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Playing games can improve physical performance in children with autism

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder that is characterized by deficits in social communication, interaction, and stereotypical behaviours. Children with ASD have not enough opportunities to participate in physical activity (PA), which lead to increase fitness and health problem. The aim of this study was to compare two programs on motor skills. In the current investigation, 30 high functioning autistic children were diagnosed by a psychiatrist and randomly divided into control and experimental groups. The evaluation tools included the Brininx-Oresetsky Test (BOT) and a program named "I can have physical literacy" (ICPL) and Sport, Play, and Active Recreation for Kids (SPARK). The experimental intervention groups received sixteen sessions of 60 min, while the control group did not receive any treatment. Analysis of covariance was used to determine the difference between the groups. Post-hoc test was used to compare pairs of groups. Results showed that the experimental ICPL and Spark groups had increased motor skills (MS). There were significant differences between groups on gross motor skills. There were significant differences between the control and experimental ICPL groups, and between the experimental Spark and experimental ICPL groups. Both of these programs increased MS. ICPL program that address the characteristics of children with ASD, have a positive effect on their MS.

Keywords: Physical activity, Fundamental motor skill, Developmental disorder, Physical literacy

Introduction

Physical activity (PA) plays an important role in children's life (Sit *et al*. 2019). It is defined as "bodily movement produced by skeletal muscles that result in energy expenditure"P.126 (Caspersen *et al*. 1985). The global recommendation for health-enhancing PA for children and adolescents is 60 min of moderate to vigorous PA (MVPA) a day; vigorous PA (VPA) is recommended at least three times per week (World Health Organization 2010). The VPA is a subdomain of PA and connected to young people's recreational hobbies and sports outside school (World Health Organization 2017). However, these levels of PA during the school schedule are not always possible due to the demands of the curriculum (Mears and Jago 2016, Trost *et al*. 2008). Indeed, a small percentage of children meet the recommended 60 min of MVPA when PA is averaged across the week (Colley *et al*. 2017). After school time offers a possible opportunity for increasing children's daily PA and it seems to be very helpful in preventing illnesses and enhancing fundamental motor skills (FMS) and children's development (Battista *et al*. 2005, Biddle and Asare 2011, Cheung 2019, Remmers *et al*. 2019, Yang *et al*. 2019). Leisure-time VPA has increased for children in several countries. Structured leisure-time activities have a positive effect on mental and physical health in children and adolescents (Badura *et al*. 2015, Eime *et al*. 2013).

This is also the case for children with autism spectrum disorder (ASD), a neuro-developmental disability characterized by deficits in social and emotional reciprocity (American Psychiatric Association 2013). This deficit involves challenges in entering social activities,

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inappropriate behaviours, lack of eye contact, distance from people, non-functional use of language, and a lack of communicative (Syriopoulou-Delli *et al*. 2018). Children with ASD have been found rarely to attend physical education (PE) lessons and leisure-time activities (Mache and Todd 2016). This is for a variety of reasons that include inappropriately adapted PE, lack of disability-specific knowledge in coaches, teachers and parents and poorly developed motor skills (MS) in children with ASD who participate in PA less than their typically developing peers (Broder-Fingert *et al*. 2014, Toscano *et al*. 2018). MS are just one part of children development and include fine and gross skills. Gross skills include big muscles such as walking, running, jumping, catching, and kicking. Fine skills are movements using small muscles (Komaini and Mardela 2018). MS are very important to develop, in sports, as well as in PA or work-related activities that are closely related to physical and mental health and to cognitive achievement (Hill 2010). Children with ASD have some problems with coordination of both fine and gross skills, balance, flexibility, and speed (Cairney *et al*. 2019, Srinivasan *et al*. 2015). Their higher rates of MS impairments often mean that children with ASD are less likely to participate in PA and sports programs (Cairney *et al*. 2010). However, several studies indicate that PA such as swimming (Wilson 2019), aerobic exercise (Schmitz *et al*. 2017), riding a bike to school, running (Sandt and Frey 2005), Sport, Play and Active Recreation for Kids (SPARK) (Najafabadi *et al*. 2018), football (May *et al*. 2018), and FMS (Crawford 2018, Duronjić and Válková 2010) are effective approaches to improve their motor skill competence (MSC), social skills, and communication skills. Furthermore, the development of MS is important for children with ASD, as they often lack the MS needed for balance, strength, and flexibility and sport provides a gateway for them to learn those skills (Jenkins 2018), and improve FMS.

SPARK is a comprehensive health-related program, which focuses on increasing moderate to vigorous PA through engaging, fun, non-traditional and adapted traditional activities (Dowda *et al*. 2005). The SPARK program is generally used just for typically developing children. Furthermore, the I can have physical literacy (ICPL) program is another PA program in British Columbia designed to develop movement and social skills in children with ASD and can have large effects (Jull *et al*. 2014). Physical literacy (PL) reflects the motivation, confidence, physical competence, knowledge and understanding necessary to value and take responsibility for engagement in PA for life (Whitehead 2013). However, children with ASD who have social, behavioural, and motor difficulties have less opportunities to take part in physical activities than do their peers (Pan *et al*. 2016). Both SPARK and ICPL are designed to increase children's physical activity. The aim of the current study was to compare the effectiveness of two programs, SPARK and ICPL for developing MS in children with ASD.

Methods

Participants

Thirty girls and boys (10 girls and 20 boys) with high functioning autism diagnosed by a psychiatrist and on the DSM-5 (Diagnostic State Manual-5) (American Psychiatric Association 2013), aged 8-11 years, were recruited for this study. Additional inclusion criteria were the on the opinion having an IQ higher than 70, having been confirmed to have healthy sight and hearing by a General Practitioner, and having the ability to attend the training sessions required by the program.

Procedure

The study was conducted from July 2019 to October 2019. Initially, through the help of the Autism Institute in Tehran, parents of children with ASD were contacted by telephone and through snowball sampling. At the first meeting, parents who would like their children to participate in the study, completed written consent forms that included the process and goals of the study, and they were assured the information would be kept confidential. Some parents were unable to commit their children to participation in the interventions in two months, so these children were placed in the control group. The remainder of the children were randomly divided into two experimental groups, ICPL and SPARK. At the second meeting, parents and their children were seen at an appointment in the arena where Brininx-Oresetsky Test (BOT) test and interventions were to take place. Participants were tested individually by research assistants who had been trained to interact with young people with ASD and to understand behavioural modification techniques designed to ensure favourable performance on each outcome measure for the test protocols. In the study, research assistants were blind to the group to which the participants had been allocated. Each test item was explained and demonstrated before the intervention began. If a participant made a procedural error, instructions and demonstrations of the task were repeated before they made a new attempt. The BOT test protocol recorded the participant's response on each attempt and, where relevant, the best performance on each test item was recorded. The participants were given verbal encouragement and support throughout the testing procedure to.

Initial data were converted to points according to the protocol and tests, and tests in each subscale were combined. The data collection for each child took 60 Minutes, with the BOT test being given once before the intervention and once after the intervention. The intervention for the experimental group consisted of

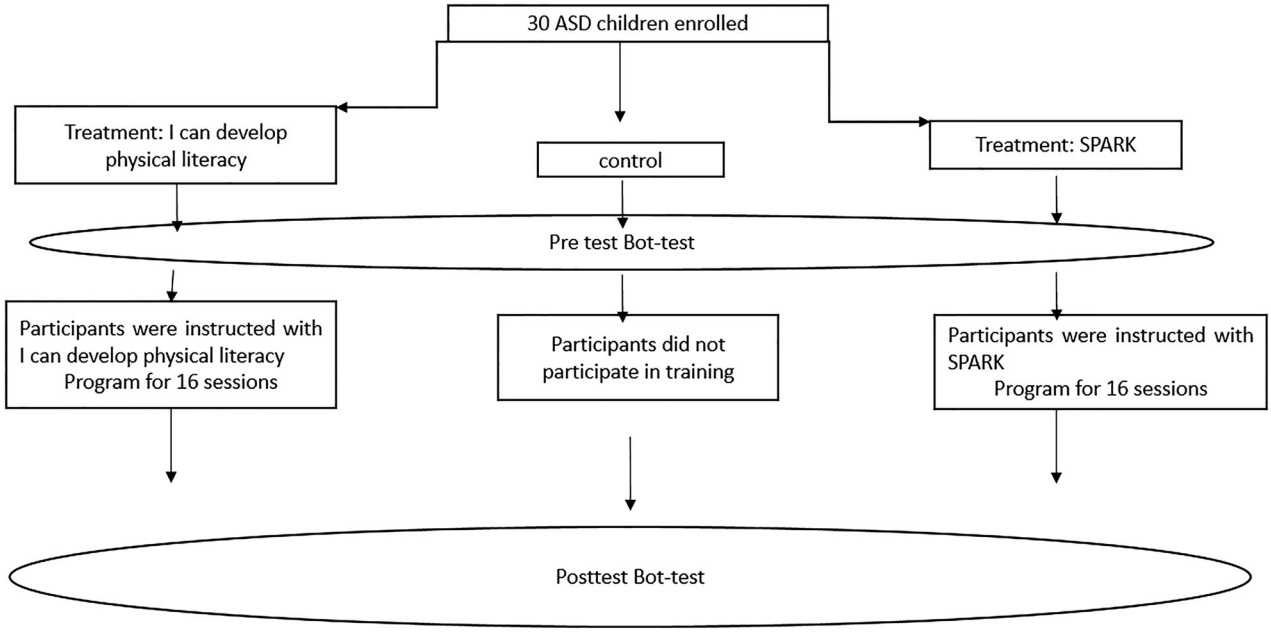

Figure 1. Study design.

two sessions per week either of SPARK or ICPL in the sport arena. Each intervention group performed protocols in the same arena on separate days with a different researcher and researcher assistants who had a Physical Education undergraduate degree (Fig. 1).

Measure

Motor skill competence

BOT test of Motor Proficiency (Bruininks and Bruininks 2005) was used to assess participants' MSC. The BOT measures fine and gross motor development and assesses the motor functioning of children from 4 ½ to 14 ½ years of age. The complete battery - eight subtests comprised of 46 separate items - provides a measure of gross and fine MS. Each of the eight subtests in the BOT is designed to assess an important aspect of motor development; four of the subtests measure gross MS (running speed and agility, balance, bilateral coordination, and strength), fine MS (response speed, visual motor control, upper –limb speed and dexterity), and upper limb coordination (Bruininks 1978, Flegel and Kolobe 2002). The reliability of this instrument on test-retest reliability is 0.89, and reliability for gross and fine skill, respectively, are 0.85 and 0.77(Hattie and Edwards 1987, Shahrasfenghar *et al*. 2019).

Intervention program

SPARK training

The training program chosen in this study was derived from the Spark Motor Training Program, which deals with the FMS of children (Najafabadi *et al*. 2018). It consists of sixteen indoor sessions, with two sessions of 60 min each per week performed after school. This protocol consisted of ten minutes for warm-up and 40 min for MS like balance skills, locomotor skills such as running, jumping, hopping, and galloping, and ball skills like catching, throwing, and kicking, and ten minutes for cool-down.

I Can have a physical literacy(ICPL)

ICPL was produced by the Canucks Autism Network (CAN) and Pacific Institute for Sport Excellence (PISE) and is suitable for children aged 7 to 11. This program is a resource for anyone that works with ASD children, such as coaches, teachers, and leaders. Specifically, this program focuses on MS like locomotor, balance, kicking, throwing and using of various tools such as visual cards for every skill like skipping, throwing, kicking, and communication boards and tools such as alphabet beanbag, foam dice, bean bags, bubbles, balloons, cons, balls, hope, scarves that are designed to aid PL and to be fun for children. At the first stage of each session, the participants met to communicate and, sitting in a circle, spoke about different things, such as favourite colour, animals, and exercise (Jull *et al*. 2014).

Statistical analysis

All data were analysed based on the analysis of covariance (ANCOVA) using SPSS (IBM, Version 25). The Shapiro-Wilk test was used to check the normal distribution of data, and the Levenes test to check the equality of variances. To determine paired groups, the different LSD post-hoc test was applied. All values in the figures and text are presented as means ± SD. P-values of ≤ 0.05 were considered statistically significant.

Results

The descriptive statistics are shown in Table 1. The mean and standard deviations of subtests is shown for

Table 1. Group differences in demographic characteristics.

Participant characteristics	Control	Ex. Spark	Ex. ICPL	Total
N	9	10	11	30
Age	8.70 ± 0.70	9.10 ± 0.87	8.55 ± 0.68	8.77 ± 0.77
Sex (n (%))	–	–	–	–
Male	6 (66.7%)	6 (60.0%)	8 (72.7%)	20 (66.7%)
Female	3 (33.3%)	4 (40.0%)	3 (27.3%)	10 (33.3%)
Ethnicity(n)	–	–	–	–
Persian	6	8	10	23
Azerbaijan	3	2	1	6
Kurd	–	1	–	1

SPARK: Sport, Play, and Active Recreation for Kids.
Ex.ICPL: Excercise I Can have a physical literacy

Table 2. Descriptive statics of variables and groups.

Variables /Groups	Pre-Con	Post-Con	Pre-Ex-Spa	Post-Ex-Spa	Pre-Ex-ICPL	Post-Ex-ICPL
Running and speed and agility	2.44 ± 1.94	2 ± 1.58	2.40 ± 1.50	3.40 ± 1.57	2.55 ± 1.86	4.36 ± 1.50
Balance	4.89 ± 1.05	5.22 ± 5.2	4.90 ± 0.73	9 ± 1.05	5.27 ± 1.34	10.36 ± 1.36
Bilateral coordination	1.67 ± 1.11	1.67 ± 1.11	1.50 ± 0.97	4.20 ± 1.39	1.55 ± 1.12	6.45 ± 1.03
Strength	5.89 ± 1.61	6.89 ± 0.78	6.60 ± 1.26	10 ± 1.49	6.45 ± 1.36	11.55 ± 1.29
Upper limb coordination	0.67 ± 0.50	0.89 ± 0.78	0.80 ± 0.63	6.20 ± 1.75	0.73 ± 0.64	9.18 ± 1.40
Visual motor control	2 ± 1.11	4.44 ± 1.94	2.40 ± 1.07	5.70 ± 1.76	2.27 ± 1.00	9.27 ± 2.10
Upper-limb speed and dexterity	3.11 ± 0.78	7.11 ± 0.78	3.70 ± 1.16	8.20 ± 1.61	3.64 ± 1.20	13.36 ± 2.24
Gross skill	14.89 ± 3.25	15.67 ± 2.91	15.30 ± 2.54	26.60 ± 3.71	15.82 ± 2.56	32.55 ± 1.69
Fine skill	5.44 ± 0.88	11.67 ± 1.80	5.90 ± 1.28	13.80 ± 2.25	5.82 ± 1.60	22.64 ± 3.93
Motor skill	21 ± 3.70	28.22 ± 3.59	26 ± 3.26	46.70 ± 5.03	22.36 ± 3.17	64.36 ± 4.45

Variables as Mean ± SD, Control, Experimental Spark, Experimental ICPL.
Note: ICPL: I Can have a physical literacy; Pre-Con: pertest –control; Post-con: post-test-control; Pre-Ex-Spa: pre-test-exercise-spark; Post-Ex-Spa: post-test-exercise-spark; Pre-Ex-ICPL: pre-test-exercise-ICPL; Post-Ex-ICPL: post-test-exercise-ICPL; SPARK: Sport, Play, and Active Recreation for Kids .

each group (control group, experimental SPARK group, experimental ICPL) in Table 2.

An ANCOVA was conducted to compare the impact of two different modes of exercise in comparison to the control group on the MS of children with ASD. Results show that there is a difference between the control, experimental SPARK, and ICPL groups in gross skills ($F(2, 26) = 97.89$, $p = 0.000$), in fine skills ($F(1, 26) = 83.66$, $p = 0.000$), and MS ($F(1, 26) = 221.11$, $p = 0.000$). LSD post-hoc test in gross skill showed that there are significant differences between control group and each experimental group ($p = 0.005$), and experimental ICPL and experimental SPARK group in relation to the gross MS ($p = 0.005$), as shown in Table 3 (Fig. 2). In fine MS, there is no significant difference between the control group and experimental SPARK group ($p = 0.086$), and there are significant differences between the control group and experimental ICPL group ($p = 0.005$), and also between the experimental SPARK group and experimental ICPL group ($p = 0.005$) (Fig.3). Table 3 shows there are significant differences between groups (control & experimental SPARK, control & experimental ICPL, and experimental SPARK & experimental ICPL, ($p = 0.005$) in MS (Fig.4).

Discussion

The main finding is that both intervention groups demonstrated improvement in MS that included gross, fine, and upper limb coordination skills. Participation in the eight-week ICPL program was associated with significantly greater improvement in the performance of gross skills compared with SPARK program. Furthermore, the ICPL group had higher improvement of fine skills. This is an important finding in that MS that develops throughout childhood is important to participation in sport and the development of complicated skills (García-Villamisar *et al.* 2017). Accordingly, SPARK provide simple regular and predictable play for children with ASD. Another program used in this study was ICPL that PISE and CAN launched to create a program for movement and social skills. It is based on problems that children with disabilities such as ASD have, and also focuses on support strategies, behaviour support tools, and modifying activities to create optimal challenge (Jull *et al.* 2014). The results showed that children in both experimental groups improved on subscales (running and speed agility, balance, bilateral coordination, and strength). The ICPL program had significantly more effect on balance, bilateral coordination, and strength of these children. One of the limitations of children with ASD is a lack of fine skill. This problem makes them unable to perform activities that require eye and hand coordination such as eating, button pressing, homework, and so on. In this study, fine skills in the BOT test included response speed, visual motor control, and upper-limb speed and dexterity. The ICPL exercise had a great effect on fine skill. It is notable that the ICPL program included games that were played using simple tools of different size and materials. Children with ASD are also involved in non-verbal

Table 3. LSD post-hoc test in gross, fine, motor skill.

Variables	Groups		Mean ± SD (95% CL)	P- Values
Gross skill	Control	Experimental SPARK	10.60 ± 1.18 (-13.06_ −8.15)	0.005*
		Experimental ICPL	16.49 ± 1.17 (-18.91_ −14.08)	0.005*
	Experimental SPARK	CONTROL	10.60 ± 1.18 (8.15_ 13.06)	0.005*
		Experimental ICPL	5.89 ± 1.13 (-8.22 _ −3.55)	0.005*
	Experimental ICPL	CONTROL	16.49 ± 1.17 (14.08 _ 18.91)	0.005*
		Experimental SPARK	5.89 ± 1.13 (3.55_ 8.22)	0.005*
Fine skill	Control	Experimental SPARK	1.60 ± 0.89(-3.44_0.24)	0.086
		Experimental ICPL	10.40 ± 0.87(-12.20_-8.59)	0.005*
	Experimental SPARK	CONTROL	1.60 ± 0.89(-0.24_3.44)	0.086
		Experimental ICPL	8.79 ± 0.82(-10.50_-7.09)	0.005*
	Experimental ICPL	CONTROL	10.40 ± 0.87(8.59_12.20)	0.005*
		Experimental SPARK	8.79 ± 0.82(7.09_10.50)	0.005*
motor skill	Control	Experimental SPARK	17.63 ± 1.77(-21.30_-13.97)	0.005*
		Experimental ICPL	35.06 ± 1.74(-38.67_-31.45)	0.005*
	Experimental SPARK	CONTROL	17.63 ± 1.77(13.97_21.30)	0.005*
		Experimental ICPL	17.42 ± 1.67(-20.88_-13.96)	0.005*
	Experimental ICPL	CONTROL	35.06 ± 1.74(31.45_38.67)	0.005*
		Experimental SPARK	17.42 ± 1.67(13.96_20.88)	0.005*

*Significant values between experimental groups ($p < 0.05$).
ICPL: I Can have a physical literacy; SPARK: Sport, Play, and Active Recreation for Kids.

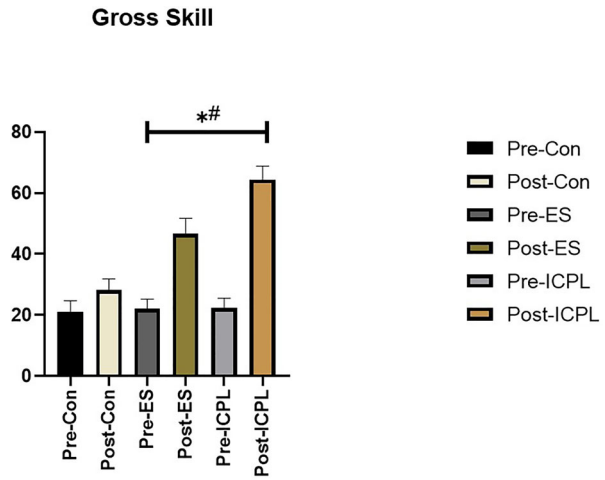

Figure 2. Gross motor skills in control, SPARK, and ICPL groups in the pre and post-test.
Note: ICPL: I Can have a physical literacy; Pre-Con: pre-test in control group, Post-Con: post-tests in control group. Pre-ES: pre-test in experimental SPARK group, Post-ES: post-tests in experimental SPARK group, Pre-ICPL: pre-test in experimental ICPL group, Post-ICPL: post-tests in experimental ICPL group; SPARK: Sport, Play, and Active Recreation for Kids. *: Significant different between groups (P = 0.005). #: Significant different between experimental SPARK, and experimental ICPL (P = 0.005).

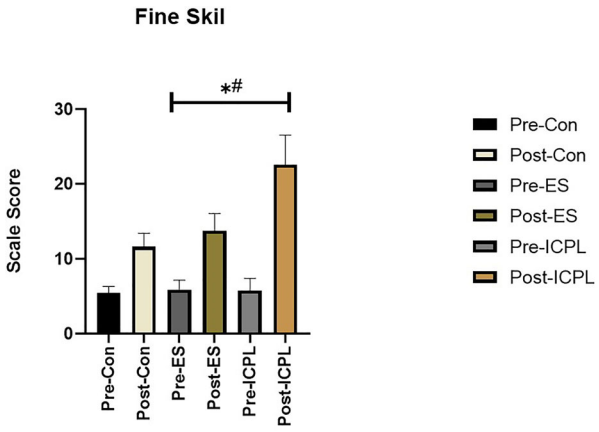

Figure 3. Fine motor skills in control, SPARK.ICPL groups in the pre a post-test.
Note: ICPL: I Can have a physical literacy; Pre-Con: pre-test in control group, Post-Con: post-tests in control group. Pre-ES: pre-test in experimental SPARK group, Post-ES: post-tests in experimental SPARK group, Pre-ICPL: pre-test in experimental ICPL group, Post-ICPL: post-tests in experimental ICPL group; SPARK: Sport, Play, and Active Recreation for Kids. *: Significant different between experimental ICPL and control groups (P = 0.005). #: Significant different between experimental SPARK, and experimental ICPL (P = 0.005).

activities, problem-solving, and interventions designed around interaction with the environment, objects, and other participants (Bal *et al.*, 2019). Fine skills are strongly linked to reading in elementary school (Suggate *et al*. 2019) and affect arithmetic ability (Asakawa *et al*. 2019) and language (Bal *et al.*, 2019, Bedford *et al*. 2016) in children. Given that the chosen exercise training focuses more on gross skill, and these children also need to participate in physiotherapy in order to enhance their fine skill, it is important for future work to design exercises that can enhance fine skill.

It is worth nothing that the biggest concern for PE teachers and coaches inside and outside PA classes in schools is finding a way to participate in PA, improving fitness performance, and other health life style behaviours in children with and without ASD (Kozlowski *et al*. 2020, Stone *et al*. 1998). Children's physical, emotional, cognitive growth are fast and changeable and participating in PA and acquiring MS can lead to academic achievement and success in other aspects of life (Deng 2017). It is, therefore, important to pay attention to how school-based PE classes can make contributions to this. The SPARK program is designed to promote high level PA among students in PE classes and outside school without sacrificing the enjoyment of PA or academic achievements(Mostafavi *et al*. 2013). Many studies have shown the effect of the SPARK program in, physical fitness, MS development, in typically development children (Chen and Sun 2017, McKenzie

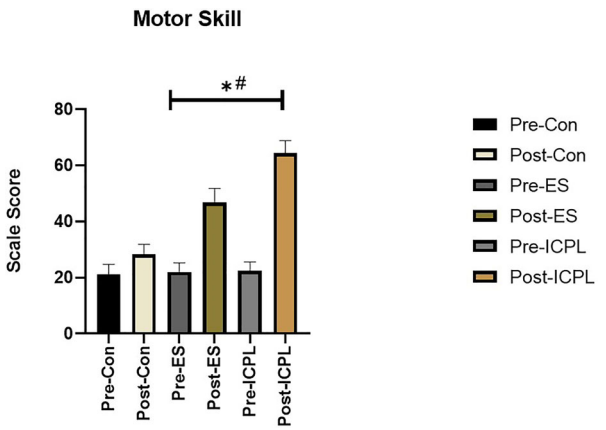

Figure 4. Motor Skills in control, SPARK, ICPL groups in the pre and post-tests.

Note: ICPL: I Can have a physical literacy; Pre-Con: pre-test in control group, Post-Con: post-test in control group. Pre-ES: pre-test in experimental SPARK group, Post-ES: post-test in experimental SPARK group, Pre-ICPL: pre-test in experimental ICPL group, Post-ICPL: post-test in experimental ICPL group; SPARK: Sport, Play, and Active Recreation for Kids. *: Significant different between groups (P = 0.005). #: Significant different between experimental SPARK, and experimental ICPL (P = 0.005).

et al. 2016, Nigg *et al*. 2017, Roth *et al*. 2019). PA and health are positively related and increased PA has been shown to improve both physical and mental health (Sowa and Meulenbroek 2012). Physical fitness such as aerobic and musculoskeletal fitness, flexibility, and body composition are all influenced by level of PA (Fragala-Pinkham *et al*. 2012). Intervention that includes MS can help to improve FMS, participation in physical activity and social skills (Colombo-Dougovito and Block 2019).

MSC is an important factor in PL (Cairney *et al*. 2019), and it has a positive association with health-related fitness in children with ASD (Bremer and Cairney, 2020). Increased physical competence has been found to enhance self-confidence and motivation, both of which increase children's participation in PA and, in addition, lead to enjoyment, recreation, and friendly relationships (Cairney *et al*. 2016).

Conclusion

Children with ASD generally lack the competence to be involved in physical activity. Therefore, the range of activities for these children are reduced in comparison with their age peers. The aim of this study was to find the best way to encourage children with ASD to participate in PA like their peers in order to improve their MS. The findings show that exercise programs designed to enable children with ASD to participate greatly improve their MS. PL may, therefore, provide a useful framework for PA programming for children with ASD.

Limitations

The current study is limited by the use of a BOT-test to assess motor skills, as response speeds were not recorded because the children were unable to perform the reaction time test. Body Mass Index (BMI) and enjoyment which were also not measured. In addition, the number of sample size was low ($n = 30$) due to this protocol was carried out after school. Therefore the authors have ongoing project to assess in a large group of sample size.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethical approval was obtained from the Sport Sciences Research Institute (SSRI) in Iran.

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