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ORIGINAL PAPER

The Effect of Karate Techniques Training on Communication Deficit of Children with Autism Spectrum Disorders

Fatimah Bahrami[1] · **Ahmadreza Movahedi**[1] · **Sayed Mohammad Marandi**[1] · **Carl Sorensen**[2]

Abstract This investigation examined the long term effect of Karate techniques training on communication of children with autism spectrum disorders (ASD). Thirty school aged children with ASD were randomly assigned to an exercise (n = 15) or a control group (n = 15). Participants in the exercise group were engaged in 14 weeks of Karate techniques training. Communication deficit at baseline, post-intervention (week 14), and at 1 month follow up were evaluated. Exercise group showed significant reduction in communication deficit compared to control group. Moreover, reduction in communication deficit in the exercise group at one month follow up remained unchanged compared to post-intervention time. We concluded that teaching Karate techniques to children with ASD leads to significant reduction in their communication deficit.

Keywords Autism · Communication · Karate · Exercise · Language

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✉ Fatimah Bahrami
fatimah.bahrami@yahoo.com; fatimah.bahrami@ut.ac.ir

Ahmadreza Movahedi
a.movahedi@spr.ui.ac.ir

Sayed Mohammad Marandi
s.m.marandi@spr.ui.ac.ir

Carl Sorensen
sorensec@email.sc.edu

[1] College of Sport Sciences, University of Isfahan, HezarJarib Street, Isfahan, Iran

[2] University of South Carolina, Columbia, SC, USA

Introduction

Profound and striking impairment in communication, language, and speech development is described as a core deficit in the majority of individuals with autism spectrum disorders (ASD; APA 2013). Approximately 50 % of children with autism never acquire functional expressive language (Rutter 1978; Prizant 1983; Lord and Rutter 1994), yet those who develop functional language will demonstrate difficulties in learning more complicated verbal interactive skills such as conversation. Individuals with autism confront a wide range of language related deficits in the areas of expressive language, receptive vocabulary, comprehension of extensive directions, initiating communication, engaging in reciprocal conversations as well as typical social interactions such as expressing affection (Charlop and Walsh 1986), requesting information, asking questions (Charlop and Trasowech 1991), requesting interactions (Matson et al. 1993), pronominal reversal, utility of subtleties of language such as the sarcasm, humor, jokes, and the rhythms of language, interpretation of body language, facial expressions, and connotations behind questions (Kanner 1943; Piven et al. 1997). Moreover, individuals diagnosed with autism are more likely to use unconventional forms of non-verbal communication, such as leading an adult's hand, aggression, informal gestures, and self-injurious behaviors not observed in their typically developing peers (Carr and Kemp 1989; Stone et al. 1997).

Communication is crucial for learning and establishing connections with others, so that deficits in communication skills not only characterize the syndrome, but set limits on opportunities for play, academic achievement, and social integration (Prelock et al. 2011). There is also considerable evidence showing that communication deficits in children

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with autism correlate markedly with executive dysfunction (Russell 1997; Russell et al. 1999) and impaired social interaction (Kuhl et al. 2005). Therefore, interventions aimed at improving communication in ASD are vital to success both in school programs and functional, real-world adaptation (Prelock et al. 2011).

A growing number of studies suggest numerous communication treatment approaches to improve communication deficit in individuals with autism. These strategies include but are not limited to imitation (McDuffie et al. 2005), play (Yoder 2006), joint attention (Charman 2003), verbal behavior (Paul and Sutherland 2005), teach me language (Freeman and Dake 1997), scripting and fading (Krantz and McClannahan 1993), social stories (Gray and Garand 1993), video modeling (Haring et al. 1987), and physical exercise-based intervention programs (Staples et al. 2011). Physical exercise-based treatment has been recently introduced as a novel intervention for treatment of individuals with ASD (Watters, and Watters 1980; Powers et al. 1992; Celiberti et al. 1997; Prupas and Reid 2001; Yilmaz et al. 2004). Investigations have demonstrated the beneficial effects of engaging in physical exercise and sport training across a wide variety of skills in children with developmental disabilities (Hornyak and Hurvitz 2008; Tsai 2009) including children with autism spectrum disorders (Pitetti et al. 2007; Movahedi et al. 2013).

After receiving physical exercise interventions, individuals with ASD have experienced profound improvements in out-of-seat behaviors (Gordon et al. 1986), social skills (Bass et al. 2009; Movahedi et al. 2013), cognitive function (Anderson-Hanley et al. 2011), stereotypic behaviors (Bumin et al. 2003; Bahrami et al. 2012), attention (Bass et al. 2009), self-injurious behaviors (Elliott et al. 1994), aggression (Allison et al. 1991), and academic skills (Nicholson et al. 2011).

The efficiency of physical exercise-based treatment on improvement of communication deficit of children with autism has been infrequently studied. Investigators have documented the benefits of therapeutic horseback riding (Gabriels et al. 2012), equine-assisted therapy (Hameury et al. 2010), swimming (Best and Jones 1974; Yilmaz et al. 2004), and muscle toning and stretching techniques including arm circles, toe touches, leg bicycling, and sit-ups (Reid et al. 1988) on communication deficit of individuals with autism.

The majority of the studies in the field of exercise- based interventions and autism have used case studies, single subject, or small number research designs with short intervals of exercise and brief experimental periods to determine whether these interventions were effective (Matson et al. 2007). Studies on individuals with developmental disabilities including autism are needed to be carried out with larger sample sizes and with control groups to find out whether similar findings will result. Further, the most commonly cited studies reporting communication-related benefits of exercise for individuals with ASD do not report quantitative results (Best and Jones 1974), do not use well-established measures (Hameury et al. 2010), or report very small effects (Gabriels et al. 2012). The present study will be among the first to examine exercise effects on communication deficits among children with ASD, the first to examine the effects of Karate training on communication deficits for this population, and employs a more rigorous design (i.e., N = 30, well-validated measures, well-specified exercise protocol) than most studies of exercise benefits for children with ASD to date. The primary aim of the present study was to determine whether teaching Karate techniques to children with ASD leads to significant reductions in their communication deficits. The main hypothesis was that children with autism who participated in a 14 week Karate techniques training program would illustrate improvement in communication deficit, as compared to children with autism who do not engage in Karate techniques training. We also hypothesized that the improvements in communication deficits in participants assigned to the exercise group would be maintained at 1-month follow-up. The results of the present investigation will provide empirical evidence for the use of Karate techniques training for improving communication deficit in children with ASD.

Methods

Participants

Participants were (N = 30; 26 male) students ranging in age from 5 to 16 years (M = 9.13 years, SD = 3.27) from one of three specialized institutions for youth with ASD who were selected randomly to participate in the present study (see Table 1 for additional demographic information and baseline ASD-specific symptom severity). Additionally, participants in the present study had formal ASD diagnoses using criteria from the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition, Text Revision (DSM-IV-TR; APA 2000). Data from participants without verbal communication skills (N = 8) were not included in analyses. No participants or participants' caregivers reported the youth participants had previous experience or formal instruction with Karate or related martial arts. Matched pairs (i.e., based on age, gender, and autism severity) were randomly assigned to either an exercise (n = 15) or control (n = 15) condition. None of the participants dropped out of the study and all of them completed training sessions in full. During the present study, all participants continued routine medical care with regular health care providers. The Committee for Ethical Considerations in Human Experimentation of College of Sport Sciences, University of Isfahan evaluated and approved all experimental protocols, procedures and measures. Parents

Table 1 Participants' characteristics (age, gender, and autism severity) at the pre-intervention time

Participants							
Exercise group				Control group			
Nos.	Age (year)	Gender	Autism severity[a]	No	Age (year)	Gender	Autism severity
1	5	B	29*	1	5	B	25
2	5	B	31*	2	5	B	33*
3	5	B	69	3	5	B	31*
4	6	B	18	4	6	B	15
5	7	B	34*	5	7	B	42*
6	8	B	18*	6	8	B	47
7	9	B	39	7	8	B	41*
8	9	G	58	8	9	B	76
9	10	B	37	9	9	G	29
10	10	B	77	10	10	B	54
11	10	G	67	11	10	B	54
12	12	B	31	12	12	B	58
13	13	B	58	13	13	B	85
14	13	B	31	14	13	G	69
15	16	B	41	15	16	B	50
Mean ± SD	9.20 ± 3.32	–	42.53 ± 18.65		9.06 ± 3.33	–	47.27 ± 19.53

B boy, *G* girl

* We did not administer the subscale of communication because they did not talk, sign or use any form of communication

[a] Sum of the GARS-2 (Gilliam Autism Rating Scale-Second Edition) three subscales (stereotypy, communication and social interaction) raw scores

or caregivers of all participants had provided informed consent before any procedures were implemented.

Experimental Task

Participants in the exercise condition were administered adapted instruction in Heian Shodan Kata, consists of a predetermined series of movements that are performed with explosive swiftness against imaginary (see Online Resource 1). Kata incorporates techniques from various schools of martial art and athletes move in several directions in space. It is not regarded as a symbolic battle to be performed alone, but rather as a battle against one or more invisible opponents. Various schools incorporate different numbers of kata techniques, and refer to them by distinct names (see Doria et al. 2009; Bahrami et al. 2014).

Material

We used the communication subscale of Gilliam Autism Rating Scale-Second Edition (GARS-2; Gilliam 2006) to assess changes in the severity of communication deficits. GARS-2 is widely used for research purposes and to inform educational placement decisions (Owens et al. 2008). The communication subscale of GARS-2 includes 14 items on which parents, teachers, or other caregivers compromise on rating the communication deficits of the participants based on a four-point likert-type scale (0 = never observed; to 3 = frequently observed). Parents, caregivers, and teachers are asked to rate the individual based on the frequency of occurrence of each communication behavior under ordinary circumstances in a 6-h period. The items of the communication subscale ask caregivers how often a child: (1) Repeats words, (2) Repeats words out of context, (3) Repeats over and over, (4) Speaks with flat affect, (5) Responds inappropriately, (6) Looks away when name called, (7) Avoids asking, (8) Fails to initiate conversation, (9) Uses ''yes''/"no'' inappropriately, (10) Uses pronouns inappropriately, (11) Uses ''I'' inappropriately, (12) Repeats unintelligible sounds, (13) Uses gestures instead of speech, (14) Inappropriately answers questions. We concentrate on the total raw score in the communication subscale of GARS- 2. The Communication subscale is not completed for non-verbal individuals and has excellent psychometric properties (Worley and Matson 2011).

Procedure

Twenty qualified and certified trainers whom we recruited to instruct Karate protocol to participants took part in a 20-h training course in which they were assisted by an expert in ASD symptoms and characteristics to adapt

Karate techniques for youth with ASD. The trainers were provided with a schedule detailing the list and the time of techniques instruction to ensure that the intervention was delivered uniformly across settings (see Bahrami et al. 2012). In addition, training sessions were videotaped to further ensure that the instructional methods were delivered identical. The instructors were notified if they followed a different schedule. We administered communication subscale of GARS-2 via in-person interviews with parents, caregivers, and teachers as well as by participant direct observation. Data were collected at pre-intervention, post-intervention (week 14) and one month follow-up (see Table 2).

Prior to interviews, participants' parents, caregivers, and teachers were asked to make precise observations of the participants at home and in regular school environments for 7 days. During a separate formal meeting, we asked participants' parents, caregivers, and teachers to discuss their ratings and reach consensus on a set of joint ratings. In the exercise condition, participants received 56 sessions (i.e., 4 days/week, 14 weeks) of adapted instruction in Karate techniques. Prior to direct, in-person instruction sessions, participants observed a videotape of the adapted Karate techniques performing by an expert model (see Bahrami et al. 2014; Online Resource 1). Following the video modeling, trainers were required to instruct the standardized adapted Karate protocol. The initial duration of exercise session was 30 min, which was progressively increased to approximately 90 min over the first 8 weeks and remained at that duration for the remainder of the intervention (i.e., weeks 9–14). The 90 min sessions were divided among the following activities: warm-up (15 min; 10 min stretching, 5 min jogging), adapted Karate instruction (65 min), and cool-down (10 min). The adapted Karate instruction portion of each session was further divided into 1:1 instruction followed by synchronized group practice. Both 1:1 and group sessions were video-recorded for further analysis. During warm-up and cool-down portions of each session, pre-recorded Persian music was provided in the exercise area. We progressively used motivational techniques, systematic reinforcement, and psyching up strategies, including verbal exhortation, evaluation, and rewards to keep the participants of the experimental group motivated to keep on training and approach them to the experience (for more details see Schmidt and Lee 2005; Bahrami et al. 2012; Lewthwaite and Wulf 2012). Parents of the participant in the exercise group were presenting during the training sessions and we used their assistant when a child did not obey the rules or expectations. We usually let the child to be alone in a separate room with his/her interests and tried to return him/her to his/her normal mood. We had no child to be dropped out of the study for behavioral concerns. Participants in the control group received an educational intervention (i.e., academic skills, cognitive and language skills) which incorporated structured teaching strategies similar to those described for participants in the exercise condition. The participants did not continue or participate in any other fitness or organized physical exercise programs during or following the 14 weeks of Kata sessions.

Statistics

Within and between group comparisons were tested using a 2×2 mixed factorial ANOVA model as well as independent and paired samples t-tests using SPSS software (Version 11.5). Group differences at baseline were evaluated using an independent samples t test. Separate 2-factor mixed-model ANOVAs (2 groups $\times$ 2 time points) with time as the repeated factor were used to determine the effects of the intervention program on the dependent variable (baseline to post-intervention). Paired t-tests were used to evaluate within group pre-post changes when ANOVA models demonstrated significant interactions. Additionally, paired t tests were used to investigate whether treatment effects were maintained from post-intervention to 1 month follow-up. Criterion for statistical significance was set at $p < 0.05$. Data are presented as mean $\pm$ standard deviation (SD).

Results

In order to examine the differences in communication deficit severity between the groups at the pre-intervention time (baseline), we performed an independent t test for the communication subscale of GARS-2. We found no significant difference at baseline, t (20) = 0.13, $p = 0.90$.

Table 2 The experimental design

Groups	Pre-intervention	Intervention (day 1-day 104)	Post-intervention (day 107)	Follow up (day 135)
Exercise	Communication was assessed	Participants were instructed Kata techniques for 56 sessions	Communication was assessed after 2 days of no practice	Communication was assessed after 30 days of no practice
Control	Communication was assessed	Participants did not participate in formal physical exercises	Communication was assessed	Communication was assessed

We performed a 2-factor mixed-model ANOVAs (2 groups × 2 time points) with time as the repeated factor to determine the effects of Karate techniques training on communication deficit. The ANOVA revealed a significant group- by- time interaction, F (1, 20) = 22.35, $p = 0.000$. Since a significant interaction was demonstrated, we used post hoc testing to determine whether the exercise or control groups improved with time. To investigate the change in communication deficit in the exercise group, we compared the mean score of communication subscale of GARS-2 that individuals in the exercise group achieved in pre-intervention time with its mean score in their post-intervention time. We found a significant decrease, t (10) = 6.70, $p < 0.001$, however, we did not find any significant difference for the control group, which was initially tested in the pre-intervention time and then in the post-intervention time, t (10) = 0.72, $p = 0.49$.

To investigate whether the results obtained in the post-intervention persisted, we compared the post-intervention mean score of each group with its mean score in the follow-up test. At the follow-up time, the communication score remained significantly unchanged in exercise, t (10) = −0.83, $p = 0.43$, and control group, t (10) = 0.00, $p = 1.00$, compared to post intervention time (see Table 3; Fig. 1).

Discussion

In the present study we investigated the effect of Karate techniques training on communication of children with autism spectrum disorders. Results illustrated that Karate training improved communication deficit of children diagnosed with ASD. Results also indicated that after 30 days of no practice, communication deficit in the exercise group remained significantly decreased compared to post-intervention time.

The results of our study are consistent with the results of previous studies finding decreased levels of communication-related deficits following physical exercise among individuals with neurological disorders including ASD (Reid et al. 1988; Friedman and Tappen 1991; Reynolds et al. 2003; Reynolds and Nicolson 2007; Hameury et al. 2010; Nocera et al. 2010; Gabriels et al. 2012).

Despite these promising findings investigators have not yet provided a compelling theoretical account to interpret the beneficial effects of exercise based-interventions on communication and language improvement in individuals with communication disorders. In light of important new findings from psychology and neurosciences, however, we propose a neurobiological mechanism for these benefits. One of mechanism includes well documented increases in levels of brain-derived neurotrophic factor (BDNF)

Table 3 Results of the communication subscale of GARS-2 in response to intervention*

	Baseline	Post-intervention (14 weeks)	Follow-up (1 month)	Difference (14 weeks-baseline)	Difference (1 month-14 weeks)	Difference (1 month-baseline)
Exercise group						
CSGARS-2	21.36 ± 7.21	15.18 ± 6.46	16.00 ± 8.83	−6.18 ± 3.06**	0.82 ± 3.28**	−5.37 ± 4.46**
				95 % CI[a] 4.13, 8.24	95 % CI −3.02, 1.39	95 % CI 2.37, 8.36
Control group						
CSGARS-2	20.91 ± 8.92	20.36 ± 9.91	20.36 ± 9.91	−0.54 ± 2.50 95 % CI −1.14, 2.23	0.00 ± 2.93	−0.55 ± 2.21
					95 % CI −1.97, 1.97	95 % CI −0.94, 2.03

CSGARS-2 communication subscale of Gilliam Autism Rating Scale-Second Edition; higher scores indicate a higher level of communication deficit

* Data are mean ± SD

** Significant at $p < 0.001$

[a] CI = 95 % confidence interval

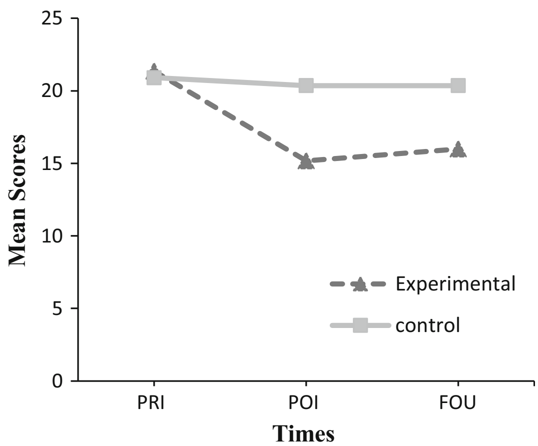

Fig. 1 Mean communication scores of the groups in pre-intervention (PRI), post- intervention (POI), and follow-up (FOU) times

following bouts of exercise (Cotman and Berchtold 2002; Ang and Gomez-Pinilla 2007; Langdon and Corbett 2012). BDNF plays important roles in neurological functioning, neurogenesis, regulating the survival and differentiation of neurons, as well as guiding axonal paths, dendritic density, dendrite spine proliferation, and synaptic plasticity (for a recent review see Phillips et al. 2014). Moreover, increases in levels of BDNF have been associated with improvements in memory and learning capacity (Cotman and Berchtold 2002; Phillips et al. 2014). Additionally, BDNF has been implicated as a key factor in a variety of neurodevelopmental disorders (e.g., ASD, Rhett syndrome) and neurodegenerative diseases (e.g., Huntington's disease, Alzheimer's disease, Parkinson's disease), leading to increased interest in BDNF as both a biomarker and therapeutic mechanism for these conditions (Cotman and Berchtold 2002; Kasarpalkar et al. 2014). Further, serum levels of BDNF have been associated with levels of symptom severity for youth with ASD (Kasarpalkar et al. 2014). Multiple lines of research provide empirical support for BDNF as a mediator of the relationship between exercise and associated cognitive benefits including: (1) BDNF is upregulated for up to 7 days following bouts of endurance exercise (Berchtold et al. 2005); (2) physical exercise has been shown to improve BDNF regulation (Langdon and Corbett 2012); and (3) blocking BDNF receptors has been shown to reduce the cognitive benefits of exercise (Vaynman et al. 2006; Ang and Gomez-Pinilla 2007). Based on the relationships among BDNF, exercise, psychiatric symptoms, and learning and skill acquisition, we propose that elevated levels of BDNF following Karate techniques training leads to increased neural plasticity and thus increased capacity for learning and skill acquisition, which in turn leads to improvements in a variety of skills including communication skills.

The results of the present investigation could also be explained by approaches such as the Doman and Delacato's neurological organization (Doman et al. 1960) and Ayres's sensory integration theories (Baranek 2002). These theories include delivery of structured, theory-based activities to children with chronic neurological conditions (e.g., traumatic brain injury, ASD, Down syndrome, cerebral palsy, autism) in order to stimulate compensatory neural development and recover a child's neurological organization via some specific prescribed sensory/motor exercises (Golden 1980). Techniques used in Ayres's and Doman–Delacato's neurological organization approaches include highly structured, systematic introduction of patterned and rhythmic movements, breathing and balance exercises, gravity/counter gravity practices and play designed to provide high levels of motor and sensory stimulation (Doman et al. 1960; Golden 1980; Baranek 2002). These exercises have been supposed to expand functioning of the central nervous system in children with developmental brain disorders. While the biomedical assumptions of both theories have been criticized as outdated (Golden 1980; Baranek 2002), the role of sensory experiences in learning is becoming less controversial (Baranek 2002) and the evidence for benefits of physical activity is well-established (Sorensen and Zarrett 2014). Organized physical activity programming such as Karate training, especially when specifically tailored to children needs as in the present study, typically utilizes highly structured and patterned teaching methods while providing high levels of sensory stimulation. Karate training includes exercises that resemble the exercises suggested in Doman and Delacato's neurological organization and Ayres's sensory integration methods, and might improve functioning of a child with autism.

Finally, this issue merits further investigations and examinations to adequately address the underlying reasons and mechanisms of the neurochemical, behavioral, and structural changes responsible for the beneficial effects of physical activity-based interventions on communication deficit. The finding suggests that Karate training may provide individuals with ASD with an effective intervention to improve communication deficits. However, it is unknown whether this effect will be generalized to other motor skills.

The following comments are representative of those written by the parents and couches during the study regarding improvements in communication skills among participants:

> "[He] speaks a little more, has developed his sentence structure, and uses more words correctly." "He asks more questions than before."

> "He pays more attention to the techniques [during instruction]."

"He seems to interact with others more than before, takes part in group plays and tries to communicate with other children."

"He greets others more often."

"He says 'Good bye."

Conclusion

The present investigation indicated that 14 weeks of Karate techniques training effectively reduce communication deficit of children with ASD. The results of the present investigation may be used for establishing strategic plans under which martial arts techniques will best be instructed to children with ASD, and further, provide caregivers of children with ASD with a recommendation for complementary care by demonstrating substantial and prolonged effects of a tailored martial arts program. Additionally, these findings are consistent with findings that physical exercise is beneficial for individuals with neurological and psychiatric conditions, across age and diagnostic categories and for a variety of symptoms and areas of adaptive functioning. Because this is among the few studies demonstrating communication benefits of physical exercise for children with ASD, additional studies are needed as well as investigations of specific mechanisms for these benefits.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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