The Effects of SPARK and FBS Training Programs on some indicators of physical fitness and aerobic capacity in Children with Intellectual Disabilities

Abstract

Aims: Children with intellectual disabilities have lower levels of physical fitness indices due to neurological impairments, motor delays, and physical limitations. The present study was conducted to investigate the effects of SPARK and FBS training programs on selected physical fitness indices and aerobic capacity in children with intellectual disabilities.

Methodology: This semi-experimental study included 36 children with intellectual disabilities from Aligodarz city (mean age: 9.57 ± 1.69 years). Participants were purposefully selected and randomly assigned to three groups (n=12 each): SPARK training group, FBS training group, and control group. The training groups underwent selected SPARK or FBS protocols for 8 weeks (3 sessions per week, 45–60 minutes per session), whereas the control group received no exercise intervention. Balance was assessed using the Timed Up and go, muscular endurance using modified pull-up and sit-up tests, flexibility using the sit-and-reach test, and aerobic capacity using the 20-meter shuttle run test. Measurements were taken 48 hours before and after the training period. Data were analyzed using mixed-design ANOVA with repeated measures, Duncan's post-hoc test, and paired t-tests at a significance level of P ≤ 0/05.

results: Both SPARK and FBS training programs significantly improved balance (15.48% and 12.36), muscular endurance (26.4% and 25.8%), flexibility (26.13% and 18.36%), and aerobic capacity (10.16% and 12%%, respectively) compared to the control group (P ≤ 0.05). However, no significant differences were found between the two training programs on any of the variables (P > 0.05).

Conclusion: SPARK and FBS training programs are equally effective, safe, enjoyable, and efficient interventions that can simultaneously enhance physical fitness indices and aerobic capacity in children with intellectual disabilities. These findings highlight the importance of incorporating multidimensional, play-based exercise programs into the educational and rehabilitation curricula for children with intellectual disabilities.

Keywords: SPARK training, FBS training, physical fitness, intellectual disability

Introduction

Intellectual disability (ID) is a developmental disorder in which an individual's intellectual functioning and adaptive behaviors are significantly below the average level of the general population (1). Based on standardized intelligence tests such as the Wechsler scales, individuals with an IQ below 70–75, accompanied by significant limitations in adaptive behaviors, are classified as having intellectual disability (ID). "Furthermore, based on IQ classification, individuals with an IQ of approximately 50–70 are categorized as having mild intellectual disability, those with an IQ of 35–50 as moderate, those with an IQ of 20–35 as severe, and individuals with an IQ below 20 as profound intellectual disability (2). Intellectual disability manifests before the age of 18 years (during the developmental period) and its prevalence is reported to be approximately 1.5 times higher in males than in females (3). Furthermore, the risk of chronic diseases in individuals with intellectual disability is reported to be approximately twice that of the general population, and their average life expectancy is estimated to be half that of peers with typical development (4). Moreover, the reported prevalence of intellectual disability varies depending on the methods of data collection and the different operational definitions used for this disorder (5). According to the latest estimates, the global prevalence of this disorder is approximately 2–3% (6). In Iran as well, according to available statistics, over 1.5 million people live with some form of intellectual disability, with approximately 3% having profound intellectual disability—a significant figure given the total population (3). This disorder is one of the most important developmental challenges that begins in childhood and is characterized by limitations in intellectual functioning and adaptive behavior (7). Children with intellectual disability, due to impaired cognitive functioning, frequently show impairments or delays in the development of motor skills(8) . These children often display atypical and inefficient behaviors in activities that require precise bodily coordination. Their motor problems include poor fine and gross motor skills, impaired balance, and difficulties in performing activities of daily living (9). Numerous studies have shown that children with intellectual disability, compared with their typically developing peers, obtain lower scores in physical fitness components such as muscular strength, cardiorespiratory endurance, agility, speed, reaction time, and balance (10). For instance, Rahmaty et al. reported a significant correlation between cardiorespiratory fitness, muscular strength, static and dynamic balance, and postural abnormalities in this group (11). Additionally, Fedulova et al. demonstrated that children with intellectual disability exhibit poorer performance in balance, throwing, catching, and jumping skills compared to typically developing children (12). "Given that children with intellectual disability exhibit poorer performance in physical fitness indicators compared to typically developing peers, implementing strategies to enhance their physical abilities holds particular importance. In this regard, several studies have shown that children and adolescents with intellectual disability, through an active lifestyle and regular participation in sports activities, can improve their muscular strength to levels comparable to their typical peers (13, 14) .

"According to these findings, individuals with intellectual disability often experience premature aging, a condition that leads to increased disability and a higher incidence of various diseases, and consequently places them at greater risk of impaired balance and reduced physical fitness indices compared with others. Such problems can increase the likelihood of falls, complicate the performance of occupational and social roles, and restrict activities of daily living (15). Therefore, the need for high-quality fitness programs in this population is particularly pressing. In this regard, improving neuromuscular function, enhancing coordination, strengthening proprioception, increasing static and dynamic balance, and empowering core muscles through resistance and functional training programs can markedly improve their physical capacity and ability to perform these tasks and activities.

The Functional Body System (FBS) training program is a combined therapeutic and physiotherapy-based regimen that incorporates functional, balance, and strengthening exercises, grounded in theoretical principles of motor control and learning, postural adjustment, and muscle strengthening (16). The FBS exercises, as a combination of functional, balance, and strengthening training, have been introduced as an effective method for improving health. Among the benefits of FBS exercises are enhancements in muscular strength through hyperplasia (increased muscle fibers), hypertrophy (increased fiber size), improved coordination and synchronization of motor units, high exercise variety, engagement of all systems involved in maintaining static and dynamic posture, and their cost-effective and practical nature. Such training is particularly effective for preserving balance and coordination (17). In contrast, the SPARK program is a play- and fun-based activity that, beyond physical benefits, positively impacts the mental and emotional well-being of children with intellectual disability (18). This program, designed to enhance physical fitness and motor skills, has been implemented and evaluated in U.S. elementary schools as a health-related physical education curriculum (19). Domestic studies have also shown that SPARK training has a significant effect on improving gross motor and manipulative skills in children with intellectual disability (20).

"Despite the effectiveness of both training approaches, no study to date has directly compared the effects of SPARK and FBS exercises on physical fitness indices and aerobic capacity in children with intellectual disability. This research gap underscores the importance of the present study, as maintaining muscular strength, endurance, and dynamic balance is essential for achieving independent living in individuals with intellectual disability. Moreover, exercise programs tailored to the physical and psychological characteristics of this population not only improve physical and mental health, but also prepare them for more active participation and a better quality of life in society. Accordingly, the present study was designed and conducted to examine and compare the effects of a period of SPARK and FBS training on physical fitness indices and aerobic capacity in children with intellectual disability, thereby addressing this research need and providing a scientific basis for developing effective training programs for this group.

Materials and Methods

Study Design and Participants

The present study is a semi-experimental, applied research with a pre-test/post-test design. The statistical population consisted of all children with intellectual disabilities (Wechsler IQ scores 35–50) attending special education schools in Aligudarz city. Sample size was determined a priori using G*Power 3.1 for repeated-measures ANOVA (time × group interaction) or one-way ANOVA on change scores, with the following parameters: effect size $f = 0.25$ (medium, Cohen 1988), $\alpha = 0.05$, power = 0.80, 3 groups, 2 measurements. This yielded a minimum total $N \approx 36–42$ ($\approx 12–14$ per group). Due to the limited accessible population (children with IQ 35–50 in special schools of Aligudarz), 36 eligible children were purposively selected and randomly assigned to three groups of 12 each

(SPARK, FBS, control; total N = 36). This meets the calculated requirement and is consistent with similar studies in adapted physical activity for children with intellectual disabilities. No attrition occurred. No exercise intervention was provided to the control group during the study; they continued their usual lifestyle and only participated in pre- and post-testing. Children with sensory impairments (e.g. blindness, deafness, or tactile deficits) were excluded. Written informed consent was obtained from all parents. Participant information remained confidential, and voluntary withdrawal was permitted at any stage. Exclusion criteria included parental dissatisfaction, voluntary withdrawal, illness or inability to perform exercises, injury during training, and absence from more than two sessions.

Personal Characteristics Questionnaire: A questionnaire designed by the therapist was used to collect demographic information, including gender, age, medication use, father's occupation, and parents' education level.

Wechsler Intelligence Scale: The Wechsler Intelligence Scale for Children is an analytical test for ages 5–15, scored based on performance rather than all-or-nothing. It comprises 12 subtests (two optional: digit span and mazes, which can substitute others). Subtests are divided into verbal (e.g. general information, similarities, vocabulary, and digit span) and performance (e.g. picture completion, block design, mazes, coding) sections. Internal consistency is high within sections but lower between verbal and performance. The test demonstrates acceptable reliability and validity: internal consistency coefficients of 0.96 (full scale), 0.94 (verbal), and 0.90 (performance); good test-retest reliability over one month and two years; standard error of measurement 3.19 (full), 3.60 (verbal), 4.66 (performance). Highest error was in digit span, lowest in vocabulary. (21) Studies by Abedi et al. confirm good validity and reliability in Iranian samples (22).

Variable Assessment

Standard tests were used to measure physical fitness indices: flexibility (sit-and-reach), muscular endurance (modified pull-up and trunk curl), dynamic balance (Timed Up and Go; lower time = higher score; validity 0.79, reliability 81.5% (23)), and aerobic capacity (20-meter shuttle run) (24). Validity and reliability of these tests have been confirmed in prior studies (12, 13, 19).

Exercise Protocols

SPARK Training Protocol

The 8-week SPARK program consisted of three 45–60-minute sessions per week, structured in four parts: warm-up, locomotion skills, manipulation skills, and cool-down (25). Exercise content for sessions 1–9 is presented in Table 1; sessions 10–24 repeated earlier sessions for continuity and consolidation.

Table 1: SPARK Exercise Program

Session	Exercises
Session 1	- Static and dynamic balance - Visual, auditory, and shape perception (spatial and temporal) - Locomotion and manipulation skills - Lateral dominance and body awareness - Coordinated and simultaneous movements and movement patterns - Combined activities
Session 2	- Hopping backward and sideways on a straight line - Drawing shapes on the board and having the child describe their direction - Crumpling newspaper - Hopping on the dominant foot inside squares - Searching in sand to find small hidden objects - Review of previous exercises
Session 3	- Double-leg jump inside a square - Moving inside squares with pre-marked left and right foot positions - While performing double-leg jumps, hitting a ball to the ground with both hands - Holding paper with the non-dominant hand and cutting with the dominant hand - Imitating animal walking - Opening and closing nuts and bolts
Session 4	- Standing on a balance board - Running and kicking a ball thrown by the instructor - Butterfly movement (jumping jacks) - Completing a human body puzzle - Hitting a balloon in space - Review of previous exercises
Session 5	- Standing on one leg with eyes closed - Zigzag passing through obstacles - Hitting a tennis ball with the back and front of a racket - Hopping on the dominant foot and

	landing on both feet in the eight-square game - Guessing the structure of shapes with eyes closed - Building shapes with play dough
Session 6	- Standing on one leg on a soft surface - Tracking a pendulum ball with the eyes - Throwing a ball into a basket - Drawing the human body and naming body parts - Touching the tip of the nose with eyes closed - Review of previous exercises
Session 7	- Walking on a balance board - Coordinated striking with the instructor using two wooden sticks - Double-leg jump over a small obstacle - Instructor touches a limb and the child repeats the movement - Throwing a rubber ring into a designated area - Building shapes with play dough
Session 8	- Standing on a tube - Drawing shapes on paper and recreating them with play dough - Passing through a hoop (frontally) - Passing sideways through a hoop - Standing on a tube and imitating the instructor's movements - Review of exercises
Session 9	- Hopping and rotating on one leg - Throwing a ball to different areas - Hopping and rotating on one leg while holding a ball - Learning the function of different body parts - Hitting a ball to a specific area on the wall - Review of previous exercises

FBS Training Protocol

The FBS intervention group also performed combined functional, balance, and strengthening exercises in supine, sitting, and standing positions over eight weeks, with three sessions per week, each session lasting approximately 45–60 minutes. The FBS exercises consisted of activities that incorporate all three characteristics—functional, balance, and strengthening—within a single exercise (26). The content of the exercises from sessions 1 to 12 is presented in Table 2.

Table 2: FBS Exercise Program

	Exercise Title	**Repetitions Weeks 1–2**	**Repetitions Weeks 3–4**	**Repetitions Weeks 5–6**	**Repetitions Weeks ٨7–8**	**Notes**
1	Pressing a small Pilates ball with the back of the head against the wall	38	310	312	312	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
2	From prone position, forehead on rolled hands, rolling head backward and upward	38	310	312	312	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
3	Sitting, placing Pilates band behind head and pressing head backward	38	310	312	312	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
4	Hands behind body, lifting abdomen forward with straight legs	308	301	3912	3512	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
5	Standing on both feet, holding band in front at horizontal level, opening arms (scapular retraction)	208	3010	2012	3012	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
6	Angel movement with band under one foot and opening arms to the sides	208	2010	2012	3912	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
7	On all fours, simultaneously lifting opposite arm and leg	358	3510	2012	3912	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
8	On all fours, band under one hand, pulling the other end of the band sideways	308	3010	2012	3312	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set
9	Prone on Swiss ball, arm flexion forward	208	3510	3512	3012	Each movement: 6–8 sec hold Rest between sets: 1.5 × duration of set

10	Standing on both feet, band under both feet, arm flexion forward to overhead	358	3510	2012	3912	Each movement: 6–8 sec hold
11	Plank position, one hand on ground, opposite hand to the side	308	3510	3512	3012	Each movement: 6–8 sec hold
12	Prone on Swiss ball, raising arms upward from sides	308	301	2012	3512	Each movement: 6–8 sec hold

Statistical Methods

Descriptive statistics were used to calculate central tendency and dispersion indices for data analysis. The normality of the data was assessed using the Shapiro-Wilk test, and the homogeneity of variances was evaluated with Levene's test. Given that the assumptions for parametric tests were met, paired t-tests, one-way analysis of variance (ANOVA), and Tukey's post-hoc test were employed to test the hypotheses. All analyses were conducted using SPSS software version 25, with a significance level of 0.05.

Results

The descriptive characteristics of the participants, including age, height, and weight, are summarized in Table 3. Participants in the SPARK group had a mean age of 8.25 ± 0.96 years, weight of 38.42 ± 3.7 kg, and height of 148 ± 6.42 cm. The FBS group showed similar values, with a mean age of 8.75 ± 0.96 years, weight of 38.25 ± 3.28 kg, and height of 145 ± 6.66 cm. In the control group, the mean age was 9.08 ± 0.79 years, weight 39.08 ± 2.31 kg, and height 146.3 ± 4.69 cm. The groups exhibited comparable baseline anthropometric profiles.

Table 3: Mean and Standard Deviation of Research Variables

Variable	SPARK	FBS	Control
Age (years)	8.25 ± 0.96	8.75 ± 0.96	9.08 ± 0.79
Weight (kg)	38.42 ± 3.7	38.25 ± 3.28	39.08 ± 2.31
Height (cm)	148 ± 6.42	145 ± 6.66	146.3 ± 4.69

Levene's test for equality of variances was conducted to verify the homogeneity assumption for the dependent variables across groups at both pre-test and post-test time points (Table 4). For all variables—balance, muscular endurance, flexibility, and aerobic power—the test results indicated homogeneous variances (all p > 0.05).

Table 4: Homogeneity of Variances (Levene's Test)

Variable	Pre-test		Post-test	
	Statistic	Sig.	Statistic	Sig.
Balance	0.59	0.45	0.029	0.87
Muscular endurance	0.18	0.67	0.91	0.35
Flexibility	0.57	0.46	0.001	0.97
Aerobic power	2.94	0.13	3.09	0.09

Paired t-tests were performed to evaluate within-group changes in the dependent variables from pre-test to post-test (Table 5). In the SPARK group, significant improvements were observed across all variables: balance improved by 15.48% (t = 9.75, p = 0.001), muscular endurance increased by 26.4% (t = -9.89, p = 0.001), flexibility increased by 26.13% (t = -12.09, p = 0.001), and aerobic power increased by 10.16% (t = -18.99, p = 0.001). Similarly, the FBS group demonstrated significant positive changes: balance improved by 12.36% (t = 18.1, p = 0.001), muscular endurance by 25.8% (t = -18.1, p = 0.001), flexibility by 18.36% (t = -13.47, p = 0.001), and aerobic power by 12% (t = -12.59, p = 0.001). In contrast, the control group showed no significant changes in any variable (all p > 0.05), with percentage changes ranging from -0.38% for balance to +1.95% for flexibility.

Table 5: Within-Group Changes in Research Variables SPARK, FBS, and Control Groups

Variable	Group	Mean ± SD		Change (%)	Paired t	Sig.
		Pre-test	Post-test			
Balance	SPARK	2.52 ± 0.36	2.13 ± 0.28	−15.48%	9.75	0.001
	FBS	2.67 ± 0.4	2.34 ± 0.39	−12.36%	18.1	0.001
	Control	2.65 ± 0.29	2.64 ± 0.26	−0.38%	0.19	0.85
Muscular endurance	SPARK	12.33 ± 2.35	15.58 ± 2.27	+26.4%	−9.89	0.001
	FBS	12.58 ± 2.02	15.83 ± 1.89	+25.8%	−18.1	0.001

	Control	13.58 ± 2.11	13.67 ± 2.74	+0.74%	−0.17	0.87
Flexibility	SPARK	15.92 ± 1.83	20.08 ± 1.78	+26.13%	−12.09	0.001
	FBS	16.83 ± 1.64	19.92 ± 1.44	+18.36%	−13.47	0.001
	Control	16.92 ± 2.15	17.25 ± 2.71	+1.95%	−0.89	0.39
Aerobic power	SPARK	19.99 ± 1.41	22.02 ± 1.22	+10.16%	−18.99	0.001
	FBS	19.58 ± 1.12	21.93 ± 1.09	+12%	−12.59	0.001
	Control	19.97 ± 0.91	19.98 ± 0.88	+0.05%	−0.18	0.86

The magnitude of changes in the dependent variables across the three groups (SPARK training, FBS training, and control) is illustrated in Figure 1. This figure highlights the comparative improvements in the intervention groups relative to the negligible changes observed in the control group.

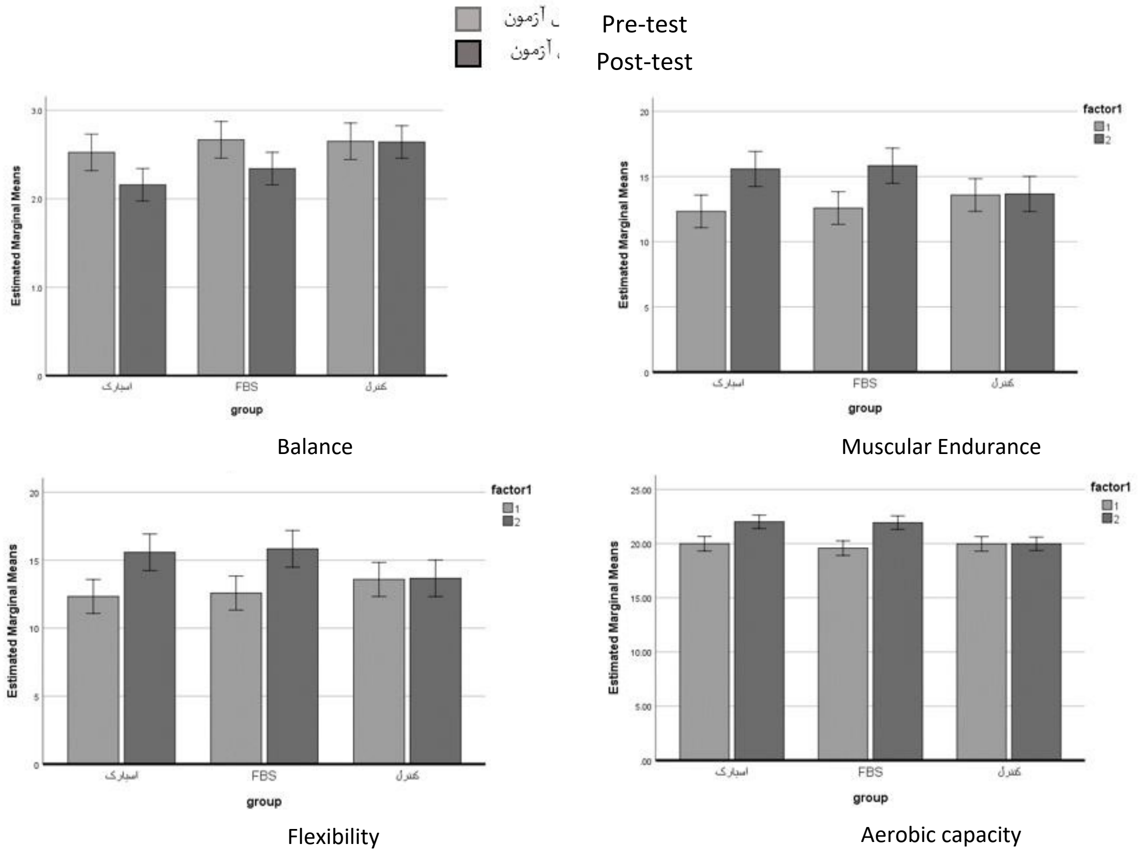

Figure 1: Changes in balance, muscular endurance, flexibility, and aerobic capacity in the three groups (Spark exercises, FBS exercises, and control)

Discussion

The findings of the present study indicated that eight weeks of implementing the SPARK and FBS exercise programs (three sessions per week, each session lasting 45–60 minutes) significantly improved balance, muscular endurance, flexibility, and aerobic power in children with intellectual disabilities, whereas the control group showed no significant changes. Direct comparison of the two exercise programs also revealed no significant differences in any of the variables, indicating that both methods were approximately equally effective.

Balance in children improved by 15.48% in the SPARK group and 12.36% in the FBS group (P=0.001). These results are fully consistent with many studies, including those by Rajabi et al. (27), Moradi et al. (28). However, some studies have reported different findings; Shafizadeh et al. observed only a 4.7% improvement in dynamic balance and no change in static balance after eight weeks of SPARK (29), and Babadi et al. found improvement only in static balance following functional-balance exercises in children with autism spectrum disorder accompanied by intellectual disability (30). The observed improvements in the present study are likely due to the progressive increase in training load, the appropriate combination of static and dynamic tasks, and the high motivation of the children resulting from the play-based nature of the SPARK program and the engaging structure of FBS. From a neurophysiological perspective, cerebellar abnormalities are a consistent feature of intellectual disability (31). Both programs, by creating tasks that require rapid shifts in the base of support, reactive responses, and continuous postural adjustments, strongly activate spinocerebellar and cerebello-cortical pathways, leading to increased synaptic plasticity in lobule VI and Crus I of the cerebellum (31).

On the other hand, muscular endurance of the upper and lower limbs increased by 26.4% and 25.8%, respectively, which is consistent with the studies by Bouzas et al. (32) and Štrucelj et al. (33). In contrast, Dehghani et al. found significant improvement only in the sit-up test and no change in the push-up test (34). The differences in results are likely related to exercise intensity, the actual volume performed, and the level of intellectual disability among participants. Both the SPARK and FBS programs, due to their circuit-based, multi-joint nature and lack of long rest periods, create high oxygen demands, leading to increased mitochondrial density, angiogenesis, conversion of type IIx fibers to IIa, and improved intra- and inter-muscular coordination (35). These adaptations are of double importance in children with intellectual disabilities, who naturally have lower oxidative capacity.

Regarding flexibility indices, the findings of the present study showed that flexibility increased by 13.26% in the SPARK group and approximately 18.36% in the FBS group. This finding is consistent with other studies, including those by Salehian et al. (7) and Samatovich et al. (36); however, Rahmani et al. reported only a non-significant 3.8% improvement following a SPARK training period (37). Additionally, Konrad et al. emphasized that dynamic stretches typically have less effect than static stretches when performed for less than eight weeks (38). In the present study, the intelligent combination of prolonged static stretches with mental focus (SPARK) and repetitive dynamic stretches (FBS), along with stretching durations exceeding 60 seconds per muscle group, led to strong activation of Golgi tendon organs, reduced stretch reflex, sarcomere lengthening, and increased stretch tolerance.

Additionally, following eight weeks of SPARK and FBS training, aerobic capacity increased by 10.16% in the SPARK group and 12% in the FBS group, which represents the first direct report comparing the effects of these two programs on VO_2peak in children with intellectual disabilities. The results of this study are consistent with indirect studies by Khaliq et al. (39) and Maicas-Pérez (40). These studies have shown that SPARK and FBS training likely increase aerobic capacity in participants by enhancing engagement of core and lower body muscles and improving neuromuscular coordination. On the other hand, Kofki et al. found only a non-significant 4.2% increase in aerobic capacity and suggested that more time may be required to induce aerobic adaptations from these exercises (41). The greater improvement in the present study is due to the inclusion of continuous jumping and rope-skipping activities, as well as the interval-like structure of the programs (particularly SPARK), which led to increases in stroke volume, muscular angiogenesis, mitochondrial density, and movement economy (42).

In summary, both SPARK and FBS training programs, as non-pharmacological, safe, low-cost, enjoyable, and feasible interventions in special education schools and rehabilitation centers, demonstrated equal effectiveness in improving physical fitness indices and aerobic capacity in children with intellectual disabilities. This equivalence, despite apparent differences in the programs' structures, stems from the high overlap in physiological, neurophysiological, and motivational mechanisms. The results of the study emphasize the importance of multidimensional, play-based, and functional programs and indicate that there is no need to exclusively choose one of these two methods; rather, either one or a combination of them can be used. Therefore, it is recommended that these programs be incorporated into the physical education curriculum of special education schools, that coaches receive training, and that the programs continue at home and in rehabilitation centers. For future research, it is suggested to investigate long-term effects (more than 12 weeks), post-intervention retention, impacts on cognitive-emotional variables, and structural brain changes using functional imaging. Additionally, comparing these programs with modern methods such as aquatic exercise, virtual reality, and active gaming is recommended.

Conclusion

The results of this study provide strong evidence that SPARK and FBS exercises are effective, generalizable, and sustainable options for improving physical fitness indices and aerobic capacity in children with intellectual disabilities. They can be integrated into comprehensive rehabilitation programs for these children.