or model in the F2F sessions and by the caregiver in the telehealth-based sessions). Repetition involves repeating skills and moves during individual sessions and throughout the entire training process. Positive reinforcement includes verbal encouragement such as, “great work!” or gestural moves such as a high-five. Exploration is achieved by the flexibility of each session, i.e. providing opportunities for child-led activities where the adults followed the child’s lead and practiced activities/games that the child preferred. Additionally, the activities are structured so that the child can choose certain moves to do within them. Boards are used to provide a sequential picture schedule of each session and facilitate transitions from one activity to the next. Structure is maintained throughout the sessions by using the same people (trainer, model, parent), the same location, the same order of activities, and the same props.

**Modes of Intervention Delivery**

*In-person*

Five of the participants being evaluated in this paper received their play group interventions in-person. For 8 weeks, participants were visited twice a week by an instructor and model for the interventions. Sessions were approximately 90 minutes.

*Online*

The other five participants being evaluated in this paper received their play group interventions via a web platform, Zoom. For 8 weeks, participants and an adult in the household logged onto Zoom with an instructor and model. Sessions were approximately 90 minutes.
Measures

Pre and Post Testing

Participants underwent testing before and after their 8 week training period. The items of the pretest and posttest being evaluated in this paper are the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) and Joint Attention Task (JTAT).

BOT-2 Test

The Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) (Bruininks & Bruininks, 2005) was delivered at the pretests and posttests for all participants. The standardized, valid and reliable test of motor performance for 4-21 year old children and evaluates their fine and gross motor skills using 8 subtests. This paper focuses on gross motor skills and included the subtests of bilateral coordination, balance, running speed and agility, upper-limb coordination, and strength. We coded the best attempt for each participant for each of the items used to score the 5 subtests of the BOT. Point scores were obtained for all items within the subtests. Intrarater reliability and interrater reliability of over 90% were established on this coding scheme using 20% of the entire data set. Additionally, each score used in this thesis was coded by myself and another undergraduate student, to double-check the accuracy of the findings. If there were discrepancies between our scores, we would re-watch the testing item together and come to a consensus using input from the PI.

Bilateral Coordination. The bilateral coordination of individuals was evaluated with 7 different items. We count the number of correct moves for each of the items and this raw number of correct moves determines the child’s point score. Refer to table 1 below for the description of each item.
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scoring Criteria</th>
<th>Maximum Scores</th>
<th>Visual</th>
</tr>
</thead>
</table>
| Touching Nose with Index Finger – Eyes Closed | The participant stands with eyes closed and arms straight out. They then touch the tip of their pointer finger to the tip of their nose. | A nose touch does not count if the participant:  
  ● Opens their eyes  
  ● Fails to alternate arms  
  ● Fails to touch the tip of the nose  
  ● Fails to maintain continuous movements  
  ● Fails to extend arms fully  
  ● Moves head to meet index finger | Raw: 4  
  Point: 4 | ![Image](image1.png) |
| Jumping Jacks                              | The participant stands with feet together and arms at their side and performs a jumping jack by jumping and bringing their feet to the side and their arms up. | A jumping jack does not count if the participant:  
  ● Fails to maintain continuous movements  
  ● Jumps with legs but fails to swing arms and vice versa  
  ● Fails to synchronize arm and leg movements | Raw: 5  
  Point: 3 | ![Image](image2.png) |
| Jumping in Place – Same Sides Synchronized | The participant jumps by putting the same arm and leg forward. They alternate sides. | A jump does not count if the participant:  
  ● Fails to maintain continuous movements  
  ● Fails to move leg and arm on same sides together  
  ● Takes extra steps | Raw: 5  
  Point: 3 | ![Image](image3.png) |
| Jumping in Place – Opposite Sides Synchronized | The participant jumps by putting the opposite arm forward and leg back, then alternates. | A jump does not count if the participant:  
  ● Fails to maintain continuous movements  
  ● Fails to move leg and arm on opposite sides together  
  ● Takes extra steps | Raw: 5  
  Point: 3 | ![Image](image4.png) |
| Pivoting Thumbs and Index Fingers           | The participant touches the thumb and index finger of opposite hands and pivots the hand so the bottom thumb and index finger separate and come back together. | A pivot does not count if the participant:  
  ● Fails to maintain continuous movements  
  ● Fails to place thumbs or index fingers correctly  
  ● Allows pivot thumb and finger to separate prematurely | Raw: 5  
  Point: 3 | ![Image](image5.png) |
| Tapping Feet and Fingers – Same Sides Synchronized | While sitting, the participant simultaneously taps foot and fingers. | A tap does not count if the participant:  
  ● Fails to maintain continuous movements | Raw: 10  
  Point: 4 | ![Image](image6.png) |
Balance. Balance of the participants was evaluated by 10 items. We count the number of correct steps for the walking items and time the others in seconds. The raw number of correct steps and time corresponds to a point score. Refer to table 2 below for the description of each item.

**Table 2.** Individual items of the balance subtest of the BOT-2 (Bruininks, R. H., Bruininks, B. D., 2005).

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>ScorerCriteria</th>
<th>Maximum Score</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking Forward on a Line</td>
<td>The participant walks placing their feet on a line with their hands on their hips.</td>
<td>A step does not count if the participant:</td>
<td>Raw: 6</td>
<td><img src="image" alt="Visual" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Steps off the line</td>
<td>Point: 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Fails to keep hands on hips</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Stumbles</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Falls</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Walking Heel to Toe on a Line                  | The participant walks placing their feet on a line and touching their heel to their toe with their hands on their hips. | Each correct step is scored, up to 6. A step does not count if the participant: | Raw: 6         | ![Visual](image) |
|                                                |                                                                           | ● Fails to step heel-to-toe                                                     | Point: 4      |        |
|                                                |                                                                           | ● Steps off the line                                                             |               |        |
|                                                |                                                                           | ● Fails to keep hands on hips                                                    |               |        |
|                                                |                                                                           | ● Stumbles                                                                      |               |        |
|                                                |                                                                           | ● Falls                                                                        |               |        |

<p>| Standing with Feet Apart on a Line – Eyes Open | The participant stands with one foot in front of the other on a line with their hands on their hips. They attempt to balance up to 10 seconds. | This test is recorded in seconds. The trial is stopped if the participant:     | Raw: 10 s      | <img src="image" alt="Visual" /> |
|                                                |                                                                           | ● Steps off the line                                                             | Point: 4      |        |
|                                                |                                                                           | ● Fails to keep hands on hips                                                    |               |        |</p>
<table>
<thead>
<tr>
<th>Standing with Feet Apart on a Line – Eyes Closed</th>
<th>The participant stands with one foot in front of the other on a line with their hands on their hips and eyes closed. They attempt to balance up to 10 seconds.</th>
<th>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the line ● Fails to keep hands on hips ● Opens eyes</th>
<th>Raw: 10 s. Point: 4</th>
<th>Same as above, with eyes closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing on One Leg on a Line – Eyes Open</td>
<td>The participant stands with one foot on a line with their hands on their hips. They attempt to balance up to 10 seconds.</td>
<td>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the line ● Fails to keep hands on hips ● Fails to keep raised leg lifted to 45 degrees</td>
<td>Raw: 10 s. Point: 4</td>
<td>Same as above, with eyes closed</td>
</tr>
<tr>
<td>Standing on One Leg on a Line – Eyes Closed</td>
<td>The participant stands with one foot on a line with their hands on their hips and eyes closed. They attempt to balance up to 10 seconds.</td>
<td>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the line ● Fails to keep hands on hips ● Fails to keep raised leg lifted to 45 degrees ● Opens eyes</td>
<td>Raw: 10 s. Point: 4</td>
<td>Same as above, with eyes closed</td>
</tr>
<tr>
<td>Standing Heel to Toe on a Balance Beam – Eyes Open</td>
<td>The participant stands with one foot in front of the other on a balance beam with their hands on their hips. They attempt to balance up to 10 seconds.</td>
<td>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the balance beam ● Fails to keep hands on hips</td>
<td>Raw: 10 s. Point: 4</td>
<td>Same as above, with eyes closed</td>
</tr>
<tr>
<td>Standing Heel to Toe on a Balance Beam – Eyes Closed</td>
<td>The participant stands with one foot in front of the other on a balance beam with their hands on their hips and their eyes closed. They attempt to balance up to 10 seconds.</td>
<td>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the balance beam ● Fails to keep hands on hips ● Opens eyes</td>
<td>Raw: 10 s. Point: 4</td>
<td>Same as above, with eyes closed</td>
</tr>
<tr>
<td>Standing on One Leg on a Balance Beam – Eyes Open</td>
<td>The participant stands with one foot in front of the other on a balance beam with their hands on their hips. They attempt to balance up to 10 seconds.</td>
<td>This test is recorded in seconds. The trial is stopped if the participant: ● Steps off the balance beam ● Fails to keep hands on hips ● Fails to keep raised leg lifted to 45 degrees</td>
<td>Raw: 10 s. Point: 5</td>
<td>Same as above, with eyes closed</td>
</tr>
<tr>
<td>Standing on One Leg on</td>
<td>The participant stands with one</td>
<td>This test is recorded in seconds. The trial is stopped if the participant:</td>
<td>Raw: 10 s. Point: 5</td>
<td>Same as above, with eyes closed</td>
</tr>
</tbody>
</table>
The participant steps off the balance beam.
- Fails to keep hands on hips
- Fails to keep raised leg lifted to 45 degrees
- Opens eyes

Running Speed and Agility. Running speed and agility were tested with 5 items. We count the number of correct moves for each of the items and this raw number of correct moves determines the child’s point score. Refer to table 3 below for the description of each item. The shuttle run item needed to be adapted in order to accommodate for the at-home testing of children receiving interventions via telehealth. A scale was developed and used to estimate the expected time for the shuttle run with a 50-foot distance, which is what the BOT-2 test calls for.

Table 3. Individual items of the running speed subtest of the BOT-2 (Bruininks, R. H., Bruininks, B. D., 2005).

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scoring Criteria</th>
<th>Maximum Score</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuttle Run</td>
<td>The participant stands on one side of a 50-foot line, runs to the other side, grabs a block and returns.</td>
<td>This test is recorded in seconds. Timing continues if the participant stumbles, falls, fails to pick up the block, or drops the block.</td>
<td>Raw: ≤ 5.9 s. Point: 12</td>
<td>![Shuttle Run Image]</td>
</tr>
</tbody>
</table>
| Sideways Stepping over a Balance Beam | The participant steps over the balance beam one foot at a time with their hands on their hips. They complete as many steps as they can in 15 seconds. | Each correctly placed foot is counted. A step does not count if the participant:  
  - Fails to keep hands on hips  
  - Fails to move one foot at a time | Raw: ≥ 50 Point: 10 | ![Sideways Stepping Image] |
| One-Legged Stationary Hop | The participant hops up and down on their preferred leg with their hands on their hips. They complete as many hops as they can in 15 seconds. | A hop does not count if the participant:  
  - Touches the raised foot to the floor  
  - Fails to keep hands on hips | Raw: ≥ 50 Point: 10 | ![One-Legged Stationary Hop Image] |
**Upper-limb Coordination.** Participants used a tennis ball during this subtest and were tested on 7 items. We count the number of correct catches/dribbles for each of the items and this raw number of correct moves determines the child’s point score. Refer to table 4 below for the description of each item.

**Table 4.** Individual items of the upper limb coordination subtest of the BOT-2 (Bruininks, R. H., Bruininks, B. D., 2005).

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scoring Criteria</th>
<th>Maximum Score</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dropping and Catching a Ball – One Hand</td>
<td>The participant drops the ball, allows it to bounce and catches it with their preferred hand.</td>
<td>A catch does not count if the participant:  - Traps the ball against their body  - Catches the ball with both hands  - Catches the ball with non-preferred hand</td>
<td>Raw: 5  Point: 5</td>
<td><img src="image1.png" alt="Visual" /></td>
</tr>
<tr>
<td>Dropping and Catching a Ball – Both Hands</td>
<td>The participant drops the ball, allows it to bounce and catches it with two hands.</td>
<td>A catch does not count if the participant:  - Traps the ball against their body  - Catches the ball with one hand</td>
<td>Raw: 5  Point: 5</td>
<td><img src="image2.png" alt="Visual" /></td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>Scoring Rules</td>
<td>Raw</td>
<td>Point</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----</td>
<td>-------</td>
</tr>
</tbody>
</table>
| Catching a Tossed Ball – One Hand            | The participant is tossed a ball from 10 feet and they catch it with their preferred hand. | Each correct catch is scored, up to 5. A catch does not count if the participant:  
  - Traps the ball against their body  
  - Catches the ball with both hands  
  - Catches the ball with non-preferred hand | 5  | 5     |
| Catching a Tossed Ball – Both Hands          | The participant is tossed a ball from 10 feet and they catch it with both hands. | Each correct catch is scored, up to 5. A catch does not count if the participant:  
  - Traps the ball against their body  
  - Catches the ball with one hand | 5  | 5     |
| Dribbling a Ball – One Hand                  | The participant drops the ball then uses their preferred hand for each dribble. | Each correct dribble is scored, up to 10. A dribble does not count if the participant:  
  - Dribbles with non-preferred hand  
  - Catches the ball  
  - Allows the ball to bounce more than once between dribbles | 10 | 7     |
| Dribbling a Ball – Alternating Hands         | The participant drops the ball and then alternates hands for each dribble. | Each correct dribble is scored, up to 10. A dribble does not count if the participant:  
  - Does not alternate hands with each dribble  
  - Catches the ball  
  - Allows the ball to bounce more than once between dribbles | 10 | 7     |
| Throwing a Ball at a Target                  | The participant stands 7 feet away from a red target taped on the wall. They use their preferred hand to throw the tennis ball at the target with overhand form. | Each target hit is scored, up to 5. A throw does not count if the participant:  
  - Misses the target  
  - Throws underhand  
  - Steps over the line while throwing | 5  | 5     |

**Strength.** The strength subtest consisted of 5 items. A raw score is collected for each item which translates to a point score. Refer to table 5 below for a description of each item.
### Table 5. Individual items of the strength subtest of the BOT-2 (Bruininks, R. H., Bruininks, B. D., 2005).

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scoring Criteria</th>
<th>Maximum Score</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing Long Jump</td>
<td>The participant jumps forward with both feet on a line while swinging their arms.</td>
<td>The length of each jump is measured in inches. The length is measured to the closest heel. If a participant falls back, measure to where the hand lands.</td>
<td>Raw: ≥ 85” Point: 12</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
</tbody>
</table>
| Push-ups      | The participant places their weight on their knees or toes and bends their arms to 90-degrees, lowering their chest to the ground while maintaining a straight back.                                                   | A push-up does not count if the participant:  
  - Sags or lifts hips so that back is not straight                                                                                                 | Raw: ≥ 36 Point: 9 | ![Image](image2.png) or ![Image](image3.png) |
| Sit-ups       | The participant lies on the ground with their knees at 90-degrees. They raise their head, shoulders, and shoulder blades off the ground towards their knees. They complete as many sit-ups as they can in 30 seconds.            | A sit-up does not count if the participant:  
  - Pushes up from the floor with elbows  
  - Pulls on the floor or uses clothing to “climb” to the knees  
  - Fails to keep flat on the floor  
  - Fails to touch shoulder blades to the floor before another attempt                                                                 | Raw: ≥ 36 Point: 9 | ![Image](image4.png) |
| Wall Sit      | The participant sits with their back against the wall with their knees at a 90-degree angle and their arms crossing their chest. They complete as much of the 1-minute wall-sit they can.                        | Each second the participant holds the wall-sit is scored. The wall-sit is not valid if the participant:  
  - Fails to keep knees bent to a 90-degree angle  
  - Fails to keep back against wall  
  - Uncrosses arms                                                                                                                                   | Raw: 60 s. Point: 6 | ![Image](image5.png) |
| V-up          | The participant lies on the ground and raises their head, chest, arms, and legs off the floor. They hold this for as much of the 1 minute v-up they can.                                                           | Each second the participant holds the v-up is scored. The v-up is not valid if that participant:  
  - Touches head, chest, arms, or legs to the floor                                                                                                                                                                            | Raw: 60 s. Point: 6 | ![Image](image6.png) |
The Joint Attention Task (JTAT) test was used to assess the child’s ability to respond to the tester’s bids to share attention (Bean & Eigsti, 2012). The test assesses responsive joint attention, i.e. the child’s ability to share focus of attention with the tester in response to verbal and gestural bids initiated by the tester. The original test has a total of 9 items (4 verbal and 5 gestural bids). The test was revised to accommodate for testing over online platforms. Some of the previously tester-administered bids were administered by the parent or caregiver instead of the tester. For the children seen F2F, 2 additional tester reinforcement bids were coded for the reinforcement bids so that there were a total of 4 reinforcement bids coded across both modes of intervention delivery. This accommodation resulted in coding 11 items (4 verbal and 6 gestural) for each child. Additionally, parents were asked to also respond appropriately to the bids to help the child understand what the tester on the screen was referring to (for example, if the child was expected to look at a specific object in the room that the tester was bidding towards through the virtual platform, the parent was also asked to look in the same direction of the object being referred to). For both types of intervention, the tester follows prompts in order to test the participant’s ability to share attention. Individuals earn a point score and a response level score for each item in the JTAT test. The point score reflects the individual's response to the bid. For each response provided, we give one point to the child. The expected responses vary by the JTAT item but generally one point is awarded for each of the following responses: looking at the tester, making eye contact, providing an appropriate response in terms of gestures or actions, and an added verbal response. For the hello and bye bids, an additional point is reserved for the child smiling at the tester during them. Table 6 below lists the responses that were evaluated per item of the JTAT. For the response score, the greater the score, the better the child’s performance. We
are also assessing how much tester bidding is required for the child to respond to the specific item. The level of response score is based on the amount of prompting needed for the child’s response. A response level one requires the least amount of prompting whereas level three is the most amount of prompting. We reverse coded the level of response so that more points were given for the response that required the least amount of prompting. For each item, we calculated a composite score by summing the child’s point score and level of response. Intrarater reliability and interrater reliability were established for the JTAT over 90% using 20% of the entire data using the same procedure as the BOT-2 items.

Table 6. Individual JTAT bids (Bean, J. L., & Eigsti, I. M., 2012).

<table>
<thead>
<tr>
<th>JTAT Item</th>
<th>Description</th>
<th>JTAT Points</th>
<th>Verbal (V) or Gestural (G) Bid</th>
</tr>
</thead>
</table>
| Hello     | The tester waves “hi” or puts their hand out to shake or waves through the screen. | ● Correct action (waving or shaking hand)  
● Look at face  
● Eye contact  
● Smile  
● Verbal response | G |
| Hand pen  | The tester hands a pen or pencil to the participant without a verbal prompt. | ● Correct action (grabbing pen)  
● Look at face/pen  
● Eye contact  
● Verbal response | G |
| Side object | The tester makes a comment about something to the side of the participant and looks in that direction. (ex. poster) | ● Correct action (look at object)  
● Look at face  
● Eye contact  
● Verbal response | V |
| Back object | The tester makes a comment about something behind the participant and looks in that direction. | ● Correct action (look at object)  
● Look at face  
● Eye contact  
● Verbal response | V |
| Novel object | A metal object is placed on the ground and the tester looks at it and says it looks interesting. | ● Correct action (look at object)  
● Look at face  
● Eye contact  
● Verbal response | V |
| Personal | The tester looks at something on the | ● Correct action (look at personal) | V |
object | child and makes a comment about it. (ex. glasses) | item | *Look at face*  
*Eye contact*  
*Verbal response*  

| High-5 | The tester puts their hand up for a high-five. For the telehealth testing, the tester put their hand to the screen and an additional in-person parent bid was added. | *Correct action (give a high-5)*  
*Look at face*  
*Eye contact*  
*Verbal response*  

| Low-5/ Fist Bump | The tester puts their hand out for a low-five or fist bump. For the telehealth testing, the tester put their hand to the screen and an additional in-person parent bid was added. | *Correct action (give a low-5 or fist bump)*  
*Look at face*  
*Eye contact*  
*Verbal response*  

| Bye | The tester waves goodbye. | *Correct action (waving)*  
*Look at face*  
*Eye contact*  
*Smile*  
*Verbal response*  

**Dependent Variables and Statistical Approach**

For the BOT-2, we are using point scores on all the subtests. For the JTAT, our dependent variables include total scores for all bids (a sum of the composite scores for 11 items), total verbal bid score (a sum of the composite scores of verbal items), and total gestural bid score (a sum of the composite scores of gestural items). For each outcome measure, i.e. BOT-2 and JTAT, we report on dependent $t$ tests to assess changes in motor and social skills from pretest to posttest. For each variable, descriptive statistics of mean, standard deviation, and frequencies were calculated in order to draw these comparisons. An independent $t$ test was also used to note any differences between the changes in the individuals that received F2F interventions versus those that received interventions via telehealth. Statistical analyses were performed for point scores in each individual item within the subscales of the BOT as well as for total subscale scores calculated by summing point scores on all items within a subtest.
Results

In this analysis, 9 participants were evaluated. Participants were 10.61 (SD = 2.30) years old on average at the time of their pretests. The sample was 88.89% male and 11.11% female. Below we report data on training-related changes in motor skills as assessed using the subtests of the BOT-2 and in social skills as assessed using the JTAT. Given the small sample size and the associated lack of statistical power to detect training-related improvements, for each set of analyses, we report group data suggesting overall data trends as well as show individual data from all 9 children to provide information on the number of children in the group that followed the group trends. Finally, although these analyses are preliminary in nature due to the small sample size, we also show individual data trends related to differences in outcome measures based on the mode of intervention delivery F2F versus TH.

Change in Motor Skills assessed on the BOT-2 test

As shown in Figure 1, there were significant improvements in the bilateral coordination (Pretest M (SD) - 17.67 (5.32), Posttest M (SD) - 20.22 (4.17), \( p < 0.001 \)), running speed (Pretest M (SD) - 18.29 (8.75), Posttest M (SD) - 23.14 (6.62), \( p = 0.018 \)), and strength (Pretest M (SD) - 9.11 (5.08), Posttest M (SD) - 13.22 (4.49), \( p = 0.003 \)) subtests although there was a trend for improved posttest compared to pretest performance on all subtests of the BOT-2. Next, we discuss changes in performance on each of the individual subtests of the BOT-2.
Figure 1. Changes in the total point scores of each of the BOT-2 subtests evaluated in this paper from pretest to posttest. Note: error bars represent standard errors of the mean.

**Change in the Bilateral Coordination Subtest**

Our data suggests that 9 out of 9 children improved in performance from pretest to posttest for the bilateral coordination subtest. As shown in Figure 2a), we found the greatest improvements in the jumping items. We found the most significant improvement in jumping jacks (Pretest M (SD) - 2.67 (0.50), Posttest M (SD) - 3.00 (0.00, p = 0.08). Out of the 7 items assessed in the bilateral coordination subtest, as shown in the figure, children also demonstrated small improvements in the nose touch, jumping with the same side, jumping with opposite sides, and pivoting. Moreover, as suggested in Figure 2b), there do not seem to be significant differences in trends for improvement by intervention delivery mode suggesting that both children seen F2F and via TH improved their bilateral coordination skills with training (p = 0.245).
Figure 2. a) Changes in point score of individual items in the BOT-2 bilateral coordination subtest from pretest to posttest. Note: error bars represent standard errors of the mean, b) Changes in point score of the BOT-2 bilateral coordination subtest from pretest to posttest separated by face to face and telehealth interventions.

**Change in the Balance Subtest**

Our data suggests that 7 out of 9 children improved in performance from pretest to posttest for the balance subtest. The largest improvements were seen in standing one leg on a balance beam with eyes closed (Pretest M (SD) - 1.33 (0.71), Posttest M (SD) - 2.67 (0.87), $p = 0.02$) and standing one leg on a balance beam with eyes open (Pretest M (SD) - 2.22 (1.39), Posttest M (SD) - 2.89 (1.05), $p = 0.08$). Out of the 10 items assessed in the balance subtest, as
shown in the figure, children also demonstrated small improvements in walking heel to toe, standing with feet apart on a line with eyes open, standing on one leg with eyes open and with eyes closed, and standing heel to toe on a balance beam with eyes closed. As suggested in Figure 3b), there do not seem to be significant differences in trends for improvement by intervention delivery mode ($p = 0.785$).

**Figure 3.** **a)** Changes in point score of individual items in the BOT-2 balance subtest from pretest to posttest. Note: error bars represent standard errors of the mean, **b)** Changes in point score of the BOT-2 balance subtest from pretest to posttest separated by face to face and telehealth interventions.
Change in the Running Speed Subtest

Two children were not included in the analysis of the running speed subtest because they were not tested on these items. Our data suggests that 6 out of 7 children followed the group trends of improvement in performance from pretest to posttest for the running speed subtest. As shown in Figure 4a), we found improvements in all 5 items. We found a trend in improvement in the shuttle run (Pretest M (SD) - 1.57 (1.99), Posttest M (SD) - 2.57 (2.30), \( p = 0.06 \)). Moreover, as suggested in Figure 4b), there do not seem to be significant differences in trends for improvement by intervention delivery mode suggesting that both children seen F2F and via telehealth improved their running speed skills with training \( (p = 0.645) \).
Figure 4. a) Changes in point score of individual items in the BOT-2 running speed subtest from pretest to posttest. Note: error bars represent standard errors of the mean., b) Changes in point score of the BOT-2 running speed subtest from pretest to posttest separated by face to face and telehealth interventions.

Change in the Upper limb Coordination Subtest

Our data suggests that 5 out of 9 children improved in performance from pretest to posttest for the upper limb coordination subtest. We found the most significant improvement in catching a tossed ball with both hands (Pretest M (SD) - 3.89 (1.76), Posttest M (SD) - 4.22 (1.72), \( p = 0.081 \)). Out of the 6 items assessed in the upper limb coordination subtest, as shown in the figure 5a), children additionally demonstrated small improvements in dropping and catching the ball with one hand, catching a tossed ball with one hand, and dribbling with one hand. Further, as suggested in Figure 5b), there do not seem to be significant differences in trends for improvement by intervention delivery mode for the upper limb coordination subtest (\( p = 0.206 \)).
Figure 5. a) Changes in point score of individual items in the BOT-2 upper limb coordination subtest from pretest to posttest. Note: error bars represent standard errors of the mean. b) Changes in point score of the BOT-2 upper limb coordination subtest from pretest to posttest separated by face to face and telehealth interventions

**Change in the Strength Subtest**

Our data suggests that 9 out of 9 children followed the group trends of improvement in performance from pretest to posttest for the strength subtest. Out of the 5 items assessed in the strength subtest, as shown in figure 6a, children demonstrated improvements in all items except push-ups. Of these significant improvements were seen on the sit-ups (Pretest M (SD) - 1.67 (1.50), Posttest M (SD) 2.89 (1.17), $p = 0.038$) well as trends for improvement in wall sit (Pretest M (SD) - 3.00 (1.50), Posttest M (SD) - 4.11 (1.67), $p = 0.095$), and v-up performance (Pretest M (SD) - 1.11 (1.36), Posttest M (SD) - 2.00 (1.66), $p = 0.069$). Moreover, as suggested in Figure 6b), there do not seem to be significant differences in trends for improvement by intervention delivery mode suggesting that both children seen F2F and via TH improved their strength with training ($p = 0.765$).
**Figure 6. a)** Changes in point score of individual items in the BOT-2 strength subtest from pretest to posttest. Note: error bars represent standard errors of the mean, **b)** Changes in point score of the BOT-2 strength subtest from pretest to posttest separated by face to face and telehealth interventions.

**Change in Social Skills assessed on the JTAT**

The $t$ test for JTAT indicated no significant improvement in scores following training (Pretest M (SD) - 37.33 (3.87), Posttest M (SD) - 37.78 (4.94), $p = 0.29$). As shown in figure 7b), however, 6 out of 9 children saw improvements in their total JTAT score. Also seen in the figure, there is no significant difference in improvement between the training F2F or via TH ($p = 0.832$).
Figure 7. a) Changes in combined point and level of response from pretest to posttest for gestural JTAT items, verbal JTAT items and total JTAT score. Note: error bars represent standard errors of the mean, b) Changes in the total composite score of the JTAT from pretest to posttest separated by face to face and telehealth interventions.
Discussion

This thesis paper investigated whether an 8-week training program using whole-body movement games to music was effective in improving the motor and social skills of school-age children with ASD. Although our data are preliminary given our small sample size, we found trends for improvement in gross motor performance as assessed on the BOT-2 across different subtests in all 9 children in the play group. Children scored high on the JTAT to begin with and although not statistically significant, 6 out of 9 children showed a trend for improvement on overall JTAT scores from pretest to posttest.

In line with our hypothesis, motor skills improved after a play-based intervention program. This research expanded upon the ideas presented regarding the benefits of full-body movement programs (Srinivasan, Kaur, Park, Gifford, Marsh, & Bhat, 2015; Rafiei Milajerdi, et. al., 2021) and the potential of music integration (Bharathi, Jayaramayya, Balasubramanian, & Vellingiri, 2019; Srinivasan, & Bhat, 2013). Though we saw improvements across all tests, only three of the five subtests showed statistically significant improvement.

The three subtests where we saw significant improvement were bilateral coordination, running speed, and strength. The training sessions incorporate moves that involve multi-limb movements that require the child to coordinate movements involving both sides of the body, strengthening the skills tested in the bilateral coordination and running speed subtests. As seen in figure 2a) jumping with the same side was not an adequate measure as each participant scored the maximum score at their pretest and could not show improvement within the restraints of the BOT-2 coding scheme. The training emphasizes full-body movement and coordination, skills needed across all of these subtests. Each session the child engages in a variety of full-body movements that increase their overall strength. For instance, the yoga activities specifically
target core strength which may have contributed to improvements in the strength items of the BOT-2. As you can see in figure 6a), the push-up item of the strength subtest appears to be too challenging of a measure. Each of the 9 participants in this study was never able to complete even one push-up. However, while coding this subtest, I did note potential qualitative improvements in the push-up item that cannot be captured by the restraints of the BOT-2 coding. For instance, from pretest to posttest, some children demonstrate smoother form, even if they are still not able to complete a push-up according to the BOT-2 scoring criteria. I recommend this observation is further explored. A different coder could analyze the movement quality and form of the push-up along with strength items in order to capture the improvements I have observed.

Contrary to the promise shown in the Tai Chi Chaun study (Sarabzadeh, Azari, & Helalizadeh, M, 2019) and the pilot study (Srinivasan, Kaur, Park, Gifford, Marsh, & Bhat, A. 2015), we did not find significant improvements in balance. Our sample size is small which may explain this contradiction to previous indications of improvement. Balance is targeted during the yoga activities, yet we do not practice with eyes closed, which is tested in BOT-2. Further, 1 leg balance is practiced during the moving games, but we do not integrate balancing on narrow surfaces like the balance beam used in testing. All of these factors may have limited improvements in the balance subtest. An interesting find of the balance subtest analysis, however, was a significant improvement in the most challenging item, balancing one foot on a balance beam with eyes closed. I feel this could be reflective of an overall improvement in physical ability after the sessions. Moreover, since it was the lowest scoring item from the beginning, it left more room for improvement at the posttest. Going forward, I think that more balance could be incorporated into the play group sessions in order to target this subtest. I would recommend that yoga poses are also practiced with eyes closed and movements incorporated into
the moving game could engage the child in balance practice, such as shifting weight from one foot to the other.

There was also no significant improvement in the upper limb coordination subtest, rejecting the prediction and contradicting previous evidence (Sarabzadeh, Azari, & Helalizadeh, 2019). Similar to the explanation for balance, the play group training does not involve any ball work and each item of this subtest uses a tennis ball. The move group of the study, however, does practice ball-related skills so we expect to see improvements in this group on this subtest. If these trends continue, ball work should be incorporated into the sessions in order to improve upper limb coordination and hand-eye coordination. Ideas to accomplish this are tossing a ball to the person you want to sing hello to in the hello song, or treating the ball as the “talking ball” so that the individual with the ball can ask or answer questions, which could be useful during the embedded social bids from the model. With this indication from a small sample of the study, it would be worthwhile to consider how the upper limbs could be better engaged in such a training program.

Contrary to the hypothesized association and leads presented in the pilot study (Srinivasan, Eigsti, Gifford, & Bhat, 2016), this analysis shows no significant improvement in the joint attention (JTAT) test across the 9 participants. During the sessions, the child is engaged in communication, but sharing attention is not necessarily practiced. The JTAT test tends to be extremely scripted and unnatural, unlike the flow of communication in the actual sessions. Though not an aim and reported in this thesis paper, our lab codes the child’s communication skills and behavioral responses during naturalistic exchanges, which may be a better measure of the level of engagement, compliance, and communication of the child rather than the scripted and structure JTAT bids and is something to look at upon completion of the study. Further,
administering this test over the screen and ensuring parents were following the bids is extremely challenging. Moreover, due to the nature of ASD, this test is a difficult measure for these children because some days they may be extremely attentive and engaged socially, while others they may not. Although there was no significant improvement across the sample, ⅔ of the children saw improvements in their score, which is promising. A better gauge on the conclusion of this intervention method and its effectiveness in improving joint attention can be made after this study and with further investigation looking at naturalistic communication improvements as well.

The secondary aim of this thesis paper was to examine any significant differences in the changes pretest to posttest between the five children who received their training face to face and the four who received their training over web platforms.

There were no significant differences across modes of intervention delivery which is a comfort to know that treatment was not compromised due to COVID-19 and shows promise for the future of telehealth. It was obvious that any intervention would be better than none but it is extremely gratifying to know that there is no difference in their effectiveness, according to this analysis in further support of previous findings (Hao, Franco, Sundarraj, & Chen, 2021). The COVID-19 pandemic is also changing the look of healthcare. We anticipate more and more treatments will be transitioning to telehealth, therefore researching this discipline is pivotal and urgent. If findings continue to follow this trend, it could lead to the development of a hybrid training and treatment plan for individuals with ASD. After all, implementing interventions and testing at home is much easier for the families. Time is saved and there are no restraints on the distances between the trainer, model, and child, expanding access to more individuals. There are also drawbacks to telehealth interventions that should be considered, such as the need for greater...
parental support and difficulty engaging certain, more affected children via the screen. Overall, there is a need for more research to systematically and rigorously compare F2F and telehealth-based intervention delivery for the delivery of movement-based interventions for children with ASD.

The results of this thesis exhibit promise for the improvements in the play group for the remainder of the Play & Move Study. If these trends continue, clinicians and families should consider implementing such training programs into the lives of children with ASD in order to improve their motor trajectories and ultimately, their quality of life. These results, that expand upon previous research and evidence, should be taken into account when considering how to tend to children with ASD. The use of music, play and full-body motions should not be overlooked when treating and providing therapies for children with ASD. The rest of this study will look at how the play group compares to the move and create groups, answering the remaining question of whether a movement-based program with music is more effective than one without music.

Overall, the study had a strong research design in order to generate reliable results. Each child’s experience with ASD can differ greatly. Using a within-subjects design for my analysis allows me to see the change to the individual participant first and then draw conclusions based on the entire group trends, which serves to the nature of ASD and how each child on the spectrum has differing functioning levels. Additionally, each subtest of the BOT-2 has many individual items within itself and does not rely on just one specific move to show improvement. Some items, like the push-up and jumping with the same side may not be very sensitive in capturing training-related improvements due to floor or ceiling effects, respectively. Having multiple items within each test accounts for this and still allows me to get reliable results.
Moreover, as mentioned previously intrarater and interrater reliability was established which is especially important for these outcome measures as the scoring criteria and movements can be ambiguous. Further, having two coders for each item led to a productive discussion between the coders and the principal investigators when there were discrepancies, resulting in a clear conclusion on a final score. In addition, both myself and the other coders were blinded to which group the participant belonged to at the time of our coding, eliminating any bias.

Despite the strong research design, this analysis has its limitations. First, this is a small sample size, therefore we lacked the power to detect smaller changes in outcome measures and limiting the conclusion to initial findings that show promise for the future of the study. The reliability of the data is impacted by tester errors. For multiple items of the BOT-2 test, participants were not always explained the correct form, such as putting their hands on their hips for balance and running speed items. In these cases, if the child was not told to do something and the coders did not think it was influencing their ability to balance or complete the task, points were not deducted. Another testing error seen during timed items is occasionally the tester stopped the child before reaching the given time, limiting their possible score. Due to these testing errors, there is occasionally a decrease in the score of items from the pretest to posttest even if there is no qualitative decrease in the participant’s ability. Additionally, of the nine participants, only one was female. Although I did not look at gender specifically, a sample with a more evenly distributed gender would provide a more representative sample and would allow me to investigate differences between gender. Lastly, it is beyond the scope of this investigation to conclusively determine whether music therapies are effective in improving the motor and social skills of children with ASD. This conclusion can be made only after the completion of the entire
study and a comparison between the play and move groups. Further studies should take into consideration and account the errors I faced in this analysis in order to refine these findings.

In summary, the study suggests that socially-embedded, whole-body music and movement activities are enjoyable and engaging contexts that are effective in promoting the very motor skills that are impaired in children with ASD. Our study provides preliminary evidence in support of the inclusion of these activities in the standard-of-care treatment of children with ASD. Although this is a promising first step and indication, continued research needs to explore music and movement and other combinations of interventions aimed at promoting motor and social communication skills in children with ASD.
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