Brief Report

Mixed martial arts training improves social skills and lessens problem behaviors in boys with Autism Spectrum Disorder

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ABSTRACT

Background: Difficulties with social functioning are a defining core characteristic among children with Autism Spectrum Disorder (ASD). Fortunately, adaptive social skills can be acquired. Physical exercise has gained interest among researchers as a practical way to improve social functioning in children with ASD. The present study evaluated the effectiveness of a Mixed Martial Arts (MMA) intervention for improving social skills and lessening problematic social behaviors in school-aged boys with ASD.

Method: Thirty-four boys and girls (n = 28 boys, 6 girls) with ASD were randomly assigned to either a community-based MMA intervention or a Waitlist Control (WLC) condition. Randomization resulted in an intervention group of all boys. Assessments of child functioning were conducted pre- and post-intervention. The 26-session MMA intervention consisted of learning and practicing increasingly challenging motor movements in a structured class with ASD and typically-developing peers. The WLC group did not participate in any intervention between pre- and post-test. Measures of implementation fidelity were included.

Results: Results indicated significant interactions between group and predicted social functioning over time. Compared to the control group, parents of boys with ASD in the martial arts group reported significantly higher positive social behaviors and significantly lower negative social behaviors between pre- and post-test.

Conclusions: The results of this study increase our understanding of the benefits of martial arts training for boys with ASD within a community setting. Practical implications highlight the importance of providing a social component with physical exercise, helping to address the physical needs of children with ASD and perhaps conferring social benefits as well.

1. Introduction

Poor social functioning affects children with Autism Spectrum Disorder (ASD) by limiting the individual’s ability to effectively communicate and engage in social exchanges, which has consequences for interpersonal relationships and daily functioning (American Psychiatric Association, 2013). Past research has indicated that deficiencies in social functioning can be improved through intervention (e.g., social skills groups; Reichow & Volkmar, 2010). The current study examined the learning of martial arts in a social

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context with the aim of improving the social functioning of school-aged children with ASD. In the present study, two components of social functioning were emphasized: 1) presence of and efficient use of adaptive social skills (i.e., learned behaviors that promote positive social interactions), and 2) absence of social deficits and dysfunction (i.e., problematic social behaviors that inhibit social skills)

Examples of adaptive social skills involved maintaining appropriate eye contact and attention, initiating and responding to social overtures, asking for help from adults, forgiving others, and expressing feelings when wronged (Gresham & Elliott, 2008; Lord et al., 2012). Examples of social dysfunction and/or problematic social behaviors included having temper tantrums, talking back to adults, lying or withholding the truth, not maintaining appropriate reciprocity during conversation, and not abiding by social/cultural norms (American Psychiatric Association, 2013; Gresham & Elliott, 2008; Lord et al., 2012).

Structured physical exercise is an understudied and widely-variable intervention that has emerged as an efficacious way to improve children’s social functioning. A growing body of research of physical activity interventions with children and adolescents with ASD suggests that physical activities yield benefits for social functioning (Bremer, Crozier, & Lloyd, 2016). The relationship between physical exercise and social functioning appears to be bidirectional. Children with social difficulties may be less likely to be enrolled in activities that promote physical exercise (Must, Phillips, Curtin, & Bandini, 2015). The lower rates of participation in physical activities may limit the opportunities available to practice social skills and acquire certain motor skills that depend on interacting with another person like catching and throwing a ball (Memari et al., 2017). Indeed, physical exercise provides a social context that offers unique opportunities for social learning to take place; children are given an opportunity outside of academic and clinical settings to practice social skills such as observation, imitation, and emotion regulation (Habib, Montreuil, & Bertone, 2018).

The types of physical exercises implemented in past intervention studies with children with ASD have included individualized activities. For example, one study implemented a six-week golfing program with 46 children and young adults with ASD and reported statistically significant increases in communication, social, motor, and regulatory skills between pre- and post-test (Shanok, Sotelo, & Hong, 2019).

Results of a meta-analysis of 16 behavioral studies that examined structured physical activities among 133 children and adults with ASD revealed that individual interventions appeared to generate a larger positive effect on social interaction relative to group interventions (Sowa & Meulenbroek, 2012). However, the authors noted that they could not find any publications with a naturalistic group-based sports intervention such as soccer. It was unclear whether the eight studies categorized as “group” interventions in the meta-analysis included actual meaningful social interactions between the participant with ASD and others (Sowa & Meulenbroek, 2012). Although some individualized physical activities may involve social components (e.g., talking to coaches and teammates), social interactions are not a requirement of participating in the activity itself. In contrast, group physical activities, broadly defined as two or more persons interacting in a structured manner (Weinberg & Gould, 2018), require social interactions during participation (e.g., throwing and catching a ball). For example, Howells et al. (2020) implemented a community-based organized junior football program (Auskick) with 19 children with ASD. Compared to the control group, caregiver-reported social problems decreased after children participated in the program, but there were no group differences in socialization and communication. These results justify the need for more research in group physical activities, which have been less studied than individualized physical activities.

To address the limitation in the Sowa and Meulenbroek (2012) meta-analysis, Howells et al. (2019) conducted a separate meta-analysis focused on studies that examined group-based organized physical activity on social outcomes among youth with ASD. Organized physical activity was defined as “formal and structured training sessions that were supervised by a paid or volunteer coach/adult and were organized by a club or recreational association” (Howells et al., 2019). Eleven articles reporting on a total of 379 children and adolescents with ASD were included in the meta-analysis. Results indicated that group-based organized physical activities yielded a small-to-medium effect for improving social functioning, but no significant improvement was found in levels of communication (Howells et al., 2019). Although the number of studies and total number of participants in the meta-analysis is not large, structured group physical activities that include clear rules and adequate adult support may provide opportunities for children with ASD to further develop social skills and minimize social problems in naturalistic settings (Howells et al., 2019).

Another form of structured physical exercise has shown promise for improving social functioning in children with ASD: martial arts. Martial arts are unique compared to the activities discussed previously because they are an individualized physical activity learned in the context of a group. In essence, martial arts are both individual- and group-based. Martial arts learning occurs in a social context and requires an experienced instructor to teach a group of students. Students practice the techniques on their own (e.g., shadowboxing) in addition to practicing interactively with one or more partners (e.g., partner-drilling). Yet, unlike traditional team sports, martial arts focus on self-improvement rather than social comparison or score-keeping. Therefore, the associated physical rigor and motor complexity combined with both individual- and group-based training make martial arts practice a potentially effective structured physical activity to improve social functioning.

We know of two studies that have examined the impact of martial arts on social functioning in children with ASD. In one study, Movahedi, Bahrami, Marandi, and Abedi (2013) examined social dysfunction; children and adolescents with ASD were randomly assigned to participate in Kata training (i.e., Japanese karate forms) or a no-exercise control group. Caregivers and teachers reported on the severity of children’s social dysfunction pre-, immediately post-, and one-month post-intervention. Children who received the Kata training had less social dysfunction immediately post- and one-month post-intervention compared to their pre-test scores (Movahedi et al., 2013). Similar results were found by Bahrami, Movahedi, Marandi, and Sorensen (2016) using the same study design to examine the lessening of communication deficits through Kata training. The findings from these studies indicate that martial arts can be effective for decreasing social communication deficits. In addition to lessening social communication deficits, children with ASD also need to improve their social skills. In the current intervention study, adaptive social skills were included as an outcome. In these previous studies, participant ages varied widely (5- to 16-years-old); the present study focused only on children in middle-childhood (8- to 11-years-old).
1.1. The current study

The goal of the current study was to evaluate the effectiveness of a Mixed Martial Arts (MMA) intervention on both improving social skills and decreasing social dysfunction in children with ASD. Hypothesis 1 states that children who receive the martial arts intervention improve their parent-reported social skills compared to a wait-list control group that does not receive the intervention. Hypothesis 2 states that children who receive the martial arts intervention demonstrate fewer parent-reported problematic social behaviors compared to the control group.

2. Method

2.1. Participants

The current study was approved by the university’s institutional review board. Children with ASD were recruited from a departmental database of families who consented to be contacted for future studies and through recruitment flyers distributed to community organizations. The sample consisted of 34 children with ASD (aged 8–11 years, $M_{age}=9.34$ years, $SD=1.08$; 82.4% boys, $n=28$) and one of their parents ($n=27$ mothers, 7 fathers). Three sets of criteria were used to determine ASD status: met criterion for having a parent-reported clinical diagnosis of ASD, met qualifying criteria on the researcher-implemented Autism Diagnostic Observation Schedule – 2nd Edition (ADOS-2; Lord et al., 2012), and met qualifying criteria on the parent-reported Lifetime Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003). Demographic characteristics are shown in Table 1.

2.1.1. Mixed Martial Arts (MMA) group

Due to an unintended consequence of randomization, the MMA group consisted of all boys ($n=14$) with ASD. This group had two lab visits separated by the targeted 13-week martial arts intervention in which they participated (Table 1).

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
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<tbody>
<tr>
<td>Demographic Characteristics of Study Participants.</td>
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<tr>
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<tr>
<td>Child characteristics</td>
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<tr>
<td>Sex</td>
</tr>
<tr>
<td>Girls</td>
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<tr>
<td>Boys</td>
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<tr>
<td>Ethnicity</td>
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<tr>
<td>Latino/Hispanic (non-Caucasian)</td>
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<tr>
<td>White/Caucasian (non-Hispanic)</td>
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<tr>
<td>Asian/Asian American</td>
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<tr>
<td>Multiracial/other</td>
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<tr>
<td>M(SD)</td>
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<tr>
<td>Child age</td>
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<tr>
<td>SCQ total</td>
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<tr>
<td>ADOS-2 Comparison score</td>
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<tr>
<td>WASI-II Full-Scale IQ</td>
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<tr>
<td>CBCL Internalizing problems</td>
</tr>
<tr>
<td>CBCL Externalizing problems</td>
</tr>
<tr>
<td>SRS-2 total</td>
</tr>
<tr>
<td>SSIS – Social Skills pre-test</td>
</tr>
<tr>
<td>SSIS – Problem Behaviors pre-test</td>
</tr>
<tr>
<td>Family characteristics</td>
</tr>
<tr>
<td>Income</td>
</tr>
<tr>
<td>$\leq$49,999</td>
</tr>
<tr>
<td>$50,000–99,999</td>
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<tr>
<td>$100,000–149,999</td>
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<tr>
<td>$150,000–199,999</td>
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<tr>
<td>$200,000–249,999</td>
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<tr>
<td>$250,000+</td>
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<tr>
<td>Maternal education (highest level)</td>
</tr>
<tr>
<td>High school</td>
</tr>
<tr>
<td>Post high school certificate/specialized training</td>
</tr>
<tr>
<td>Community college (AA)</td>
</tr>
<tr>
<td>University/college (BA, BS)</td>
</tr>
<tr>
<td>Graduate/professional degree</td>
</tr>
</tbody>
</table>

*a LR = Likelihood ratio for cell frequencies < 5.

| b p < .10.

| c p < .05.
2.1.2. **Waitlist Control (WLC) group**

The WLC group consisted of 20 children (n = 14 boys, 6 girls) with ASD. This group had two lab visits separated by a similar lapse in time in which the children did not participate in any martial arts activities (Table 1).

2.2. **Procedures**

Study procedures included an online parent questionnaire and two family visits to the university lab for child testing and parent questionnaires. After obtaining parental consent to participate in the study, a researcher scheduled the family’s first visit to the university lab and emailed the link to the secure online questionnaire. Within one week prior to the first lab visit, parents completed the secure online questionnaire on child and family characteristics. Parents received $10 in cash/gift card as compensation for completing the online questionnaire.

During the first visit to the university lab, the lead author administered diagnostic measures to assess child intellectual functioning and to objectively confirm the ASD diagnosis. Children took water and bathroom breaks as needed. While the child and lead author were occupied, in a separate, nearby room, a research assistant (RA) administered the parent questionnaires and told parents she would remain in the room to answer any questions they might have.

After the first lab visit, children were randomly assigned to the MMA or WLC group. Children in the MMA intervention group then began the MMA intervention (see below) within 2 weeks of their pre-test assessment. In the same manner, children in the WLC group began the waiting period in which they did not participate in any martial arts between pre- and post-test. After the respective MMA intervention and waiting periods, all participants returned to the university lab for post-test assessments. All of the children in the MMA group were tested within three days of their last intervention class session and the children in the WLC group were tested at post-test after a similar waiting period. At the post-test assessment, parents once again completed questionnaires about their child with the RA nearby. Families were compensated $20 in cash/gift card at the end of each of the two lab visits ($40 total).

2.3. **Measures**

2.3.1. **Child and family characteristics**

Parents reported child and family characteristics on the online questionnaire. Child characteristics included binary sex assigned at birth (male or female), ethnicity, and age. The online questionnaire also included the SCQ (Rutter et al., 2003), a parent-report tool used by clinicians to quickly screen for ASD. In research, it has been used to confirm parent report of a clinical ASD diagnosis (e.g., Matthews, Goldberg, & Lukowski, 2013). SCQ scores of 12 or higher combined with parent report of a clinical diagnosis are consistent with the gold standard for ASD diagnostic assessment (Daniels et al., 2012). Child characteristic measures also included parent-reported internalizing and externalizing problems from the Child Behavior Checklist School-Age Form (CBCL; Achenbach & Elliott, 2008). The SSIS has been validated for use with participants 3- to 18-years-old and has been used with ASD samples (Ozonoff & Miller, 1995) to evaluate social skills (e.g., takes turns in conversations; makes eye contact with talking) and problem behaviors (e.g., repeats the same thing over and over; becomes upset when routines change) across multiple reporters, including parents, teachers, and children themselves in different contexts such as home, school, and the community. The SSIS has high internal consistency and has been used to provide a baseline measure at pre-intervention and to evaluate progress post-intervention (Gresham & Elliott, 2008). On the SSIS, parents rated the frequency of desirable and undesirable social behaviors, from 0 (never) to 2 (very often). For use in data analysis, the SSIS raw scores were converted to standard scores per scoring instructions. Standard scores loaded onto two scales: Social Skills and Problem Behaviors. Higher scores on the Social Skills Scale indicated higher social competence (i.e., assertion, communication, cooperation, empathy, engagement, responsibility, and self-control; Gresham & Elliott, 2008). Higher scores on the Problem Behaviors Scale indicated more problem behaviors (i.e., bullying, externalizing and internalizing problems, hyperactivity and inattention; Gresham & Elliott, 2008). The same parent completed the SSIS at the pre- and post-test lab visits.

2.3.2. **Diagnostic measures**

At the first lab visit (pre-test), diagnostic measures were administered to assess child intellectual functioning and to further confirm the ASD diagnosis. The Wechsler Abbreviated Scale of Intelligence – 2nd Edition (WASI-II; Wechsler, 2011) was implemented by the lead author to obtain a child IQ score. After giving the WASI-II, the lead author, who is certified to be research reliable on the ADOS-2, administered the assessment to confirm ASD diagnosis and obtain autism symptomology (Lord et al., 2012).

2.3.3. **Social functioning**

At both pre- and post-test lab visits, children’s social functioning was measured by parent report on the Social Skills Improvement System (SSIS; Gresham & Elliott, 2008). The SSIS has been validated for use with participants 3- to 18-years-old and has been used with ASD samples (Ozonoff & Miller, 1995) to evaluate social skills (e.g., takes turns in conversations; makes eye contact when talking) and problem behaviors (e.g., repeats the same thing over and over; becomes upset when routines change) across multiple reporters, including parents, teachers, and children themselves in different contexts such as home, school, and the community. The SSIS has high internal consistency and has been used to provide a baseline measure at pre-intervention and to evaluate progress post-intervention (Gresham & Elliott, 2008). On the SSIS, parents rated the frequency of desirable and undesirable social behaviors, from 0 (never) to 2 (very often). For use in data analysis, the SSIS raw scores were converted to standard scores per scoring instructions. Standard scores loaded onto two scales: Social Skills and Problem Behaviors. Higher scores on the Social Skills Scale indicated higher social competence (i.e., assertion, communication, cooperation, empathy, engagement, responsibility, and self-control; Gresham & Elliott, 2008). Higher scores on the Problem Behaviors Scale indicated more problem behaviors (i.e., bullying, externalizing and internalizing problems, hyperactivity and inattention; Gresham & Elliott, 2008). The same parent completed the SSIS at the pre- and post-test lab visits.

2.4. **Mixed Martial Arts (MMA) intervention**

The procedures for the intervention were developed through collaboration between the lead author and senior martial arts instructors at a local martial arts studio. Program content was adapted from the curriculum for the typically-developing (TD) MMA classes; intensity of the intervention (i.e., dosage) was based on a prior study that examined the effects of martial arts training on self-
regulation in TD school-aged children (Lakes & Hoyt, 2004). The intervention took place at the local martial arts studio and was designed to have 26 45-minute class sessions over 13 weeks. During this time, children with ASD in the intervention group learned increasingly challenging motor movements (e.g., combinations of punches and kicks) and practiced these movements with same-aged TD peers (i.e., peer buddies). Each class began with bowing and a mindfulness exercise (5 min), followed by a brief warm-up activity (15 min), the main martial arts activity (20 min), and a cool-down game at the end (5 min). The main activity consisted of two adult instructors demonstrating the different martial arts techniques on each other as the students watched. Then, students practiced the techniques in dyads while the instructors supervised and provided feedback; the techniques increased in complexity over the course of the program. In the first four weeks, ASD-TD partners took turns holding punching mitts and kicking pads for one another. The next four weeks of the program emphasized “partner-drilling”, wherein a child with ASD and a TD peer practiced multi-step sequences of MMA techniques repetitiously in a reciprocal, turn-taking manner. In the last five weeks of the program, dyads practiced all of the different techniques learned over the course of the program in dynamic, reciprocal interactions.

In addition to the study participants and the peer buddies, students in the class included other children with ASD not enrolled in the present research study. Peer buddies interacted with study- and non-study children with ASD during the class activities. The martial arts studio funded the class, which was free to all students. The classes were taught by experienced MMA instructors. Given that the MMA class also included students with ASD who were not enrolled in the present study, instructors were blind to which children were study participants. Sessions were assessed for implementation fidelity (i.e., the adherence to the intervention protocol as it was initially designed and intended; Carroll et al., 2007). In vivo observations (Breitenstein et al., 2010) were conducted by a researcher present at the intervention session. Implementation fidelity measures assessed per participant (e.g., attendance) and per session (e.g., number of peer buddies) were coded immediately after each session. Scores were averaged across participants and sessions and then compared to the intended initial design. Implementation fidelity for adherence to the protocol was high (range = 73–100%), indicating that the highly-structured MMA program was implemented similarly by all instructors. Session attendance averaged 22.86 (SD = 2.51) out of an expected 26 sessions (or approximately 3 absences per participant). Implementation fidelity for adherence to the duration of the intervention, which was the most common breach of implementation, averaged 73%. The breach was in the direction of the intervention taking longer than expected to complete in order to accommodate “make-up” classes to achieve the target dose per participant. This resulted in a “later-than-intended” average post-test date of 18 weeks (SD = 3.99) from the pre-test date. Total minutes of intervention (i.e., dosage) showed high (85%) implementation fidelity. Spearman correlation analyses revealed there were no significant associations between indicators of fidelity and social functioning post-test scores.

2.5. Plan of analysis

Demographic factors were compared pre-intervention. Only child sex differed significantly between the MMA and WLC groups before random assignment; child sex therefore was included as a covariate in subsequent analyses. T-tests were used to compare the intervention and control groups for selection effects (differences on pre-test scores on social functioning measures). The two SSIS pre-test scores did not significantly differ between the groups (Social Skills, p = .36; Problem Behaviors, p = .85).

Mixed-effects regression models were conducted to examine the relationship between group status (MMA versus WLC) and time (pre- versus post-test scores) on the two SSIS scales (Social Skills and Problem Behaviors). Overall intervention group and time effects were tested by examining the regression coefficients in the mixed-effect regression models. Cohen’s d-index change scores were calculated for the effect sizes for the interaction effects of time by group on child outcome measures. Positive d-index change scores indicated the MMA group had the higher scores; negative d-index change scores indicated the WLC group had the higher scores. Cohen’s (1988) classic definitions of effect sizes as small (d = .2), medium (d = .5), and large (d = .8) were used to interpret the magnitude of d-index change scores on the outcome measures.

3. Results

3.1. Mixed-effects regression models on social skills and problem behaviors

Means and standard deviations for study variables are presented in Table 2. A linear mixed-effects regression model was used to test the hypotheses that social skills would be improved (Hypothesis 1) and that problem behaviors would be lessened (Hypothesis 2) for the MMA group at post-test compared to the WLC group. Group status (MMA versus WLC group), time (pre- versus post-test), and their interaction were posited as the predictors of parent-reported child social functioning.

Table 2
Means and SD for Study Variables by Experimental Group and Time.

<table>
<thead>
<tr>
<th></th>
<th>Mixed Martial Arts (MMA) n = 14</th>
<th>Waitlist Control (WLC) n = 20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td>Pre: Time 1</td>
<td>Post: Time 2</td>
<td>Pre: Time 1</td>
</tr>
<tr>
<td>Social Skills Improvement System (SSIS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Skills Scale</td>
<td>68.36 (13.70)</td>
<td>76.36 (14.48)</td>
</tr>
<tr>
<td>Problem Behaviors Scale</td>
<td>125.36 (8.99)</td>
<td>117.14 (10.44)</td>
</tr>
</tbody>
</table>

For the analyses examining social skills, there was no significant main effect of time (b = 2.35, p = .13). However, results indicated a significant interaction between group and predicted social skills over time, such that the MMA group had a 9.60 higher social skills standard score at post-test as compared to the WLC group and controlling for pre-test scores, with a large effect size of \( d_{\text{change}} = 1.19 \) (Table 3; Fig. 1). After controlling for the effects of child sex, the interaction between group and predicted social skills over time remained significant, such that the MMA group had a 9.07 higher social skills standard score at post-test as compared to the WLC group and controlling for pre-test scores (Table 3).

For the analyses examining problem behaviors, results indicated no significant main effect of time (b = 1.06, p = .52). However, there was a significant interaction between group and predicted problem behaviors over time, such that the MMA group had a 12.16 lower problem behaviors standard score at post-test as compared to the WLC group and controlling for pre-test scores, with a large effect size of \( d_{\text{change}} = 1.61 \) (Table 3; Fig. 2). After controlling for the effects of child sex, the interaction between group and predicted problem behaviors over time remained significant, such that the MMA group had a 12.79 lower problem behaviors standard score at post-test as compared to the WLC group and controlling for pre-test scores (Table 3).

4. Discussion

The current study is novel in its rigorous implementation of a MMA intervention with random assignment conducted in collaboration with a community-based martial arts studio and intended to both improve social skills and lessen social deficits. Hypothesis 1, that parent-reported social skills would increase for the MMA group following the intervention, was supported. Hypothesis 2, that parent-reported problematic social behaviors would decrease for the MMA group after the intervention, also was supported.

Consistent with past work that focused on lessening undesirable social behaviors, the present study found lower problem behaviors between pre- and post-test for the MMA group but not for the control group. Our findings replicated the results reported by Movahedi et al. (2013) on social dysfunction, and extended them by also measuring adaptive social skills. Movahedi et al. (2013) suggested that social dysfunction decreased after Kata training because of the increased opportunities to practice social skills. The same principle might have operated in the current study. After adult instructors demonstrated the martial arts techniques, the study children with ASD engaged in dyadic and group-based interactions with peers in the class.

In the present intervention, children formed dyads to partake in the main martial arts activity, which involved holding mitts/pads for their partner and partner-drilling the technique with a TD peer. In past martial arts intervention studies, children rarely held punching mitts or kicking pads for other students or engaged in partner-drilling with peers. In addition to having opportunities to practice social skills with peers as in the Movahedi et al. (2013) study, children in the current study also learned about their own movements and, unique to the current study, also the movements of their partners. The dynamic interactions that occurred during the main martial arts activity utilized many important adaptive social skills, including imitation, verbal and non-verbal communication, turn-taking, and perspective-taking.

MMA training also required children to simultaneously inhibit problematic behaviors that are undesirable in most social settings. Controlling one’s behaviors is part of the self-regulation process, in which “the self alters its own responses, including thought, emotions, and behaviors” (Baumeister, 1997, p. 146). Traditionally, martial arts training inherently emphasizes the importance of self-regulation (Lakes & Hoyts, 2004). Martial arts training involves teaching participants strategies to enhance self-regulation (e.g., meditative breathing, mindfulness practice) and providing the opportunity to practice these strategies in a naturalistic setting with the support of adult instructors. As such, participants regularly practiced reflecting on their own behaviors and modified problematic behaviors in order to adapt to the social setting. This approach is consistent with past research that found improved self-control, such as controlling one’s temper and inhibiting rigid/impulsive behaviors, among children with ASD after receiving only eight hours of martial arts training (Chan, Sze, Siu, Lau, & Cheung, 2013). Although the present study did not isolate which aspects of the intervention were responsible for the reported improvements, the partner-drilling element could have contributed to these results; engaging in this exercise required the use and practice of adaptive social skills that are important in positive interpersonal interactions. It is also possible that the increased physical activity and confidence gained through the active MMA training could have aided social functioning. Furthermore, the structured teaching procedures utilized by the instructors could have contributed to the improved social functioning of the participants in the MMA group. However, as with the other components of the intervention, the present study did not isolate teaching procedures. Future work should aim to isolate the different aspects of the intervention, including partner-drilling.

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient a</th>
<th>SE</th>
<th>Effect size d_{\text{change}} b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Skills Improvement System (SSIS) c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Skills Scale</td>
<td>9.60**</td>
<td>2.73</td>
<td>1.19</td>
</tr>
<tr>
<td>Social Skills Scale (with sex) d</td>
<td>9.07**</td>
<td>2.95</td>
<td></td>
</tr>
<tr>
<td>Problem Behaviors Scale</td>
<td>12.16**</td>
<td>2.59</td>
<td>1.61</td>
</tr>
<tr>
<td>Problem Behaviors Scale (with sex) d</td>
<td>12.79**</td>
<td>2.79</td>
<td></td>
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</tbody>
</table>

a WLC group as the reference group.

b \( d_{\text{change}} = \) Cohen’s d-index of change scores; \( d_{\text{change}} = \) (mean treatment group change score – mean control group change score)/sdxweighted.

c Based on 34 participants with 68 observations.

d Analyses controlling for child sex.

** p < .01.
Fig. 1. Time by Group Interactions on Social Skills Scale.

Fig. 2. Time by Group Interactions on Problem Behaviors Scale.

physical activity, and teaching procedures, to elucidate the mechanisms behind these observed effects.

A related strength of the present study was the inclusion of TD peers in the class with whom to practice social skills while doing the physical activity. Past research has supported the inclusion of TD peers in interventions to improve social functioning in children with ASD. TD peers not only model socially-appropriate behaviors, they also are more accessible to act as intervention agents in school and community settings (relative to trained adult professionals) (Kamps, Mason, & Heitzman-Powell, 2017). Furthermore, TD peers provide social opportunities for children with ASD to practice initiating and responding to social overtures (Kamps et al., 2017), particularly in the context of a shared activity or interest (Koegel, Vernon, Koegel, Koegel, & Paullin, 2012). Peer interactions also are more reciprocal than interactions with adults since both children contribute to the social exchange (Vandell, Nemide, & Van Winkle, 2006). Past research has highlighted the need for more ecologically-valid interventions that include social interactions with peers in inclusive community-based settings (Watkins et al., 2015); such opportunities provide the potential benefit of generalizing these skills to naturalistic settings with other peers. Future research should enroll all classroom peers as participants to explicitly account for their role in the intervention. Additional strengths of the study included random assignment to group and blindness of the instructors in the MMA classes to which children were study participants.

Limitations of the current study included: small sample size, which limited power to detect small or moderate effects; sex imbalance favoring boys, and lack of a long-term follow-up. Another limitation was parental awareness of their child’s group assignment, which might have biased their responses, and relatedly, subjectivity bias in that parental perceptions and expectations might have influenced responses on parent-sourced measures. Replication should include a larger sample, more girls, long-term follow-up, multiple adult informants, and an objective assessment of child social functioning. Further research is needed to identify the specific components of the MMA intervention most responsible for the observed effects, such as structured opportunities to practice martial arts with peers, pairing of children with ASD and TD children, benefits from physical activity, or some other aspect.

4.1. Implications

The current study was designed around a community-based MMA class that included a diverse range of children with and without ASD, thus providing opportunities to practice social skills with peers who reflected a wide range of functioning levels. Compared to the
control group, parents of boys with ASD reported significantly higher positive social behaviors and significantly lower negative social behaviors between pre- and post-test.

The study extended intervention research that utilized physical exercise to bolster social functioning. Although we do not know whether the MMA intervention would benefit girls, study findings have implications for parents of boys with ASD as they select activities for their children. Our results suggest the value of including peers when children are learning challenging physical activities. These recommendations also might extend to school settings. Children with ASD, especially boys in middle-childhood, engage in significantly less physical activity than the rest of the general population (Gebrič et al., 2020). Providing a social context for physical exercise not only helps address the physical health domain, but may improve social skills as well. This combination could confer benefits to the quality of social relationships for the child and thereby enhance overall quality of life.

**Declaration of Competing Interest**

The authors report no declarations of competing interest.

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**References**


